Factors associated with material deprivation in persons with multiple sclerosis in Switzerland: Cross-sectional data from the Swiss Multiple Sclerosis Registry

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ABSTRACT

Background: Multiple sclerosis (MS) impacts education, future career pathways and working capability and therefore may negatively impact the financial situation of persons with MS (pwMS) in Switzerland. We therefore investigated the financial situation and its influencing sociodemographic and disease-specific factors of pwMS compared to the general Swiss population with focus on material deprivation (MD).

Methods: Data on the financial situation of pwMS were collected via a specific questionnaire added to the regular, semi-annual follow-up assessments of the Swiss Multiple Sclerosis Registry. Questions were taken in an unmodified format from the standardized "Statistics on Income and Living Conditions" (SILC) questionnaire 2019 of the Federal Statistical Office of Switzerland which evaluates the financial situation of the general Swiss population, enabling a direct comparison of pwMS with the general Swiss population.

Results: PwMS were 1.5 times more frequently affected by MD than the general Swiss population (6.3% of pwMS versus 4.2% of the general Swiss population) which was confirmed in a multivariable logistic regression analysis of pooled SILC and Swiss Multiple Sclerosis Registry (SMSR) data. High symptom burden, having only mandatory schooling, well as having a pending disability insurance application (as opposed to no application or receiving benefits) were associated with a higher odds of MD whereas higher education, older age, having a Swiss citizenship, living with a spouse or a partner or being currently employed were independently associated with a lower odds of MD.

Conclusion: MS has a negative impact on the financial situation and is associated with MD. PwMS with a high symptom burden at the transition from work force to receiving disability benefits appeared to be vulnerable for MD. Higher education, older age, having a Swiss citizenship, living with a spouse or a partner or being currently employed were independently associated with a lower odds of MD.

1. Introduction

Multiple sclerosis (MS) is a chronic inflammatory disease of the central nervous system (CNS) and, with a disease onset usually between 20 and 40 years, the most common cause of nontraumatic disability in young adults in industrialized countries (Hemmer et al., 2021; Kamm et al., 2014). Due to the time of onset, MS has a significant impact on education, future career pathways and working capability (Rumrill, 2016). Therefore, MS may negatively impact the financial situation of persons with MS (pwMS) and research on factors influencing the financial situation in pwMS is of great interest, especially with regard to the respective countries pwMS live in. Previous studies reported that even a minimal disability, defined by an Expanded Disability Systems Score (EDSS) < 3, has a significant impact on the working capability (Findling et al., 2015; Kurtzke, 1983). In addition, impaired cognition is independently correlated with lower income in pwMS (Kavaliunas et al., 2015). These impairments may lead to financial burden and material deprivation (MD).

The Organisation for Economic Co-operation and Development (OECD) as well as the Federal Statistical Office of Switzerland defines MD as the inability for individuals or households to afford consumption goods and activities that are typical in a society at a given point in time, irrespective of people's preferences with regard to these items (Switzerland, 2022; Development OfEC-oa, 2022).

In Switzerland, a yearly nationwide survey is performed by the Federal Statistical Office (FSO) to investigate MD, social exclusion and living conditions using the "Statistics on Income and Living Conditions" (SILC) questionnaire, which is based and carried out in cooperation with the Statistical Office of the European Union (Eurostat) in over 30 European countries (EU-SILC: "European Union Statistics on Income and Living Conditions") (Federal Statistical Office S, 2022). In Switzerland, over 8,000 households and more than 18,000 people that are randomly selected from the Federal Statistical Office take part every year (Federal Statistical Office S, 2022). Thus, the results can be compared with other countries (Switzerland FSO, 2022). In addition, the results of the general population can be compared to subgroups of the Swiss population such as pwMS, as done in this study.

This study had two aims. First, we wanted to investigate the level of MD in pwMS in comparison to the general Swiss population. Second, we aimed to examine sociodemographic and disease-specific factors that were associated with MD and the financial situation of pwMS. These findings may help to specifically support pwMS regarding the management of their financial situation.

2. Material and methods

2.1. Study context

This study is nested into the Swiss Multiple Sclerosis Registry (SMSR) which was initiated in 2016 and is funded by the Swiss Multiple Sclerosis Society. The SMSR is a nationwide, survey-based registry encompassing adult pwMS who reside and/or receive MS-related care in Switzerland. It pursues a citizen science approach and combines the advantages of traditional and digital research methods (Steinemann et al., 2018). Enrollment is independent of treatment status or health care setting enabling a diverse study population (Puhan et al., 2018). Regular questionnaires are answered semi-annually by the participants. Furthermore, additional questionnaires regarding a specific topic can be added, as done in this study. To date, the SMSR has collected baseline data of more than 2500 pwMS. To ensure data integrity and fulfill ethical considerations, study participants were required to provide written informed consent and confirmation of MS diagnosis from their treating physician (Puhan et al., 2018). The SMSR is approved by the Cantonal Ethics Committee Zurich (PB-2016-00894, BASEC-NR 2019-01027).

