**Supplementary material**

**eAppendix 1. Multiple imputation post-hoc analyses**

We conducted further analyses to assess whether our multiple imputation strategy was appropriate. In the main analyses, missing values (representing <3% of all data) were imputed in three separate complete datasets using the R package "mice." These were then aggregated (using the R command "merge_imputations") into a single complete dataset, which was used for all further analyses.

To determine whether a pooled analysis of multiple imputed datasets was superior to analysing a single aggregated dataset, we conducted a pooled multivariable conditional logistic regression on the three imputed datasets. We tested the association between time spent outdoors, use of sun protection, ambient UVR dose in the most recent summer before recruitment, serum 25(OH)D and paediatric MS risk, adjusting for age, sex, race, birth season, child's skin colour, mother's education, smoke exposure, BMI, and antibodies against EBV VCA (Supplementary **eTable 1**, Model 1). In addition, to determine whether three datasets was an appropriate number to impute, we repeated the analysis for a multiple imputation of ten complete datasets. We conducted a pooled analysis of all ten datasets (Supplementary **eTable 1**, Model 3) as well as analysing a single aggregated dataset (Supplementary **eTable 1**, Model 4).

In all of the above models, we were able to reproduce the key findings obtained with the approach we used elsewhere (Supplementary **eTable 1**, Model 2). Greater time spent outdoors was associated with reduced risk of MS, with evidence of a dose-dependent response. Use of sun protection was not associated with MS risk, greater ambient summer UVR dose was

associated with reduced odds of MS (although it did not always reach statistical significance),

and greater serum 25(OH)D levels were associated with increased odds of MS.

**eTable 1**: Multivariable conditional logistic regression analysis for the association between sun exposure, UVR exposure, serum 25(OH)D and paediatric MS risk, comparing various imputation strategies.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA |
| Age (years) | 9.76 | 9.21 | 9.25 | 10.26 |
| | 3.90-24.42 | 3.67-23.12 | 3.63-23.55 | 4.13-25.51 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference |
| Race: Black | 0.75 | 0.59 | 0.77 | 0.71 |
| | 0.34-1.68 | 0.28-1.23 | 0.32-1.85 | 0.35-1.44 |
| | p=0.48 | p=0.16 | p=0.56 | p=0.34 |
| Race: Asian | 0.73 | 0.82 | 0.69 | 0.74 |
| | 0.29-1.84 | 0.34-1.99 | 0.26-1.83 | 0.30-1.83 |
| | p=0.50 | p=0.66 | p=0.46 | p=0.51 |
| Race: Other | 0.78 | 0.77 | 0.84 | 0.78 |
| | 0.35-1.72 | 0.35-1.70 | 0.37-1.92 | 0.35-1.74 |
| | p=0.53 | p=0.51 | p=0.68 | p=0.54 |
| Birth season: Winter | reference | reference | reference | reference |
| Birth season: Spring | 0.76 | 0.78 | 0.83 | 0.76 |
| | 0.42-1.39 | 0.44-1.40 | 0.44-1.54 | 0.43-1.35 |
| | p=0.37 | p=0.41 | p=0.55 | p=0.35 |
| Birth season: Summer | 0.60 | 0.64 | 0.62 | 0.63 |
| | 0.34-1.08 | 0.36-1.14 | 0.34-1.13 | 0.35-1.11 |
| | p=0.09 | p=0.13 | p=0.12 | p=0.11 |
| Birth season: Autumn | 0.91 | 0.91 | 0.97 | 0.90 |
| | 0.51-1.63 | 0.51-1.61 | 0.53-1.77 | 0.51-1.58 |
| | p=0.76 | p=0.75 | p=0.93 | p=0.71 |
| Child's skin colour: dark | reference | reference | reference | reference |
| Child's skin colour: olive | 1.95 | 1.37 | 2.04 | 1.70 |
| | 0.63-6.04 | 0.51-3.67 | 0.63-6.65 | 0.65-4.41 |
| | p=0.25 | p=0.53 | p=0.24 | p=0.28 |
| Child's skin colour: fair | 1.56 | 1.14 | 1.63 | 1.31 |
| | 0.54-4.46 | 0.44-2.94 | 0.55-4.78 | 0.52-3.31 |
| | p=0.41 | p=0.78 | p=0.38 | p=0.57 |
| Mother's education: secondary school or less | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.68 | 0.67 | 0.67 | 0.68 |
| | 0.43-1.09 | 0.43-1.05 | 0.42-1.07 | 0.44-1.05 |

| | | | | |
|---|---|---|---|---|
| | p=0.11 | p=0.08 | p = 0.09 | p=0.08 |
| Mother's education: university qualification | 0.64 | 0.67 | 0.63 | 0.64 |
| | 0.32-1.28 | 0.34-1.32 | 0.32-1.23 | 0.33-1.24 |
| | p=0.21 | p=0.25 | p = 0.18 | p=0.19 |
| Tobacco smoke exposure (yes/no) | 1.96 | 1.61 | 2.07 | 1.59 |
| | 1.08-3.57 | 0.92-2.8 | 1.13-3.79 | 0.92-2.73 |
| | p=0.03 | p=0.09 | p=0.02 | p=0.10 |
| Overweight (yes/no) | 1.63 | 1.84 | 1.71 | 1.8 |
| | 0.94-2.81 | 1.09-3.1 | 0.97-3.02 | 1.06-3.05 |
| | p=0.08 | p=0.02 | p=0.06 | p=0.03 |
| EBV VCA (per unit increase in titre) | 1.4 | 1.47 | 1.41 | 1.45 |
| | 1.23-1.59 | 1.31-1.65 | 1.25-1.59 | 1.29-1.63 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: <30 minutes | reference | reference | reference | reference |
| Time outdoors: 30 minutes-1 hour | 0.32 | 0.39 | 0.34 | 0.39 |
| | 0.14-0.75 | 0.17-0.86 | 0.14-0.8 | 0.17-0.87 |
| | p=0.01 | p=0.02 | p=0.01 | p=0.02 |
| Time outdoors: 1-2 hours | 0.12 | 0.13 | 0.12 | 0.14 |
| | 0.05-0.28 | 0.06-0.31 | 0.05-0.29 | 0.06-0.32 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: 2-3 hours | 0.17 | 0.21 | 0.17 | 0.21 |
| | 0.07-0.39 | 0.09-0.46 | 0.07-0.4 | 0.09-0.46 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: >3 hours | 0.12 | 0.14 | 0.13 | 0.14 |
| | 0.05-0.28 | 0.06-0.31 | 0.05-0.3 | 0.06-0.32 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Use of sun protection | 0.96 | 0.95 | 0.95 | 0.95 |
| | 0.89-1.04 | 0.88-1.03 | 0.87-1.04 | 0.88-1.03 |
| | p=0.34 | p=0.18 | p=0.26 | p=0.19 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | 0.81 | 0.80 | 0.81 | 0.82 |
| | 0.65-1.01 | 0.64-1.00 | 0.64-1.02 | 0.66-1.02 |
| | p=0.07 | p=0.05 | p=0.08 | p=0.07 |
| Serum 25(OH)D (ng/mL) | 1.06 | 1.07 | 1.06 | 1.07 |
| | 1.04-1.09 | 1.05-1.09 | 1.04-1.09 | 1.04-1.09 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Observations | 866 | 866 | 866 | 866 |

Model 1 is a multivariable conditional logistic regression model testing the association between time spent outdoors daily in the most recent summer on the weekends, use of sun protection in the most recent summer, ambient UVR dose in the most recent summer, serum 25(OH)D concentration, and risk of paediatric MS, adjusting for sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against

EBV VCA as covariates. This model is a pooled analysis of three separate complete datasets, with missing data imputed using the R package "mice."

Model 2 tests the same associations as in Model 1, adjusting for the same covariates, but analyses a single complete dataset aggregated from the three imputed datasets used for Model 1.

Model 3 tests the same associations as in Model 1, adjusting for the same covariates, but is a pooled analysis of ten separate complete datasets.

Model 4 tests the same associations as in Model 1, adjusting for the same covariates, but analyses a single complete dataset aggregated from the ten imputed datasets used for Model 3.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

EBV VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation, 25(OH)D=25-hydroxyvitamin D.