2.2. Databases

Data on the financial situation of pwMS were collected via a single specific questionnaire (hereinafter referred to as "financial survey") added to the regular, semi-annual follow-up assessments of the SMSR distributed on the 01.09.2020. Questions were taken in an unmodified format from the standardized Statistics on Income and Living Conditions (SILC) questionnaire 2019 of the Federal Statistical Office of Switzerland which evaluates the financial situation of the general Swiss population (https://www.bfs.admin.ch/bfs/en/home.html) (Office FS, 2022). In order to keep the survey concise, only the most relevant sections pertaining to the study questions of interest were included.

The results of the respective questions of 7341 participants of the general Swiss population from the SILC 2019 were provided to us by the Swiss Federal Office of Statistics. This approach enabled a direct comparison of the population of pwMS to the general Swiss population.

The standard set of baseline and longitudinal follow-up questions of the SMSR was included in the analysis as well, which amongst others covers MS treatments, symptoms, and health-related quality of life, sociodemographic information such as age, gender, MS duration, education, employment, disability insurance eligibility, and Self-Reported Disability Status Scale (SRDSS, a validated self-reported proxy measure for the Expanded Disability Status Scale) (Kaufmann et al., 2020). Minimal requirements for study inclusion were a completed baseline assessment and the financial survey as well as complete data on education, citizenship, partnership, age, gender, and MS type.

2.3. Study outcome

The main outcome of interest was "material deprivation" (MD) as defined for the SILC questionnaire (Federal Statistical Office S, 2022). MD is present if three of the following conditions are fulfilled:

1. the inability to face an unexpected expense equal to 1/12 of the at-risk-of-poverty threshold within one month (CHF 2500 in Switzerland since 2013)
2. the inability to afford a one-week annual holiday away from home
3. the presence of payment arrears for housing, heating, taxes and/or health insurance
4. the inability to afford a meal with meat, chicken or fish (or vegetarian equivalent) at least every other day
5. to not own a car for financial reasons

It should be noted that this algorithm is an approximation of the official algorithm employed by the Swiss Federal office of Statistics, which is based on additional questions not included in our survey to reduce the financial survey size. Two algorithms of the outcome assessments were tested (one based on a subset of EU-standardized questions (EU proxy definition), and one including two additional questions on payment arrears of taxes or health insurance (Augmented proxy definition, supplementary Table 1). The two proxy algorithms were validated against the SILC dataset including the official deprivation indicator. Based on this evaluation, the augmented proxy definition was chosen for analysis because it had very high sensitivity (94.5%) and specificity (99%). Details on the algorithm validation are provided in supplementary Table 2.

2.4. Variables of interest

To explore associations of participant characteristics with MD, we examined the following variables collected at the nearest time point to the completion of the financial survey: age, gender, citizenship, partnership status, SRDSS, MS type, disease-modifying treatment status (ever/never), highest education level, work situation (not working, part-time, full-time), disability insurance benefits (not eligible, applied for, eligible), and presence of different symptoms and number of reported

symptoms, as well as EQ-5D based health-related quality of life indicators (Brooks et al., 2003).

2.5. Statistical analysis

Characteristics associated with MD indicators (MDI: no MDI, 1-2 MDIs, 3 or more MDIs) were analyzed descriptively. Continuous variables were described as medians [interquartile ranges], categorical variables as number (%).

By using a multivariable logistic regression model, we compared the odds of MDIs between the general population (SILC) data with pwMS in an analysis of the pooled databases. This regression analysis was adjusted for sex partnership status, citizenship and age.

In addition, multivariable multinomial regression models were estimated across the same three outcome levels (no MDI, 1-2 MDIS, 3 or more MDIs) by the inclusion of pre-defined confounder variables (age, gender, education, and Swiss citizenship). Additional variables were incrementally added and maintained if they improved the model fit by decreasing the Akaike Information Criterion (AIC) by 2 units or more. Since SRDSS was missing for 37 individuals, a complete case analysis as well as missing imputations were performed.

All analyses were conducted using Stata 16.1 (Stata Corp, College Station TX, USA).

3. Results

3.1. Description of study population

In total, 1007 participants were included (full sample), of whom 975 also had complete SRDSS measurements (Fig. 1). Participants' characteristics of the full sample and the MD-based subsamples are illustrated in Table 1. Median age in the full sample at the time of survey was 50 [IQR]. Most persons were female (72.6%) and had a relapsing-remitting MS (64.5%).

Data on the source of income in the full sample and subsamples are illustrated in Table 2. Overall, 60% of the study population were

working full- or part-time, 29.1% received disability insurance (age <65 years), and 13.1% received retirement benefits (age >65 years).

The median monthly net income of pwMS was similar to the general Swiss population (Federal Statistical Office SWaWC, Switzerland, 2022). Overall, 9.6% of respondents reported to have a negative income balance (i.e., to make debts or to rely on savings), and 4.6% reported to find it difficult or very difficult to make ends meet.

Concerning MDI, one in four pwMS (26.4%) reported housing costs to be a high burden and one in five (21.9%) had difficulties to cover unexpected expenses of CHF 2,500 within a month. 11.1% reported not to be able to afford a week of vacation away from home per year. Different types of payment arrears were reported ranging from 1.6% (housing) to 7.2% (taxes) of respondents.

In total, 6.3% of SMSR participants had at least three MDIs, thus fulfilling the MD criteria (augmented proxy algorithm). By comparison, 4.2% of persons in the general Swiss population met the MD definition. The nominal 1.5 times higher odds of pwMS compared to the general population was also confirmed in a multivariable logistic regression analysis of pooled of SILC and SMSR data. After adjusting for age, sex, Swiss citizenship, and living with a partner, SMSR participants had a 1.49 [1.11; 2.01] higher odds of experiencing material deprivation (not shown).

3.2. Material deprivation indicator-stratified analysis of sociodemographic and health characteristics

Table 1 also displays sociodemographic and health-related characteristics of pwMS stratified by levels of MD. Table 1 includes 720 persons without MD (no MD group) and 63 with 3 or more MDI (MD group). In addition, 224 individuals had an elevated MDI risk due to 1-2 self-reported indicators, and their characteristics are shown in the middle column of Table 1.

Persons in the no MD group tended to be older (median 50 years vs. 46 years with MD) and to have a longer disease duration (median 10 years) than persons with MD (median 8 years). Persons without MD were also more likely to live together with a partner or spouse (72.2%)
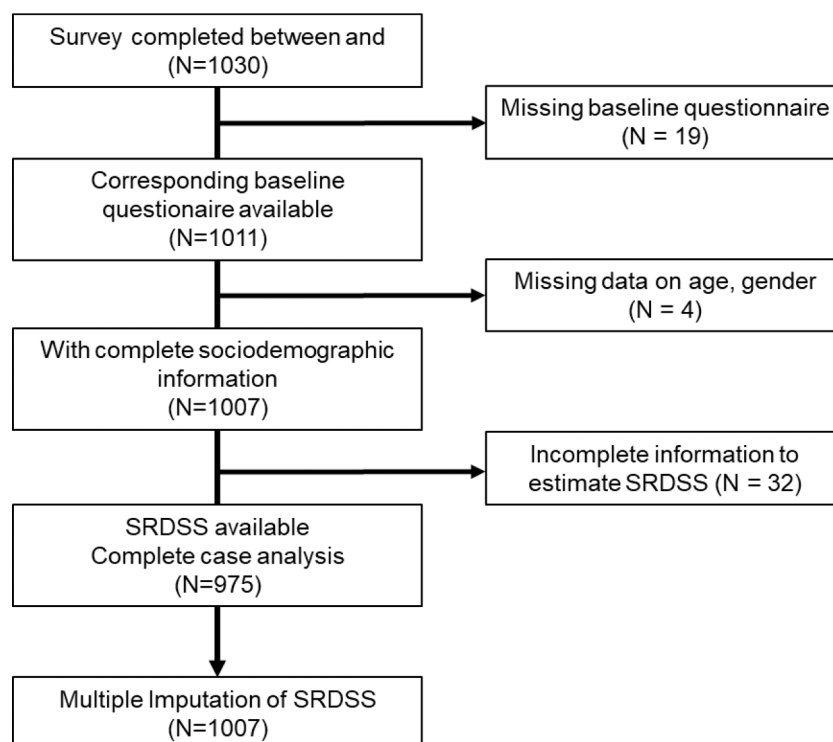

Fig. 1. Patient flow chart.

Table 1
Patient characteristics.