**Adjustment of outliers**

For numerical variables, outlier values (defined as more than 2.5 standard deviations [SD] from the mean) were adjusted in a manner that brought them closer to the mean while preserving their numerical order. No more than 3.5% of values were adjusted in this manner for any given numerical variable.

Values ($x$) greater than the mean ($\bar{x}$) by more than 2.5×SD were adjusted according to the formula below:

$$x_{adj} = \bar{x} + 2.5 \times SD + 0.1 \times [x - (\bar{x} + 2.5 \times SD)]$$

Values ($x$) less than the mean ($\bar{x}$) by more than 2.5×SD were adjusted according to the formula below:

$$x_{adj} = \bar{x} - 2.5 \times SD - 0.1 \times [(\bar{x} - 2.5 \times SD) - x]$$

**eTable 2**: Multivariable conditional logistic regression analysis for the association between time spent outdoors and paediatric MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA |
| Age (years) | 9.01 | 8.69 | 8.32 | 8.43 |
| | 3.84-21.18 | 3.67-20.59 | 3.52-19.64 | 3.58-19.84 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference |
| Race: Black | 0.47 | 0.50 | 0.49 | 0.52 |
| | 0.26-0.87 | 0.26-0.94 | 0.26-0.92 | 0.28-0.96 |
| | p=0.02 | p=0.03 | p=0.03 | p=0.04 |
| Race: Asian | 0.87 | 0.70 | 0.76 | 0.86 |
| | 0.41-1.87 | 0.31-1.61 | 0.34-1.68 | 0.40-1.87 |
| | p=0.73 | p=0.41 | p=0.50 | p=0.71 |
| Race: Other | 0.72 | 0.73 | 0.74 | 0.82 |
| | 0.37-1.43 | 0.36-1.47 | 0.38-1.46 | 0.41-1.64 |
| | p=0.35 | p=0.38 | p=0.38 | p=0.57 |
| Birth season: Winter | reference | reference | reference | reference |
| Birth season: Spring | 0.92 | 1.02 | 0.95 | 0.92 |
| | 0.56-1.50 | 0.61-1.71 | 0.58-1.57 | 0.56-1.52 |
| | p=0.73 | p=0.93 | p=0.85 | p=0.75 |
| Birth season: Summer | 0.89 | 0.83 | 0.89 | 0.93 |
| | 0.55-1.46 | 0.50-1.39 | 0.54-1.46 | 0.57-1.53 |
| | p=0.65 | p=0.48 | p=0.63 | p=0.78 |
| Birth season: Autumn | 0.86 | 1.01 | 0.91 | 0.86 |
| | 0.53-1.40 | 0.61-1.69 | 0.55-1.51 | 0.52-1.41 |
| | p=0.54 | p=0.96 | p=0.72 | p=0.54 |
| Child's skin colour: dark | reference | reference | reference | reference |
| Child's skin colour: olive | 0.96 | 1.31 | 1.10 | 1.07 |
| | 0.40-2.28 | 0.54-3.19 | 0.46-2.64 | 0.44-2.62 |
| | p=0.92 | p=0.55 | p=0.83 | p=0.87 |
| Child's skin colour: fair | 0.94 | 1.18 | 1.03 | 1.01 |
| | 0.41-2.15 | 0.51-2.76 | 0.45-2.38 | 0.43-2.35 |
| | p=0.88 | p=0.69 | p=0.94 | p=0.99 |
| Mother's education: secondary school or less | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.76 | 0.84 | 0.82 | 0.77 |
| | 0.52-1.11 | 0.56-1.26 | 0.55-1.23 | 0.52-1.15 |
| | p=0.15 | p=0.40 | p=0.34 | p=0.20 |
| Mother's education: university qualification | 0.69 | 0.81 | 0.74 | 0.67 |
| | 0.39-1.22 | 0.44-1.48 | 0.42-1.33 | 0.37-1.21 |
| | p=0.20 | p=0.48 | p=0.32 | p=0.18 |
| | 1.57 | 1.69 | 1.47 | 1.56 |

| | | | | |
|---|---|---|---|---|
| Tobacco smoke exposure (yes/no) | 0.96-2.57 | 1.01-2.83 | 0.88-2.43 | 0.95-2.56 |
| | p=0.07 | p=0.05 | p=0.14 | p=0.08 |
| Overweight (yes/no) | 1.37 | 1.30 | 1.32 | 1.31 |
| | 0.88-2.14 | 0.82-2.08 | 0.84-2.09 | 0.83-2.05 |
| | p=0.16 | p=0.26 | p=0.23 | p=0.24 |
| EBV VCA (per unit increase in titre) | 1.48 | 1.46 | 1.47 | 1.47 |
| | 1.33-1.64 | 1.31-1.62 | 1.32-1.63 | 1.32-1.63 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors (most recent summer, weekends) <30 minutes | | reference | | |
| Time outdoors (most recent summer, weekends) 30 minutes-1 hour | | 0.50 0.24-1.03 p=0.06 | | |
| Time outdoors (most recent summer, weekends) 1-2 hours | | 0.22 0.11-0.44 p<0.001 | | |
| Time outdoors (most recent summer, weekends) 2-3 hours | | 0.28 0.14-0.58 p<0.001 | | |
| Time outdoors (most recent summer, weekends) >3 hours | | 0.24 0.12-0.48 p<0.001 | | |
| Time outdoors (most recent summer, holidays) <30 minutes | | | reference | |
| Time outdoors (most recent summer, holidays) 30 minutes-1 hour | | | 0.96 0.49-1.85 p=0.89 | |
| Time outdoors (most recent summer, holidays) 1-2 hours | | | 0.43 0.22-0.85 p=0.01 | |
| Time outdoors (most recent summer, holidays) 2-3 hours | | | 0.47 0.24-0.91 p=0.02 | |
| Time outdoors (most recent summer, holidays) >3 hours | | | 0.53 0.29-0.99 p=0.05 | |
| Time outdoors (1st year of life) <30 minutes | | | | reference |
| Time outdoors (1st year of life) 30 minutes-1 hour | | | | 1.03 0.68-1.57 p=0.88 |
| Time outdoors (1st year of life) 1-2 hours | | | | 0.68 0.39-1.18 p=0.17 |

| | | | | |
|---|---|---|---|---|
| Time outdoors (1st year of life) 2-3 hours | | | | 0.35 |
| | | | | 0.13-0.94 |
| | | | | p=0.04 |
| Time outdoors (1st year of life) >3 hours | | | | 0.39 |
| | | | | 0.13-1.19 |
| | | | | p=0.10 |
| Observations | 866 | 866 | 866 | 866 |
| $R^2$ | 0.151 | 0.176 | 0.163 | 0.160 |

Model 1 is a multivariable conditional logistic regression model with sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA as predictors of paediatric MS risk.

Model 2 is the same as Model 1 with time spent outdoors in the present/most recent summer on weekends as an additional predictor.

Model 3 is the same as Model 1 with time spent outdoors in the present/most recent summer during holidays) as an additional predictor.

Model 4 is the same as Model 1 with time spent outdoors during summer in the first year of life as an additional predictor.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

EBV VCA=Epstein Barr virus viral capsid antigen.

**eTable 3**: Multivariable conditional logistic regression analysis for the association between time spent outdoors, sun protection, ambient summer

UVR dose and paediatric MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|---|---|---|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA | NA | NA | NA |
| Age (years) | 9.01 | 8.69 | 9.38 | 9.12 | 8.95 | 9.13 | 9.41 |
| | 3.84-21.18 | 3.67-20.59 | 3.99-22.05 | 3.88-21.44 | 3.78-21.14 | 3.83-21.76 | 3.95-22.41 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference | reference | reference | reference |
| Race: Black | 0.47 | 0.50 | 0.50 | 0.43 | 0.53 | 0.44 | 0.47 |
| | 0.26-0.87 | 0.26-0.94 | 0.27-0.93 | 0.23-0.81 | 0.28-1.02 | 0.23-0.85 | 0.24-0.91 |
| | p=0.02 | p=0.03 | p=0.03 | p=0.01 | p=0.06 | p=0.01 | p=0.02 |
| Race: Asian | 0.87 | 0.70 | 0.92 | 0.88 | 0.74 | 0.74 | 0.78 |
| | 0.41-1.87 | 0.31-1.61 | 0.43-1.97 | 0.41-1.90 | 0.32-1.71 | 0.32-1.7 | 0.33-1.8 |
| | p=0.73 | p=0.41 | p=0.82 | p=0.75 | p=0.49 | p=0.47 | p=0.55 |
| Race: Other | 0.72 | 0.73 | 0.79 | 0.73 | 0.81 | 0.75 | 0.82 |
| | 0.37-1.43 | 0.36-1.47 | 0.40-1.57 | 0.37-1.44 | 0.4-1.64 | 0.37-1.52 | 0.4-1.68 |
| | p=0.35 | p=0.38 | p=0.50 | p=0.36 | p=0.56 | p=0.42 | p=0.58 |
| Birth season: Winter | reference | reference | reference | reference | reference | reference | reference |
| Birth season: Spring | 0.92 | 1.02 | 0.90 | 0.91 | 0.99 | 1.01 | 0.98 |
| | 0.56-1.5 | 0.61-1.71 | 0.55-1.47 | 0.56-1.49 | 0.59-1.67 | 0.6-1.7 | 0.58-1.65 |
| | p=0.73 | p=0.93 | p=0.67 | p=0.71 | p=0.98 | p=0.98 | p=0.93 |
| Birth season: Summer | 0.89 | 0.83 | 0.89 | 0.87 | 0.82 | 0.79 | 0.78 |
| | 0.55-1.46 | 0.5-1.39 | 0.54-1.44 | 0.53-1.42 | 0.49-1.37 | 0.47-1.33 | 0.46-1.31 |

|  | | | | | | | |
|---|---|---|---|---|---|---|---|
|  | p=0.65 | p=0.48 | p=0.63 | p=0.57 | p=0.44 | p=0.38 | p=0.34 |
| Birth season: Autumn | 0.86 | 1.01 | 0.84 | 0.83 | 0.99 | 0.97 | 0.95 |
|  | 0.53-1.4 | 0.61-1.69 | 0.52-1.37 | 0.51-1.36 | 0.59-1.64 | 0.58-1.63 | 0.56-1.59 |
|  | p=0.54 | p=0.96 | p=0.49 | p=0.45 | p=0.96 | p=0.91 | p=0.84 |
| Child's skin colour: dark | reference | reference | reference | reference | reference | reference | reference |
| Child's skin colour: olive | 0.96 | 1.31 | 0.98 | 0.92 | 1.37 | 1.24 | 1.29 |
|  | 0.4-2.28 | 0.54-3.19 | 0.41-2.36 | 0.39-2.22 | 0.56-3.37 | 0.5-3.07 | 0.52-3.21 |
|  | p=0.92 | p=0.55 | p=0.97 | p=0.86 | p=0.49 | p=0.64 | p=0.58 |
| Child's skin colour: fair | 0.94 | 1.18 | 0.99 | 0.90 | 1.29 | 1.12 | 1.21 |
|  | 0.41-2.15 | 0.51-2.76 | 0.43-2.29 | 0.39-2.07 | 0.54-3.05 | 0.47-2.65 | 0.5-2.9 |
|  | p=0.88 | p=0.69 | p=0.98 | p=0.80 | p=0.56 | p=0.80 | p=0.67 |
| Mother's education: secondary school or less | reference | reference | reference | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.76 | 0.84 | 0.78 | 0.72 | 0.87 | 0.8 | 0.83 |
|  | 0.52-1.11 | 0.56-1.26 | 0.53-1.14 | 0.49-1.07 | 0.58-1.3 | 0.53-1.21 | 0.55-1.25 |
|  | p=0.15 | p=0.40 | p=0.20 | p=0.10 | p=0.49 | p=0.29 | p=0.37 |
| Mother's education: university qualification | 0.69 | 0.81 | 0.69 | 0.67 | 0.8 | 0.77 | 0.77 |
|  | 0.39-1.22 | 0.44-1.48 | 0.39-1.21 | 0.38-1.18 | 0.44-1.47 | 0.42-1.42 | 0.42-1.42 |
|  | p=0.20 | p=0.48 | p=0.19 | p=0.16 | p=0.48 | p=0.41 | p=0.41 |
| Tobacco smoke exposure (yes/no) | 1.57 | 1.69 | 1.60 | 1.52 | 1.73 | 1.63 | 1.67 |
|  | 0.96-2.57 | 1.01-2.83 | 0.97-2.62 | 0.93-2.5 | 1.03-2.91 | 0.97-2.75 | 0.99-2.82 |
|  | p=0.07 | p=0.05 | p=0.06 | p=0.10 | p=0.04 | p=0.06 | p=0.06 |
| Overweight (yes/no) | 1.37 | 1.30 | 1.42 | 1.39 | 1.35 | 1.33 | 1.37 |
|  | 0.88-2.14 | 0.82-2.08 | 0.90-2.22 | 0.89-2.18 | 0.84-2.16 | 0.83-2.12 | 0.85-2.21 |
|  | p=0.16 | p=0.26 | p=0.13 | p=0.15 | p=0.21 | p=0.24 | p=0.20 |
|  | 1.48 | 1.46 | 1.48 | 1.48 | 1.45 | 1.46 | 1.45 |

| EBV VCA (per unit increase in titre) | 1.33-1.64 | 1.31-1.62 | 1.33-1.64 | 1.33-1.64 | 1.3-1.62 | 1.31-1.62 | 1.30-1.62 |
|---|---|---|---|---|---|---|---|
| | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ |
| Time outdoors: <30 minutes | | reference | | | reference | reference | reference |
| Time outdoors: 30 minutes-1 hour | | 0.50 | | | 0.49 | 0.49 | 0.48 |
| | | 0.24-1.03 | | | 0.24-1.01 | 0.23-1.02 | 0.23-0.99 |
| | | $p = 0.06$ | | | $p = 0.05$ | $p = 0.06$ | $p = 0.05$ |
| Time outdoors: 1-2 hours | | 0.22 | | | 0.21 | 0.19 | 0.19 |
| | | 0.11-0.44 | | | 0.1-0.43 | 0.09-0.4 | 0.09-0.4 |
| | | $p < 0.001$ | | | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ |
| Time outdoors: 2-3 hours | | 0.28 | | | 0.28 | 0.26 | 0.26 |
| | | 0.14-0.58 | | | 0.13-0.57 | 0.13-0.55 | 0.12-0.54 |
| | | $p < 0.001$ | | | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ |
| Time outdoors: >3 hours | | 0.24 | | | 0.23 | 0.21 | 0.2 |
| | | 0.12-0.48 | | | 0.11-0.47 | 0.1-0.44 | 0.1-0.42 |
| | | $p < 0.001$ | | | $p < 0.001$ | $p < 0.001$ | $p < 0.001$ |
| Sun protection behaviours | | | 0.95 | | 0.94 | | 0.94 |
| | | | 0.89-1.02 | | 0.87-1.01 | | 0.88-1.01 |
| | | | $p = 0.15$ | | $p = 0.09$ | | $p = 0.11$ |
| Ambient UVR dose in the summer before recruitment ($kJ/m^2$) | | | | 0.83 | | 0.76 | 0.76 |
| | | | | 0.68-1.00 | | 0.62-0.93 | 0.62-0.94 |
| | | | | $p = 0.05$ | | $p = 0.01$ | $p = 0.01$ |
| Observations | 866 | 866 | 866 | 866 | 866 | 866 | 866 |
| $R^2$ | 0.151 | 0.176 | 0.153 | 0.155 | 0.179 | 0.183 | 0.185 |

Model 1 is a multivariable conditional logistic regression model with sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA as predictors of paediatric MS risk.

Model 2 is the same as Model 1 with time spent outdoors daily during the present/most recent summer on weekends as an additional predictor.

Model 3 is the same as Model 1 with sun protection behaviour during summer as an additional predictor.

Model 4 is the same as Model 1 with ambient UVR levels in the summer before recruitment as an additional predictor.

Model 5 is the same as Model 1 with time spent outdoors and sun protection behaviour as additional predictors.

Model 6 is the same as Model 1 with time spent outdoors and ambient summer UVR dose as additional predictors.