	No deprivation indicator	1-2 deprivation indicator	3+deprivation indicator	All participants
Number	720	224	63	1007
male sex	209 (Berthoud, 2011)	50 (22.3)	17 (Krause and Hanesch, 2003)	276 (27.4)
Year of birth (median [interquartile range])	1969 [1961; 1978]	1970.5 [1963; 1982]	1974 [1964; 1983]	1970 [1961; 1980]
Years since MS diagnosis (n, median [interquartile range])	711, 10 [5; 19]	221, 10 [5; 17]	61, 8 [3; 16]	993, 10 [5; 18]
Age at Diagnosis (n, median [interquartile range])	712, 38.0 [30.0; 46.0]	221, 36.0 [28.0; 44.0]	61, 37.0 [28.0; 45.0]	994, 38.0 [30; 45]
MS type				
CIS	13 (1.8)	4 (1.8)	0	17 (1.7)
PPMS	84 (11.7)	21 (9.4)	10 (15.9)	115 (11.4)
RRMS	458 (63.6)	151 (67.4)	41 (65.1)	650 (64.5)
SPMS	151 (Calocer et al., 2020)	41 (18.3)	10 (15.9)	202 (20.1)
unknown	14 (1.9)	7 (3.1)	2 (3.2)	23 (2.3)
SRDSS (score, range 0-10)				
0-3.5	495 (68.8)	145 (64.7)	38 (60.3)	678 (67.3)
4-6.5	137 (Helmert et al., 1989)	52 (23.2)	16 (25.4)	205 (20.4)
7 and higher	69 (9.6)	19 (8.5)	4 (6.3)	92 (9.1)
unknown	19 (2.6)	8 (3.6)	5 (7.9)	32 (3.2)
Swiss Citizen	662 (91.9)	199 (88.8)	54 (85.7)	915 (90.9)
Living with a spouse/partner	520 (72.2)	136 (60.7)	25 (39.7)	681 (67.6)
Highest professional education				
Mandatory schooling	14 (1.9)	16 (7.1)	5 (7.9)	35 (3.5)
Apprenticeship	246 (34.2)	104 (46.4)	32 (50.8)	382 (37.9)
Higher professional education	171 (23.8)	47 (21.0)	10 (15.9)	228 (22.6)
University degree	229 (31.8)	35 (15.6)	7 (11.1)	271 (26.9)
unknown	60 (8.3)	22 (9.8)	9 (14.3)	91 (9.0)
Has ever received DMT	460 (63.9)	143 (63.8)	35 (55.6)	638 (63.4)
Paper questionnaire participant	102 (14.2)	48 (21.4)	13 (20.6)	163 (16.2)
EQ-5D (median [interquartile range])	90.7 [78.7; 97.8]	88 [71.8; 94.1]	72.2 [58.4; 86.4]	89.6 [74; 95.8]
Visual Analogue Scale (median [interquartile range])	80 [62; 90]	70 [50; 84.5]	50 [35; 66]	75 [60; 87]
Current symptoms				
self-reported symptoms (median [interquartile range])	3 [0; 7]	5 [0; 9]	9 [4; 12]	4 [0; 8]
Affective disorder	46 (6.4)	20 (8.9)	16 (25.4)	82 (8.1)
Balance problems	229 (31.8)	78 (34.8)	34 (Saunders, 2006)	341 (33.9)
Bladder problems	203 (28.2)	68 (30.4)	27 (42.9)	298 (29.6)
Concentration problems	171 (23.8)	72 (32.1)	30 (47.6)	273 (27.1)
Depression	66 (9.2)	36 (16.1)	21 (33.3)	123 (12.2)
Dizziness	115 (Patti et al., 2007)	50 (22.3)	27 (42.9)	192 (19.1)
Fatigue	314 (43.6)	126 (56.3)	46 (73)	486 (48.3)
Gait problems	235 (32.6)	76 (33.9)	30 (47.6)	341 (33.9)
Gastrointestinal problems	139 (19.3)	54 (24.1)	25 (39.7)	218 (21.6)
Memory problems	96 (13.3)	63 (28.1)	29 (Koziarska et al., 2018)	188 (18.7)
Pain	180 (Wiberg et al., 2015)	76 (33.9)	33 (52.4)	289 (28.7)
Spasms	202 (28.1)	52 (23.2)	27 (42.9)	281 (27.9)
Visual disturbances	102 (14.2)	49 (21.9)	24 (38.1)	175 (17.4)
Weakness	199 (27.6)	75 (33.5)	36 (57.1)	310 (30.8)

Results are shown in number (n) and percentage (%) if not otherwise noted; CIS, Clinically Isolated Syndrome; PPMS, Primary progressive MS; RRMS, Relapsing remitting MS, SPMS, Secondary progressive MS; SRDSS, self-reported disability status scale; DMT, disease-modifying treatments; EQ-5D, European Quality of Life 5 Dimensions questionnaire

compared with persons with MD (39.7%). Several health-related indicators also point towards a lower disease burden in persons without MD, such as a higher percentage in the lowest SRDSS stratum (68.8% vs. 60.3% with MD), a higher median self-reported quality of life score in the EQ-5D (90.7 vs. 72.2 with MD on a 0 (worst) to 100 (best) quality of life scale), as well as a lower median number of self-reported MS symptoms (3 vs. 9 with MD).

When comparing other financial indicators and income sources that were not part of the MDI definition (Table 2), persons without MD were more often employed (63.6% vs. 39.7% with MD) or retired (14% vs. 9.5% with MD). Moreover, fewer persons without MD were observed in the lowest monthly household income bracket (9.7% vs. 58.7%), and they rated their financial situation substantially higher (median score of 8 on a scale from 0 (worst) to 10 (best satisfaction)) compared with persons with MD (median score 3).

3.3. Exploratory regression analysis of factors associated with material deprivation

Multivariable regression analyses, shown in Table 3, suggest several factors to be independently associated with MD. In the following, results from the imputed analysis (right columns) are presented, which yielded

almost identical effect estimations as the complete case analysis (middle columns). Compared with persons without MD, several factors were associated with a decreased likelihood for MD, namely older age (odds ratio [95% confidence interval], 0.7 [0.51;0.95]), currently being employed (0.23 [0.11; 0.47]), having a Swiss citizenship (0.32 [0.13; 0.82]), and living with a spouse or a partner (0.19 [0.10; 0.35]), or having a university degree (0.19 [0.07; 0.51]). By contrast, a high symptom burden (8.07 [1.47; 44.15] for reporting 9 or more symptoms) or having applied for disability insurance (3.14 [1.18; 8.34]) was associated with MD.

4. Discussion

In this study, we investigated MD of pwMS in comparison to the general Swiss population.

In 2019, 6.3% of pwMS were affected by MD compared to 4.2% of the general Swiss population. MD is therefore 1.5 times higher in pwMS compared to the general Swiss population. These findings are not surprising as MS affects young adults with the median age at diagnosis of 38 in our cohort and therefore education, apprenticeship, and capacity to work (Findling et al., 2015; Patti et al., 2007; Krause et al., 2013). In addition, these findings are in line with other chronic diseases like sleep

Table 2

Source of income and financial situation.