Model 7 is the same as Model 1 with time spent outdoors, sun protection behaviour and ambient summer UVR dose as additional predictors.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI). EBV VCA=Epstein Barr virus viral capsid antigen,

UVR=ultraviolet radiation.

**eTable 4**: Multivariable conditional logistic regression analysis for the association between ambient UVR dose and paediatric MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA | NA | NA |
| Age (years) | 9.12 | 9.28 | 9.11 | 8.81 | 9.01 | 8.90 |
| | 3.88-21.44 | 3.94-21.82 | 3.85-21.53 | 3.74-20.75 | 3.84-21.18 | 3.78-20.96 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference | reference | reference |
| Race: Black | 0.43 | 0.47 | 0.47 | 0.45 | 0.47 | 0.47 |
| | 0.23-0.81 | 0.25-0.86 | 0.25-0.87 | 0.24-0.83 | 0.25-0.87 | 0.26-0.87 |
| | p=0.01 | p=0.01 | p=0.02 | p=0.01 | p=0.02 | p=0.02 |
| Race: Asian | 0.88 | 0.90 | 0.88 | 0.90 | 0.87 | 0.90 |
| | 0.41-1.90 | 0.42-1.92 | 0.41-1.89 | 0.42-1.95 | 0.40-1.89 | 0.42-1.95 |
| | p=0.75 | p=0.78 | p=0.74 | p=0.79 | p=0.73 | p=0.80 |
| Race: Other | 0.73 | 0.72 | 0.70 | 0.74 | 0.72 | 0.74 |
| | 0.37-1.44 | 0.37-1.43 | 0.36-1.39 | 0.38-1.48 | 0.37-1.44 | 0.37-1.45 |
| | p=0.36 | p=0.35 | p=0.31 | p=0.40 | p=0.36 | p=0.38 |
| Birth season: Winter | reference | reference | reference | reference | reference | reference |
| Birth season: Spring | 0.91 | 0.92 | 0.94 | 0.91 | 0.92 | 0.75 |
| | 0.56-1.49 | 0.56-1.5 | 0.57-1.53 | 0.56-1.49 | 0.56-1.50 | 0.36-1.56 |
| | p=0.71 | p=0.73 | p=0.79 | p=0.70 | p=0.73 | p=0.44 |
| Birth season: Summer | 0.87 | 0.89 | 0.90 | 0.87 | 0.89 | 0.66 |
| | 0.53-1.42 | 0.55-1.46 | 0.55-1.48 | 0.53-1.43 | 0.55-1.46 | 0.26-1.68 |
| | p=0.57 | p=0.65 | p=0.69 | p=0.59 | p=0.65 | p=0.39 |
| Birth season: Autumn | 0.83 | 0.84 | 0.89 | 0.82 | 0.86 | 0.75 |
| | 0.51-1.36 | 0.52-1.37 | 0.54-1.45 | 0.5-1.35 | 0.53-1.40 | 0.42-1.37 |
| | p=0.45 | p=0.49 | p=0.63 | p=0.44 | p=0.54 | p=0.35 |
| Child's skin colour: dark | reference | reference | reference | reference | reference | reference |
| Child's skin colour: olive | 0.92 | 0.92 | 0.94 | 0.99 | 0.96 | 0.96 |
| | 0.39-2.22 | 0.39-2.21 | 0.39-2.24 | 0.41-2.36 | 0.40-2.28 | 0.40-2.29 |
| | p=0.86 | p=0.86 | p=0.88 | p=0.98 | p=0.92 | p=0.93 |
| Child's skin colour: fair | 0.90 | 0.91 | 0.92 | 0.94 | 0.94 | 0.94 |
| | 0.39-2.07 | 0.39-2.09 | 0.4-2.11 | 0.41-2.18 | 0.41-2.15 | 0.41-2.16 |
| | p=0.80 | p=0.82 | p=0.84 | p=0.89 | p=0.88 | p=0.89 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mother's education: secondary school or less | reference | reference | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.72 | 0.75 | 0.77 | 0.74 | 0.76 | 0.75 |
| | 0.49-1.07 | 0.51-1.1 | 0.52-1.13 | 0.50-1.08 | 0.52-1.11 | 0.51-1.1 |
| | p=0.10 | p=0.14 | p=0.18 | p=0.12 | p=0.15 | p=0.15 |
| Mother's education: university qualification | 0.67 | 0.69 | 0.70 | 0.70 | 0.69 | 0.7 |
| | 0.38-1.18 | 0.39-1.21 | 0.4-1.24 | 0.4-1.23 | 0.39-1.22 | 0.4-1.24 |
| | p=0.16 | p=0.19 | p=0.22 | p=0.21 | p=0.20 | p=0.22 |
| Tobacco smoke exposure (yes/no) | 1.52 | 1.55 | 1.56 | 1.53 | 1.57 | 1.56 |
| | 0.93-2.50 | 0.95-2.55 | 0.96-2.55 | 0.93-2.52 | 0.96-2.57 | 0.95-2.55 |
| | p=0.10 | p=0.08 | p=0.08 | p=0.09 | p=0.07 | p=0.08 |
| Overweight (yes/no) | 1.39 | 1.38 | 1.31 | 1.41 | 1.37 | 1.39 |
| | 0.89-2.18 | 0.89-2.15 | 0.84-2.06 | 0.9-2.22 | 0.88-2.14 | 0.89-2.17 |
| | p=0.15 | p=0.16 | p=0.24 | p=0.13 | p=0.16 | p=0.15 |
| EBV VCA (per unit increase in titre) | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 |
| | 1.33-1.64 | 1.33-1.64 | 1.34-1.65 | 1.33-1.64 | 1.33-1.64 | 1.33-1.64 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | 0.83 | | | | | |
| | 0.68-1.00 | | | | | |
| | p=0.05 | | | | | |
| Ambient UVR dose in the winter before recruitment (kJ/m$^2$) | | 0.80 | | | | |
| | | 0.53-1.21 | | | | |
| | | p=0.29 | | | | |
| Ambient UVR dose 6 months before recruitment (kJ/m$^2$) | | | 1.08 | | | |
| | | | 0.96-1.20 | | | |
| | | | p=0.20 | | | |
| Ambient UVR dose in the summer before birth (kJ/m$^2$) | | | | 0.83 | | |
| | | | | 0.68-1.01 | | |
| | | | | p=0.06 | | |
| Ambient UVR dose in the winter before birth (kJ/m$^2$) | | | | | 1.00 | |
| | | | | | 0.72-1.39 | |
| | | | | | p=1.00 | |
| Ambient UVR dose 6 months before birth (kJ/m$^2$) | | | | | | 0.92 |
| | | | | | | 0.75-1.14 |
| | | | | | | p=0.46 |
| Observations | 866 | 866 | 866 | 866 | 866 | 866 |
| R$^2$ | 0.155 | 0.152 | 0.153 | 0.155 | 0.151 | 0.152 |

Model 1 is a multivariable conditional logistic regression model testing the association between ambient UVR dose in the summer before recruitment and the risk of paediatric MS, adjusting

for sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA.

Model 2 tests the association between ambient UVR dose in the winter before recruitment and the risk of paediatric MS, adjusting for the same covariates as Model 1.

Model 3 tests the association between ambient UVR dose 6 months before recruitment and the risk of paediatric MS, adjusting for the same covariates as Model 1.

Model 4 tests the association between ambient UVR dose in the summer before birth and the risk of paediatric MS, adjusting for the same covariates as Model 1.

Model 5 tests the association between ambient UVR dose in the winter before birth and the risk of paediatric MS, adjusting for the same covariates as Model 1.

Model 6 tests the association between ambient UVR dose 6 months before birth and the risk of paediatric MS, adjusting for the same covariates as Model 1.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

EBV VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation.

**eTable 5**: Multivariable conditional logistic regression analysis for the association between sun exposure, serum 25(OH)D concentration and paediatric MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA |
| Age (years) | 9.01 | 9.41 | 9.53 | 9.21 |
| | 3.84-21.18 | 3.95-22.41 | 3.91-23.23 | 3.67-23.12 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference |
| Race: Black | 0.47 | 0.47 | 0.56 | 0.59 |
| | 0.26-0.87 | 0.24-0.91 | 0.28-1.11 | 0.28-1.23 |
| | p=0.02 | p=0.02 | p=0.10 | p=0.16 |
| Race: Asian | 0.87 | 0.78 | 0.94 | 0.82 |
| | 0.41-1.87 | 0.33-1.8 | 0.42-2.10 | 0.34-1.99 |
| | p=0.73 | p=0.55 | p=0.89 | p=0.66 |
| Race: Other | 0.72 | 0.82 | 0.73 | 0.77 |
| | 0.37-1.43 | 0.4-1.68 | 0.34-1.54 | 0.35-1.7 |
| | p=0.35 | p=0.58 | p=0.41 | p=0.51 |
| Birth season: Winter | reference | reference | reference | reference |
| Birth season: Spring | 0.92 | 0.98 | 0.74 | 0.78 |
| | 0.56-1.5 | 0.58-1.65 | 0.43-1.26 | 0.44-1.4 |
| | p=0.73 | p=0.93 | p=0.27 | p=0.41 |
| Birth season: Summer | 0.89 | 0.78 | 0.76 | 0.64 |
| | 0.55-1.46 | 0.46-1.31 | 0.45-1.28 | 0.36-1.14 |
| | p=0.65 | p=0.34 | p=0.3 | p=0.13 |
| Birth season: Autumn | 0.86 | 0.95 | 0.76 | 0.91 |
| | 0.53-1.4 | 0.56-1.59 | 0.45-1.30 | 0.51-1.61 |
| | p=0.54 | p=0.84 | p=0.32 | p=0.75 |
| Child's skin colour: dark | reference | reference | reference | reference |
| Child's skin colour: olive | 0.96 | 1.29 | 0.89 | 1.37 |
| | 0.4-2.28 | 0.52-3.21 | 0.34-2.29 | 0.51-3.67 |
| | p=0.92 | p=0.58 | p=0.80 | p=0.53 |
| Child's skin colour: fair | 0.94 | 1.21 | 0.83 | 1.14 |
| | 0.41-2.15 | 0.5-2.9 | 0.34-2.07 | 0.44-2.94 |
| | p=0.88 | p=0.67 | p=0.70 | p=0.78 |
| Mother's education: secondary school or less | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.76 | 0.83 | 0.61 | 0.67 |
| | 0.52-1.11 | 0.55-1.25 | 0.4-0.92 | 0.43-1.05 |

| | | | | |
|---|---|---|---|---|
| | p=0.15 | p=0.37 | p=0.02 | p=0.08 |
| Mother's education: university qualification | 0.69 | 0.77 | 0.57 | 0.67 |
| | 0.39-1.22 | 0.42-1.42 | 0.31-1.04 | 0.34-1.32 |
| | p=0.20 | p=0.41 | p=0.07 | p=0.25 |
| Tobacco smoke exposure (yes/no) | 1.57 | 1.67 | 1.52 | 1.61 |
| | 0.96-2.57 | 0.99-2.82 | 0.90-2.56 | 0.92-2.8 |
| | p=0.07 | p=0.06 | p=0.12 | p=0.09 |
| Overweight (yes/no) | 1.37 | 1.37 | 1.87 | 1.84 |
| | 0.88-2.14 | 0.85-2.21 | 1.15-3.05 | 1.09-3.1 |
| | p=0.16 | p=0.2 | p=0.01 | p=0.02 |
| EBV VCA (per unit increase in titre) | 1.48 | 1.45 | 1.51 | 1.47 |
| | 1.33-1.64 | 1.3-1.62 | 1.35-1.68 | 1.31-1.65 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: <30 minutes | | reference | | reference |
| Time outdoors: 30 minutes-1 hour | | 0.48 | | 0.39 |
| | | 0.23-0.99 | | 0.17-0.86 |
| | | p=0.05 | | p=0.02 |
| Time outdoors: 1-2 hours | | 0.19 | | 0.13 |
| | | 0.09-0.4 | | 0.06-0.31 |
| | | p<0.001 | | p<0.001 |
| Time outdoors: 2-3 hours | | 0.26 | | 0.21 |
| | | 0.12-0.54 | | 0.09-0.46 |
| | | p<0.001 | | p<0.001 |
| Time outdoors: >3 hours | | 0.2 | | 0.14 |
| | | 0.1-0.42 | | 0.06-0.31 |
| | | p<0.001 | | p<0.001 |
| Use of sun protection | | 0.94 | | 0.95 |
| | | 0.88-1.01 | | 0.88-1.03 |
| | | p=0.11 | | p=0.18 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | | 0.76 | | 0.80 |
| | | 0.62-0.94 | | 0.64-1.00 |
| | | p=0.01 | | p=0.05 |
| Serum 25(OH)D (ng/mL) | | | 1.06 | 1.07 |
| | | | 1.04-1.08 | 1.05-1.09 |
| | | | p<0.001 | p<0.001 |
| Observations | 866 | 866 | 866 | 866 |
| $R^2$ | 0.151 | 0.185 | 0.192 | 0.227 |

Model 1 is a multivariable conditional logistic regression model with sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA as predictors of paediatric MS risk.

Model 2 includes all the predictors in Model 1 as well as time spent outdoors daily during the present/most recent summer on weekends, use of sun protection and ambient UVR dose in the summer before recruitment.

Model 3 includes all the predictors in Model 1 as well as serum 25(OH)D level.

Model 4 includes all the predictors in Model 1 as well as time spent outdoors, use of sun protection behaviour, ambient UVR dose in the summer before recruitment and serum 25(OH)D level.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI). EBV VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation, 25(OH)D=25-hydroxyvitamin D.

**Sensitivity analyses**

We conducted several sensitivity analyses:

1. restricting the dataset to participants with reliable body mass index (BMI) data

2. restricting the dataset to children who had MS onset in the previous year, and their matched controls

3. restricting the dataset to children diagnosed with MS who had a negative myelin oligodendrocyte glycoprotein (MOG) antibody screen, and their matched controls

BMI (calculated as weight (kg) / [height (m)]$^2$) was excluded from our main analysis due to the amount of missing or incorrect values. In a sensitivity analysis, we excluded participants with missing BMI values and participants with extreme BMI values (>40 kg/m$^2$ or <15 kg/m$^2$). We also excluded participants whose BMI was inconsistent with their overweight status i.e. those with BMI >25 kg/m$^2$ and answered "no" to the overweight question, and those with BMI <25 kg/m$^2$ and answered "yes". We thus selected 405 participants, consisting of 173 children with MS and 232 controls, matched on age and sex. We conducted multivariable conditional logistic regression on this subset, replacing 'overweight' with BMI as a covariate. We tested the association between time spent outdoors, use of sun protection, ambient UVR dose in the most recent summer before recruitment, and paediatric MS risk, adjusting for age, sex, race, birth season, child's skin colour, mother's education, smoke exposure, BMI, and antibodies against EBV VCA (Supplementary **eTable 6**).

In another sensitivity analysis, we restricted the dataset to children who had MS onset less than 1 year ago, and their matched controls, in order to minimise any bias caused by changes in sun exposure behaviour post-diagnosis. We thus selected 529 participants, consisting of 221 children with MS and 308 controls. We conducted multivariable conditional logistic regression

on this subset to test the association between time spent outdoors, use of sun protection, ambient UVR dose in the most recent summer before recruitment, and paediatric MS risk, adjusting for age, sex, race, birth season, child's skin colour, mother's education, smoke exposure, being overweight and antibodies against EBV VCA (Supplementary **eTable 7**).

In a third sensitivity analysis, we restricted the dataset to children who were diagnosed with MS and returned a negative anti-MOG IgG screen, and their matched controls, as anti-MOG antibody-associated demyelinating disease is an entity that is distinct from typical MS. We selected 742 participants, consisting of 293 children with MS and 449 controls. We conducted multivariable conditional logistic regression on this subset, to test the association between time spent outdoors, use of sun protection, ambient UVR dose in the most recent summer before recruitment, serum 25(OH)D and paediatric MS risk, adjusting for age, sex, race, birth season, child's skin colour, mother's education, smoke exposure, overweight and anti-VCA titres (Supplementary **eTable 8**).