	No deprivation indicator	1-2 deprivation indicator	3+deprivation indicator	All participants
Work and disability insurance				
Currently employed	458 (63.6)	121 (Saunders, 2006)	25 (39.7)	604 (60)
Applied for disability insurance	29 (Findling et al., 2015)	17 (7.6)	13 (20.6)	59 (5.9)
No disability insurance	400 (55.6)	97 (43.3)	25 (39.7)	522 (51.8)
Does receive disability insurance	190 (26.4)	84 (37.5)	19 (30.2)	293 (29.1)
Retired, no disability insurance	101 (Brooks et al., 2003)	26 (11.6)	6 (9.5)	133 (13.2)
Assets (SFR)				
Unclear assets	11 (1.5)	10 (4.5)	1 (1.6)	22 (2.2)
Less than 10000	20 (2.8)	77 (34.4)	42 (66.7)	139 (13.8)
10000-50000	107 (14.9)	59 (26.3)	10 (15.9)	176 (17.5)
100000-500000	218 (30.3)	19 (8.5)	2 (3.2)	239 (23.7)
50000-100000	131 (18.2)	26 (11.6)	1 (1.6)	158 (15.7)
500000-1000000	92 (12.8)	1 (0.4)	0	93 (9.2)
More than 1000000	65 (Federal Statistical Office S, 2022)	6 (2.7)	0	71 (7.1)
Not reported	76 (10.6)	26 (11.6)	7 (11.1)	109 (10.8)
Monthly household income (SFR)				
0-4500	70 (9.7)	71 (31.7)	37 (58.7)	178 (17.7)
4501-6000	129 (17.9)	56 (Wiberg et al., 2015)	13 (20.6)	198 (19.7)
6001-9000	201 (27.9)	51 (22.8)	5 (7.9)	257 (25.5)
more than 9000	275 (38.2)	25 (11.2)	3 (4.8)	303 (30.1)
Not reported	45 (6.3)	21 (9.4)	5 (7.9)	71 (7.1)
Annual income balance (SFR)				
can put money aside	561 (77.9)	73 (32.6)	3 (4.8)	637 (63.3)
breaks even	114 (15.8)	107 (47.8)	40 (63.5)	261 (25.9)
needs savings	42 (5.8)	34 (15.2)	9 (14.3)	85 (8.4)
makes debts	1 (0.1)	1 (0.4)	10 (15.9)	12 (1.2)
Missing	2 (0.3)	9 (Findling et al., 2015)	1 (1.6)	12 (1.2)
Negative annual household balance - makes debts or uses savings	43 (Kavaliunas et al., 2015)	35 (15.6)	19 (30.2)	97 (9.6)
Difficulty in making ends meet				
very easy	218 (30.3)	8 (3.6)	0	226 (22.4)
Easy	258 (35.8)	30 (13.4)	2 (3.2)	290 (28.8)
slighly easy	199 (27.6)	71 (31.7)	8 (12.7)	278 (27.6)
slighly difficult	40 (5.6)	88 (39.3)	28 (44.4)	156 (15.5)
Difficult	2 (0.3)	15 (6.7)	13 (20.6)	30 (Rumrill, 2016)
very difficult	1 (0.1)	3 (1.3)	12 (Helmert et al., 1989)	16 (1.6)
Missing	2 (0.3)	9 (Findling et al., 2015)	0	11 (1.1)
Considering the full household income, finds it difficult or very difficult to cover the necessary expenses (vs. somewhat difficult to very easy)	3 (0.4)	18 (Development OfEC-oa, 2022)	25 (39.7)	46 (4.6)
Satisfaction with financial situation (scale from 0 (worst) to 10 (best)	8 [7; 10]	5.5 [5; 7]	3 [2; 5]	8 [5; 9]
Financial burden and deprivation indicators. Due to financial reasons,				
large financial burden by housing (vs. no or small burden)	130 (18.1)	94 (Benedict et al., 2020)	42 (66.7)	266 (26.4)
no car	0	32 (14.3)	22 (34.9)	54 (5.4)
no computer	4 (0.6)	2 (0.9)	7 (11.1)	13 (1.3)
problems paying an unexpected bill of CHF 2500 within 30 days	0	158 (70.5)	63 (100)	221 (21.9)
can't afford a full meal eod	0	3 (1.3)	15 (23.8)	18 (1.8)
can't afford a full week of vacation	0	53 (23.7)	60 (95.2)	113 (11.2)
could not pay rent/mortgage in time over last 12 months	0	7 (3.1)	9 (14.3)	16 (1.6)
could not pay gas/electricity/water/heating in time over last 12 months	0	21 (9.4)	22 (34.9)	43 (4.3)
could not pay tax bills in time over last 12 months	0	39 (17.4)	33 (52.4)	72 (7.1)
could not pay health insurance in time over last 12 months	0	12 (5.4)	18 (28.6)	30 (Rumrill, 2016)

Results are shown in number (n) and percentage (%) if not otherwise noted; SFR, Swiss francs; eod, very other day.

disorders, heart disease, migraines, depressive disorders, joint diseases or chronic back problems which are associated with low socioeconomic status and MD as well (Pförtner, 2015; Helmert et al., 1989; Geyer, 2016).