In all sensitivity analyses, we were able to reproduce the key findings of our main analysis. Greater time spent outdoors was associated with reduced risk of MS, with evidence of a dose-dependent response, although spending 30 minutes-1 hour did not always reach statistical significance. Use of sun protection was not associated with MS risk, and greater ambient summer UVR dose was associated with reduced risk.

**eTable 6**: Sensitivity analysis using body mass index data to test the association between sun exposure, UVR exposure and MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA |
| Age (years) | 99.16 | 70.97 | 75.20 | 120.04 |
| | 15.56-631.83 | 12.51-402.48 | 12.92-437.85 | 17.94-803.37 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference |
| Race: Black | 0.25 | 0.29 | 0.28 | 0.25 |
| | 0.06-1.02 | 0.08-1.04 | 0.08-0.99 | 0.06-1.02 |
| | p=0.05 | p=0.06 | p=0.05 | p=0.05 |
| Race: Asian | 0.69 | 0.96 | 0.92 | 0.71 |
| | 0.19-2.54 | 0.3-3.11 | 0.28-3 | 0.19-2.61 |
| | p=0.57 | p=0.94 | p=0.89 | p=0.61 |
| Race: Other | 0.21 | 0.39 | 0.35 | 0.26 |
| | 0.05-0.81 | 0.11-1.38 | 0.11-1.15 | 0.06-1.18 |
| | p=0.02 | p=0.14 | p=0.08 | p=0.08 |
| Birth season: Winter | reference | reference | reference | reference |
| Birth season: Spring | 0.73 | 0.80 | 0.75 | 0.63 |
| | 0.29-1.86 | 0.34-1.87 | 0.32-1.76 | 0.24-1.67 |
| | p=0.51 | p=0.61 | p=0.51 | p=0.35 |
| Birth season: Summer | 0.60 | 0.99 | 0.89 | 0.53 |
| | 0.22-1.63 | 0.41-2.38 | 0.37-2.15 | 0.19-1.48 |
| | p=0.32 | p=0.99 | p=0.79 | p=0.22 |
| Birth season: Autumn | 0.70 | 0.59 | 0.51 | 0.58 |
| | 0.27-1.78 | 0.25-1.4 | 0.21-1.24 | 0.21-1.57 |
| | p=0.45 | p=0.23 | p=0.14 | p=0.28 |
| Child's skin colour: dark | reference | reference | reference | reference |
| Child's skin colour: olive | 1.47 | 1.10 | 1.27 | 1.66 |
| | 0.3-7.3 | 0.24-4.97 | 0.28-5.75 | 0.31-8.96 |
| | p=0.64 | p=0.90 | p=0.76 | p=0.55 |
| Child's skin colour: fair | 1.10 | 0.89 | 0.93 | 1.14 |
| | 0.22-5.38 | 0.19-4.04 | 0.21-4.14 | 0.22-5.98 |
| | p=0.91 | p=0.88 | p=0.92 | p=0.88 |
| Mother's education: secondary school or less | reference | reference | reference | reference |
| Mother's education: trade cert or other | 1.31 | 1.03 | 0.97 | 1.33 |
| | 0.63-2.73 | 0.53-2.01 | 0.49-1.9 | 0.61-2.89 |
| | p=0.47 | p=0.93 | p=0.93 | p=0.47 |
| | 1.00 | 0.87 | 1.04 | 1.22 |

| | | | | |
|---|---|---|---|---|
| Mother's education: university qualification | 0.34-2.98 | 0.33-2.25 | 0.38-2.87 | 0.39-3.79 |
| | p=0.99 | p=0.77 | p=0.94 | p=0.74 |
| Tobacco smoke exposure (yes/no) | 3.78 | 3.14 | 2.93 | 3.63 |
| | 1.53-9.34 | 1.37-7.19 | 1.27-6.75 | 1.43-9.24 |
| | p<0.001 | p=0.01 | p=0.01 | p=0.01 |
| Overweight (yes/no) | 1.09 | 1.08 | 1.08 | 1.08 |
| | 1.01-1.17 | 1.01-1.15 | 1.01-1.15 | 1.01-1.16 |
| | p=0.02 | p=0.03 | p=0.03 | p=0.04 |
| EBV VCA (per unit increase in titre) | 2.11 | 2.04 | 2.06 | 2.10 |
| | 1.63-2.73 | 1.61-2.59 | 1.62-2.61 | 1.62-2.74 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: <30 minutes | reference | reference | reference | reference |
| Time outdoors: 30 minutes-1 hour | 0.88 | | | 0.79 |
| | 0.24-3.24 | | | 0.21-3.07 |
| | p=0.85 | | | p=0.74 |
| Time outdoors: 1-2 hours | 0.20 | | | 0.17 |
| | 0.05-0.75 | | | 0.04-0.68 |
| | p=0.02 | | | p=0.01 |
| Time outdoors: 2-3 hours | 0.14 | | | 0.14 |
| | 0.03-0.61 | | | 0.03-0.65 |
| | p=0.01 | | | p=0.01 |
| Time outdoors: >3 hours | 0.16 | | | 0.14 |
| | 0.04-0.64 | | | 0.03-0.6 |
| | p=0.01 | | | p=0.01 |
| Use of sun protection | | 0.96 | | 0.96 |
| | | 0.84-1.09 | | 0.83-1.11 |
| | | p=0.53 | | p=0.58 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | | | 0.70 | 0.65 |
| | | | 0.50-0.98 | 0.45-0.94 |
| | | | p=0.04 | p=0.02 |
| Observations | 405 | 405 | 405 | 405 |
| $R^2$ | 0.305 | 0.275 | 0.282 | 0.331 |

Model 1 is a multivariable conditional logistic regression model testing the association between time spent outdoors daily in the most recent summer on the weekends and risk of paediatric MS, adjusting for sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, body mass index and antibodies against EBV VCA as covariates.

Model 2 tests the association between use of sun protection in the most recent summer and risk of MS, adjusting for the same covariates as in Model 1.

Model 3 tests the association between ambient UVR dose in the summer before recruitment and risk of MS, adjusting for the same covariates as in Model 1.

Model 4 tests the association between time spent outdoors, use of sun protection, ambient summer UVR dose, and risk of MS, adjusting for the same covariates as in Model 1.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

EBV VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation.

**eTable 7**: Sensitivity analysis including only recently diagnosed MS patients (diagnosed <1 year ago) and their matched controls, to test the association between sun exposure, UVR exposure and MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA |
| Age (years) | 298.72 | 337.98 | 342.57 | 295.54 |
| | 53.5-1667.86 | 60.07-1901.62 | 60.54-1938.53 | 52.18-1673.99 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference |
| Race: Black | 0.25 | 0.25 | 0.24 | 0.24 |
| | 0.10-0.65 | 0.10-0.64 | 0.1-0.61 | 0.09-0.62 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: Asian | 0.86 | 1.00 | 0.97 | 0.83 |
| | 0.25-2.95 | 0.31-3.18 | 0.3-3.14 | 0.23-2.94 |
| | p=0.82 | p=0.99 | p=0.96 | p=0.77 |
| Race: Other | 0.75 | 0.76 | 0.71 | 0.69 |
| | 0.27-2.11 | 0.27-2.12 | 0.26-1.98 | 0.24-2 |
| | p=0.59 | p=0.60 | p=0.52 | p=0.5 |
| Birth season: Winter | reference | reference | reference | reference |
| Birth season: Spring | 0.82 | 0.76 | 0.76 | 0.81 |
| | 0.39-1.71 | 0.37-1.56 | 0.37-1.55 | 0.38-1.72 |
| | p=0.59 | p=0.46 | p=0.44 | p=0.58 |
| Birth season: Summer | 0.84 | 0.78 | 0.74 | 0.79 |
| | 0.4-1.76 | 0.38-1.59 | 0.36-1.53 | 0.37-1.68 |
| | p=0.65 | p=0.49 | p=0.42 | p=0.53 |
| Birth season: Autumn | 0.92 | 0.76 | 0.72 | 0.88 |
| | 0.43-1.96 | 0.37-1.56 | 0.35-1.49 | 0.41-1.9 |
| | p=0.83 | p=0.46 | p=0.38 | p=0.75 |
| Child's skin colour: dark | reference | reference | reference | reference |
| Child's skin colour: olive | 0.79 | 0.60 | 0.64 | 0.88 |
| | 0.22-2.9 | 0.16-2.26 | 0.17-2.49 | 0.23-3.37 |
| | p=0.72 | p=0.45 | p=0.52 | p=0.86 |
| Child's skin colour: fair | 0.62 | 0.55 | 0.55 | 0.62 |
| | 0.18-2.13 | 0.15-1.93 | 0.15-1.98 | 0.17-2.24 |
| | p=0.45 | p=0.35 | p=0.36 | p=0.47 |
| Mother's education: secondary school or less | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.80 | 0.72 | 0.69 | 0.79 |
| | 0.44-1.44 | 0.41-1.26 | 0.39-1.21 | 0.43-1.44 |
| | p=0.46 | p=0.25 | p=0.2 | p=0.43 |