Regarding participants' characteristics, higher education, older age, having a Swiss citizenship and living with a spouse or a partner, were independently associated with lower rates of MD while gender and age at diagnosis showed no difference. This is in line with results from French and Belgian MS cohort studies, which showed that having a long-term education (over more than 12 years) is protective for MD and disability (Calocer et al., 2020). Furthermore, our study showed that higher age lowers the odds of MD. This is explainable because a completed education and established career is more likely in a higher

age, as well as eligibility for own and/or a partner's retirement benefits (old-age insurance pension). The lower odds of having a Swiss citizenship with MD could be related to a better understanding of the healthcare and social security system as well as better integration in society with financial coping possibilities due to friends and family (Rommer et al., 2017). This corresponds to a lower odds for MD in pwMS living with a spouse or a partner. Besides additional income, spouses or partners can help accomplish activities of daily living and give emotional support, both factors having a positive impact on quality of live and mental health and help to cope with the disability and facilitate the return to work and participation in social life (Ratajska et al., 2020; Krokavcova et al., 2008). Interestingly, age at diagnosis, disease duration and MS-type showed no statistically significant association with

Table 3

Multivariable multinomial regression to identify factors associated with the presence one or two, respectively three or more material deprivation indicators.

	Univariable, complete-case OR [95% CI]		Multivariable, complete-case OR [95% CI]		Multivariable, imputed OR [95% CI]	
	1-2 depriv. Indices	3+ deprv. Indices	1-2 depriv. Indices	3+ deprv. Indices	1-2 depriv. Indices	3+ deprv. Indices
Male sex (vs. female)	0.70 [0.49; 1.00]	0.90 [0.51; 1.61]	0.93 [0.63; 1.37]	1.92 [0.97; 3.83]	0.94 [0.64; 1.39]	1.95 [0.96; 3.96]
Age	**0.86 [0.77; 0.97]**	**0.80 [0.66; 0.99]**	**0.72 [0.60; 0.86]**	**0.65 [0.48; 0.89]**	**0.72 [0.61; 0.86]**	**0.70 [0.51; 0.95]**
ever received DMT	1.00 [0.73; 1.36]	0.71 [0.42; 1.19]				
Currently employed (vs. not employed)	**0.67 [0.50; 0.91]**	**0.38 [0.22; 0.64]**	**0.58 [0.38; 0.87]**	**0.22 [0.11; 0.44]**	**0.65 [0.42; 0.99]**	**0.23 [0.11; 0.47]**
Swiss Citizen (vs. non-Swiss)	0.70 [0.43; 1.14]	0.53 [0.25; 1.12]	**0.56 [0.33; 0.96]**	**0.33 [0.13; 0.81]**	0.59 [0.34; 1.03]	**0.32 [0.13; 0.82]**
Living with a spouse or partner	**0.59 [0.43; 0.81]**	**0.25 [0.15; 0.43]**	**0.57 [0.40; 0.81]**	**0.19 [0.10; 0.35]**	**0.58 [0.41; 0.82]**	**0.19 [0.10; 0.35]**
SRDSS						
0-3.5	Reference					
4-6.5	1.30 [0.90; 1.87]	1.52 [0.82; 2.81]	1.01 [0.64; 1.60]	0.85 [0.39; 1.87]	1.05 [0.66; 1.68]	0.85 [0.38; 1.90]
7 and higher	0.94 [0.55; 1.61]	0.76 [0.26; 2.18]	0.86 [0.46; 1.60]	0.51 [0.15; 1.75]	0.82 [0.43; 1.56]	0.54 [0.15; 1.92]
Years since MS diagnosis						
0-5	Reference					
6-10	1.06 [0.69; 1.63]	0.73 [0.36; 1.48]				
11-19	1.23 [0.83; 1.83]	0.58 [0.29; 1.18]				
20-60	0.82 [0.52; 1.29]	0.60 [0.29; 1.26]				
Duration unclear	1.11 [0.29; 4.24]	1.92 [0.39; 9.39]				
Number of reported symptoms						
0	Reference					
1-4	0.79 [0.51; 1.24]	1.45 [0.55; 3.84]	0.59 [0.34; 1.05]	3.37 [0.97; 11.68]	0.60 [0.33; 1.07]	3.47 [0.91; 13.29]
5-8	1.16 [0.78; 1.72]	2.25 [0.94; 5.37]	0.58 [0.28; 1.18]	3.00 [0.62; 14.61]	0.57 [0.28; 1.17]	3.30 [0.65; 16.79]
9-22	**1.65 [1.10; 2.47]**	**7.59 [3.53; 16.35]**	0.65 [0.29; 1.46]	**9.19 [1.81; 46.78]**	0.66 [0.29; 1.49]	**8.07 [1.47; 44.15]**
Affective disorder	1.44 [0.83; 2.48]	**4.99 [2.63; 9.47]**				
Balance problems	1.15 [0.83; 1.57]	**2.51 [1.50; 4.23]**				
Bladder problems	1.11 [0.80; 1.54]	**1.91 [1.13; 3.23]**				
Concentration problems	**1.52 [1.09; 2.11]**	**2.92 [1.73; 4.93]**				
Depression	**1.90 [1.23; 2.94]**	**4.95 [2.77; 8.86]**				
Dizziness	**1.51 [1.04; 2.19]**	**3.95 [2.31; 6.75]**				
Fatigue	**1.66 [1.23; 2.25]**	**3.50 [1.97; 6.22]**				
Gait problems	1.06 [0.77; 1.46]	**1.88 [1.12; 3.15]**				
Gastrointestinal problems	1.33 [0.93; 1.90]	**2.75 [1.61; 4.71]**				
Memory problems	**2.54 [1.77; 3.65]**	**5.54 [3.23; 9.51]**	**2.11 [1.33; 3.35]**	1.69 [0.71; 4.02]	**2.10 [1.32; 3.34]**	1.64 [0.66; 4.07]
Pain	**1.54 [1.11; 2.13]**	**3.30 [1.96; 5.56]**				
Spasms	0.78 [0.55; 1.10]	**1.92 [1.14; 3.25]**				
Visual disturbances	**1.70 [1.16; 2.48]**	**3.73 [2.15; 6.46]**				
Weakness	1.32 [0.96; 1.82]	**3.49 [2.06; 5.90]**				
Paper-pencil participant (vs. online participant)	**1.65 [1.13; 2.42]**	1.58 [0.83; 3.00]				
Highest education level						
Mandatory schooling	**2.70 [1.27; 5.74]**	2.75 [0.93; 8.13]	**2.92 [1.32; 6.46]**	2.99 [0.84; 10.64]	**2.98 [1.35; 6.61]**	2.95 [0.83; 10.48]
Apprenticeship	Reference					
Higher professional education	0.65 [0.44; 0.97]	0.45 [0.22; 0.94]	0.69 [0.46; 1.05]	0.55 [0.25; 1.24]	0.69 [0.46; 1.05]	0.55 [0.25; 1.24]
University degree	**0.36 [0.24; 0.55]**	**0.23 [0.10; 0.54]**	**0.37 [0.23; 0.58]**	**0.19 [0.07; 0.50]**	**0.37 [0.23; 0.58]**	**0.19 [0.07; 0.51]**
Unknown education	0.87 [0.51; 1.49]	1.15 [0.52; 2.54]	0.69 [0.39; 1.25]	0.54 [0.21; 1.38]	0.68 [0.34; 1.35]	0.44 [0.13; 1.48]
Disability insurance status						
Has applied for disability insurance	**2.42 [1.28; 4.58]**	**7.17 [3.32; 15.47]**	1.70 [0.84; 3.44]	**3.09 [1.17; 8.12]**	1.68 [0.83; 3.41]	**3.14 [1.18; 8.34]**
Does not receive disability insurance	Reference					
Does receive disability insurance	**1.82 [1.30; 2.56]**	1.60 [0.86; 2.98]	1.43 [0.92; 2.22]	0.68 [0.30; 1.54]	1.46 [0.93; 2.30]	0.66 [0.28; 1.56]
Retired, no disability insurance	1.06 [0.65; 1.72]	0.95 [0.38; 2.38]	1.36 [0.66; 2.80]	0.58 [0.16; 2.15]	1.38 [0.64; 2.93]	0.41 [0.10; 1.68]
MS type						
CIS	0.93 [0.30; 2.91]	undefined				
PPMS	0.76 [0.45; 1.27]	1.33 [0.64; 2.76]				
RRMS	Reference					
SPMS	0.82 [0.56; 1.22]	0.74 [0.36; 1.51]				
Unknown MS types	1.52 [0.60; 3.83]	1.60 [0.35; 7.27]				