| | | | | |
|---|---|---|---|---|
| Mother's education: university qualification | 0.74 | 0.69 | 0.69 | 0.77 |
| | 0.32-1.7 | 0.31-1.52 | 0.31-1.53 | 0.33-1.79 |
| | p=0.47 | p=0.35 | p=0.36 | p=0.54 |
| Tobacco smoke exposure (yes/no) | 1.96 | 1.9 | 1.78 | 1.82 |
| | 0.99-3.84 | 0.98-3.67 | 0.91-3.48 | 0.91-3.64 |
| | p=0.05 | p=0.06 | p=0.09 | p=0.09 |
| Overweight (yes/no) | 1.1 | 1.22 | 1.22 | 1.09 |
| | 0.55-2.2 | 0.63-2.39 | 0.62-2.42 | 0.53-2.26 |
| | p=0.79 | p=0.56 | p=0.57 | p=0.81 |
| EBV VCA (per unit increase in titre) | 1.54 | 1.55 | 1.55 | 1.54 |
| | 1.32-1.79 | 1.34-1.8 | 1.34-1.81 | 1.32-1.8 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: <30 minutes | reference | reference | reference | reference |
| Time outdoors: 30 minutes-1 hour | 0.53 | | | 0.48 |
| | 0.19-1.47 | | | 0.17-1.38 |
| | p=0.22 | | | p=0.17 |
| Time outdoors: 1-2 hours | 0.27 | | | 0.22 |
| | 0.10-0.77 | | | 0.07-0.65 |
| | p=0.01 | | | p=0.01 |
| Time outdoors: 2-3 hours | 0.30 | | | 0.26 |
| | 0.11-0.86 | | | 0.09-0.78 |
| | p=0.02 | | | p=0.02 |
| Time outdoors: >3 hours | 0.33 | | | 0.26 |
| | 0.12-0.91 | | | 0.09-0.76 |
| | p=0.03 | | | p=0.01 |
| Use of sun protection | | 1.00 | | 1 |
| | | 0.90-1.11 | | 0.9-1.11 |
| | | p=0.96 | | p=0.99 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | | | 0.79 | 0.71 |
| | | | 0.59-1.05 | 0.52-0.97 |
| | | | p=0.11 | p=0.03 |
| Observations | 529 | 529 | 529 | 529 |
| R$^2$ | 0.262 | 0.251 | 0.254 | 0.296 |

Model 1 is a multivariable conditional logistic regression model testing the association between time spent outdoors daily in the most recent summer on the weekends and risk of paediatric MS, adjusting for sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA as covariates.

Model 2 tests the association between use of sun protection in the most recent summer and risk of MS, adjusting for the same covariates as in Model 1.

Model 3 tests the association between ambient UVR dose in the summer before recruitment and risk of MS, adjusting for the same covariates as in Model 1.

Model 4 tests the association between time spent outdoors, use of sun protection, ambient summer UVR dose, and risk of MS, adjusting for the same covariates as in Model 1.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

EBV VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation.

**eTable 8**: Sensitivity analysis using only MOG IgG-negative MS patients and their matched

controls, to test the association between sun exposure, UVR exposure and MS risk.

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA | NA |
| Age (years) | 7.87 | 9.25 | 8.80 | 8.44 |
| | 3.02-20.49 | 3.56-23.99 | 3.38-22.9 | 3.19-22.32 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Race: White | reference | reference | reference | reference |
| Race: Black | 0.56 | 0.55 | 0.49 | 0.58 |
| | 0.28-1.14 | 0.28-1.1 | 0.25-0.98 | 0.28-1.2 |
| | p=0.11 | p=0.09 | p=0.04 | p=0.14 |
| Race: Asian | 0.42 | 0.61 | 0.63 | 0.48 |
| | 0.15-1.15 | 0.25-1.52 | 0.25-1.57 | 0.17-1.37 |
| | p=0.09 | p=0.29 | p=0.32 | p=0.17 |
| Race: Other | 0.57 | 0.67 | 0.62 | 0.69 |
| | 0.25-1.3 | 0.3-1.49 | 0.28-1.37 | 0.3-1.6 |
| | p=0.18 | p=0.32 | p=0.24 | p=0.39 |
| Birth season: Winter | reference | reference | reference | reference |
| Birth season: Spring | 1.39 | 1.19 | 1.19 | 1.31 |
| | 0.76-2.54 | 0.67-2.1 | 0.67-2.11 | 0.71-2.41 |
| | p=0.29 | p=0.56 | p=0.55 | p=0.39 |
| Birth season: Summer | 0.94 | 1.05 | 1.03 | 0.88 |
| | 0.52-1.7 | 0.6-1.82 | 0.59-1.8 | 0.48-1.61 |
| | p=0.85 | p=0.87 | p=0.92 | p=0.68 |
| Birth season: Autumn | 1.02 | 0.82 | 0.80 | 0.93 |
| | 0.57-1.85 | 0.47-1.42 | 0.46-1.4 | 0.51-1.69 |
| | p=0.94 | p=0.48 | p=0.44 | p=0.81 |
| Child's skin colour: dark | reference | reference | reference | reference |
| Child's skin colour: olive | 1.54 | 1.02 | 1.00 | 1.78 |
| | 0.57-4.18 | 0.39-2.69 | 0.38-2.62 | 0.64-4.94 |
| | p=0.39 | p=0.97 | p=1.00 | p=0.27 |
| Child's skin colour: fair | 1.53 | 1.14 | 1.06 | 1.83 |
| | 0.59-3.96 | 0.45-2.88 | 0.42-2.68 | 0.68-4.9 |
| | p=0.38 | p=0.79 | p=0.90 | p=0.23 |
| Mother's education: secondary school or less | reference | reference | reference | reference |
| Mother's education: trade cert or other | 0.89 | 0.81 | 0.76 | 0.93 |
| | 0.56-1.41 | 0.52-1.25 | 0.49-1.17 | 0.58-1.5 |
| | p=0.62 | p=0.34 | p=0.21 | p=0.77 |

| | | | | |
|---|---|---|---|---|
| Mother's education: university qualification | 1.21 | 0.93 | 0.96 | 1.21 |
| | 0.59-2.49 | 0.49-1.78 | 0.50-1.84 | 0.59-2.49 |
| | p=0.6 | p=0.83 | p=0.91 | p=0.6 |
| Tobacco smoke exposure (yes/no) | 1.83 | 1.65 | 1.59 | 1.81 |
| | 1.03-3.27 | 0.95-2.87 | 0.91-2.78 | 1-3.28 |
| | p=0.04 | p=0.08 | p=0.10 | p=0.05 |
| Overweight (yes/no) | 1.45 | 1.60 | 1.59 | 1.60 |
| | 0.86-2.44 | 0.97-2.64 | 0.96-2.63 | 0.93-2.75 |
| | p=0.16 | p=0.07 | p=0.07 | p=0.09 |
| EBV VCA (per unit increase in titre) | 1.64 | 1.68 | 1.67 | 1.64 |
| | 1.44-1.87 | 1.47-1.9 | 1.47-1.9 | 1.43-1.87 |
| | p<0.001 | p<0.001 | p<0.001 | p<0.001 |
| Time outdoors: <30 minutes | reference | reference | reference | reference |
| Time outdoors: 30 minutes-1 hour | 0.46 | | | 0.43 |
| | 0.20-1.05 | | | 0.19-0.99 |
| | p=0.07 | | | p=0.05 |
| Time outdoors: 1-2 hours | 0.22 | | | 0.19 |
| | 0.10-0.49 | | | 0.08-0.43 |
| | p<0.001 | | | p<0.001 |
| Time outdoors: 2-3 hours | 0.26 | | | 0.22 |
| | 0.12-0.57 | | | 0.1-0.51 |
| | p<0.001 | | | p<0.001 |
| Time outdoors: >3 hours | 0.21 | | | 0.18 |
| | 0.10-0.46 | | | 0.08-0.4 |
| | p<0.001 | | | p<0.001 |
| Use of sun protection | | 0.94 | | 0.92 |
| | | 0.87-1.02 | | 0.85-1 |
| | | p=0.11 | | p=0.05 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | | | 0.83 | 0.76 |
| | | | 0.66-1.03 | 0.60-0.97 |
| | | | p=0.10 | p=0.03 |
| Observations | 742 | 742 | 742 | 742 |
| R$^2$ | 0.214 | 0.192 | 0.192 | 0.255 |

Model 1 is a multivariable conditional logistic regression model testing the association between time spent outdoors daily in the most recent summer on the weekends and risk of paediatric MS, adjusting for sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA as covariates.