DMT, disease-modifying treatments; SRDSS, self-reported disability status scale; CIS, Clinically Isolated Syndrome; PPMS, Primary progressive MS; RRMS, Relapsing remitting MS, SPMS, Secondary progressive MS; OR, odds ratio; CI, confidence interval.

MD. This is surprising because longer disease duration usually corresponds to more disability, and early disease onset interferes with education and job opportunities, both factors associated with MD. These may reflect a functional social system in Switzerland as well as a modern pwMS cohort with less disability due to the advanced therapeutic options.

Being currently employed decreased the odds for MD, which is reasonable due to a steady income. It is also consistent with the results from the Swiss general population, in which employment reduced the odds of MD and poverty as well (Switzerland FSO, 2022). Regarding the level of income, investigations from Sweden showed that pwMS had on average lower earnings compared to the matched control group references (Wiberg et al., 2015) and gross salary in pwMS compared to the Swedish general population was similar before, but markedly lower after disease diagnosis (Landfeldt et al., 2018). Depending on the type of insurance system in the country, the state and disability system can compensate for the difference (Kavaliunas et al., 2015). In our study, the median monthly household income of pwMS was similar to general Swiss population. This confirms other studies showing that purely income-based indicators of poverty and inequality such as employment

status and income are not a sufficient indicator of the financial and socioeconomic situation (Pförtner, 2015; Krause and Hanesch, 2003; Pfoertner et al., 2011). In contrast, MD which is independent of education, income and occupation better reflects the diversity of living conditions in different countries (Pförtner, 2015; Berthoud, 2011).

Disability as measured by the SRDSS was not associated with MD. This may be an unexpected result, but it could be explained by the overrepresentation of motor function and especially walking capability in the SRDSS (Kurtzke, 1983; Meyer-Moock et al., 2014; van Munster and Uitdehaag, 2017; Inojosa et al., 2020). Taking into account that a majority of professions in developed countries are carried out while sitting, walking distance might not be the primary driver of unemployment. Hence, the SRDSS (or EDSS) does not cover the disease heterogeneity of MS with its diverse symptoms that can lead to MD especially in populations with an SRDSS (or EDSS) mostly below 3 like in our patient cohort (Table 1) (Inojosa et al., 2020). This is additionally shown by the statistically significant univariable association of individual impairments such as visual disturbances, balance and gait problems, bladder and gastrointestinal problems with MD (Table 3). In addition, a combination of nine or more symptoms was associated with MD as well (Tables 2 and 3).

Regarding cognitive symptoms, memory was statistically significantly associated with MD in the multivariable analysis. This confirms the results from other studies, which found cognitive dysfunctions negatively affect work capacity and the financial situation of pwMS independent of physical disability (Renner et al., 2020; Kavaliunas et al., 2019a, 2019b). Cognitive impairment can occur early in the disease course, often in the absence of other neurological deficits (De Meo et al., 2021; Feuillet et al., 2007; Benedict et al., 2017; Eilam-Stock et al., 2021; Glanz et al., 2007). Information processing speed (IPS) and learning/memory problems, which play a decisive role in terms of productivity and performance in a variety of vocational activities, are the most common cognitive impairments in pwMS (Benedict et al., 2017, 2020; Costa et al., 2017).

Fatigue is one of the most frequent symptoms affecting up to 78.0% of pwMS (Oliva Ramirez et al., 2021) and can affect motor as well as cognitive functions and therefore also impacts professions with as high cognitive workload. Patients with fatigue were significantly more affected by MD which is in line with other studies that found a correlation between fatigue and unemployment in univariable analyses (Salter et al., 2017; Koziarska et al., 2018; Grytten et al., 2017). Depression and affective disorders were also associated with MD in univariable analyses. It is known that mental disorders affect working capacity and are associated with a decreased income and poverty (Raggi et al., 2019). This is relevant as depression is one of the most common symptoms in MS with up to 50% of pwMS being affected (Patten et al., 2017). However, besides being a reason, depression could also be a result of unemployment and, hence, a difficult financial situation (Grytten et al., 2017). Moreover, factors like self-efficacy and self-motivation which are in part driven by prospects of vocational success and therefore also exert an important role in patients' work and everyday performance, are also lowered in affective disorders and depression (Koziarska et al., 2018). Treating affective disorders with focus on depression could therefore improve the financial situation of pwMS.

PwMS affected by MD obtained or applied more often for disability insurance (OR 3.14) (Table 3). However, pwMS receiving disability insurance were not more likely to experience MD than persons who do not receive disability insurance or old-age pensions. Disability pension benefits also include work reintegration measures for pwMS ((FSO) FSO, 2022). The impact of these measures on the financial situation and MD was however not examined in our study and could be addressed in future research. Studies from Sweden provide information about a correlation between MS related progression and the financial situation, namely that earnings and benefits/support from the national disability insurance could be proxies of disability and thus reflect the severity and impact of the disease on life (Kavaliunas et al., 2015). In our cohort, it can be assumed that an increased degree of impairment led to receipt of disability insurance support.

Interestingly, material resources can affect the consequences and course of diseases as well, as demonstrated by studies showing mutual influence between material deprivation, ill health and chronic diseases in general (Tøge and Bell, 2016; Santana, 2002; Imlach Gunasekara et al., 2013; Saunders, 2006). In MS, several studies have shown that lower socioeconomic status and material deprivation were independently and negatively associated with global disability, disability risk measured by the EDSS, walking speed and affective symptoms including depression (Calocer et al., 2020; Boorgu et al., 2022; Briggs et al., 2019; Wang et al., 2020). This could lead to a vicious circle in which the disease course and the financial situation including MD are self-reinforcing. Thus, identifying potential risk factors for MD and developing targeted prevention of MD based on those factors could improve both the disease course and quality of life.

A strength of our study is the diverse and large study population due to the innovative recruitment procedure of the SMSR which allows pwMS to participate independent of the treating institution. Another advantage is the good comparability of our sample with the Swiss general population, which was achieved by using the same questions as SILC questionnaire which is distributed to the general population in Switzerland each year.

As limitations, our data consists of self-reported information on the individuals' financial situation and could be affected by potential recall or information bias. However, the availability of SILC data also allowed for sensitivity and plausibility checks. Furthermore, the MD definition relies on multiple, easy to answer questions and is robust (supplementary Table 3).

5. Conclusions

Our study shows that pwMS were 1.5 times more frequently affected by MD than the general Swiss population. Particularly, pwMS with a high symptom burden at the transition from work force to receiving disability benefits appeared to be vulnerable for MD. Higher education, older age, having a Swiss citizenship, living with a spouse or a partner or being currently employed were independently associated with a lower odds of MD.

CRediT authorship contribution statement

Lisa Sanak: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Christian P. Kamm:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Formal analysis, Investigation, Methodology. **Andrew Chan:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Mina Stanikić:** Conceptualization, Writing – original draft, Writing – review & editing. **Zina M Manjaly:** Conceptualization, Writing – original draft, Writing – review & editing. **Chiara Zecca:** Conceptualization, Writing – original draft, Writing – review & editing. **Pasquale Calabrese:** Conceptualization, Writing – original draft, Writing – review & editing. **Viktor von Wyl:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Formal analysis, Investigation, Methodology, Funding acquisition, Software, Supervision, Validation.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.msard.2022.104438.

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