Model 2 tests the association between use of sun protection in the most recent summer and risk of MS, adjusting for the same covariates as in Model 1.

Model 3 tests the association between ambient UVR dose in the summer before recruitment and risk of MS, adjusting for the same covariates as in Model 1.

Model 4 tests the association between time spent outdoors, use of sun protection, ambient summer UVR dose, and risk of MS, adjusting for the same covariates as in Model 1.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

MOG=myelin oligodendrocyte glycoprotein, VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation.

**Vitamin D post-hoc analysis**

Contrary to our expectation, we found that higher serum 25(OH)D concentration (post-diagnostic) was associated with increased risk of MS. To determine whether this could be the result of children with MS being given vitamin D supplementation after diagnosis, we conducted post-hoc analyses restricting the dataset to children recently diagnosed with MS and their matched controls (Supplementary **eTable 9**). When the dataset was restricted to children diagnosed <4 months ago and their matched controls, higher serum 25(OH)D concentration remained associated with increased risk of MS but the effect was not statistically significant (Model 2). When the dataset was restricted to children diagnosed <2 months ago and their matched controls, higher serum 25(OH)D concentration were associated with decreased risk of MS but the effect did not reach statistical significance due to the reduced sample size (Model 3). These observations support our view that vitamin D supplementation by the children with MS was the cause for higher serum 25(OH)D concentration being associated with increased risk of MS.

**eTable 9**: Multivariable conditional logistic regression analysis for the association between sun exposure, serum 25(OH)D concentration and paediatric MS risk, in children with recent onset of MS and their matched controls.

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | AOR, 95%CI, p | AOR, 95%CI, p | AOR, 95%CI, p |
| Sex | NA | NA | NA |
| Age (years) | 9.21 | $9.02 \times 10^3$ | $3.88 \times 10^4$ |
| | 3.67-23.12 | $198.51 - 4.10 \times 10^5$ | $18.92 - 7.96 \times 10^7$ |
| | p<0.001 | p<0.001 | p=0.01 |
| Race: White | reference | reference | reference |
| Race: Black | 0.59 | 0.02 | 0.75 |
| | 0.28-1.23 | 0.00-0.18 | 0.04-15.42 |
| | p=0.16 | p<0.001 | p=0.85 |
| Race: Asian | 0.82 | 0.68 | 1.42 |
| | 0.34-1.99 | 0.03-13.36 | 0.03-59.36 |
| | p=0.66 | p=0.80 | p=0.85 |
| Race: Other | 0.77 | 0.36 | 0.84 |
| | 0.35-1.7 | 0.07-1.94 | 0.03-20.33 |
| | p=0.51 | p=0.23 | p=0.91 |
| Birth season: Winter | reference | reference | reference |
| Birth season: Spring | 0.78 | 0.57 | 3.98 |
| | 0.44-1.4 | 0.13-2.48 | 0.30-53.46 |
| | p=0.41 | p=0.45 | p=0.30 |
| Birth season: Summer | 0.64 | 0.61 | 2.45 |
| | 0.36-1.14 | 0.15-2.39 | 0.24-25.5 |
| | p=0.13 | p=0.47 | p=0.45 |
| Birth season: Autumn | 0.91 | 0.38 | 2.24 |
| | 0.51-1.61 | 0.09-1.66 | 0.23-21.95 |
| | p=0.75 | p=0.20 | p=0.49 |
| Child's skin colour: dark | reference | reference | reference |
| Child's skin colour: olive | 1.37 | 0.01 | 2.51 |
| | 0.51-3.67 | 0-0.39 | 0.02-258.48 |
| | p=0.53 | p=0.01 | p=0.70 |
| Child's skin colour: fair | 1.14 | 0.02 | 2.58 |
| | 0.44-2.94 | 0-0.38 | 0.05-147.92 |
| | p=0.78 | p=0.01 | p=0.65 |
| Mother's education: secondary school or less | reference | reference | reference |
| Mother's education: trade cert or other | 0.67 | 0.76 | 1.57 |
| | 0.43-1.05 | 0.26-2.23 | 0.25-9.98 |
| | p=0.08 | p=0.62 | p=0.63 |
| | 0.67 | 1.02 | 0.36 |

| | | | |
|---|---|---|---|
| Mother's education: university qualification | 0.34-1.32 | 0.24-4.30 | 0.01-11.74 |
| | p=0.25 | p=0.98 | p=0.57 |
| Tobacco smoke exposure (yes/no) | 1.61 | 1.24 | 2.84 |
| | 0.92-2.8 | 0.35-4.36 | 0.35-22.93 |
| | p=0.09 | p=0.74 | p=0.33 |
| Overweight (yes/no) | 1.84 | 3.48 | 1.37 |
| | 1.09-3.10 | 0.89-13.55 | 0.22-8.37 |
| | p=0.02 | p=0.07 | p=0.74 |
| EBV VCA (per unit increase in titre) | 1.47 | 2.23 | 3.07 |
| | 1.31-1.65 | 1.49-3.33 | 1.37-6.89 |
| | p<0.001 | p<0.001 | p=0.01 |
| Time outdoors: <30 minutes | reference | reference | reference |
| Time outdoors: 30 minutes-1 hour | 0.39 | 0.96 | 0.10 |
| | 0.17-0.86 | 0.14-6.43 | 0.00-3.1 |
| | p=0.02 | p=0.97 | p=0.19 |
| Time outdoors: 1-2 hours | 0.13 | 0.26 | 0.05 |
| | 0.06-0.31 | 0.04-1.78 | 0.00-1.56 |
| | p<0.001 | p=0.17 | p=0.09 |
| Time outdoors: 2-3 hours | 0.21 | 0.33 | 0.92 |
| | 0.09-0.46 | 0.06-1.96 | 0.03-25.75 |
| | p<0.001 | p=0.22 | p=0.96 |
| Time outdoors: >3 hours | 0.14 | 0.86 | 0.06 |
| | 0.06-0.31 | 0.14-5.36 | 0.00-2.23 |
| | p<0.001 | p=0.87 | p=0.13 |
| Use of sun protection | 0.95 | 1.05 | 1.15 |
| | 0.88-1.03 | 0.86-1.29 | 0.75-1.79 |
| | p=0.18 | p=0.64 | p=0.52 |
| Ambient UVR dose in the summer before recruitment (kJ/m$^2$) | 0.80 | 0.47 | 0.63 |
| | 0.64-1.00 | 0.26-0.86 | 0.19-2.12 |
| | p=0.05 | p=0.01 | p=0.46 |
| Serum 25(OH)D (ng/mL) | 1.07 | 1.04 | 0.95 |
| | 1.05-1.09 | 0.99-1.09 | 0.87-1.04 |
| | p<0.001 | p=0.11 | p=0.30 |
| Observations | 866 | 278 | 139 |
| $R^2$ | 0.227 | 0.349 | 0.351 |

Model 1 is a multivariable conditional logistic regression model testing the association between time spent outdoors daily in the most recent summer on the weekends, use of sun protection in the most recent summer, ambient UVR dose in the most recent summer, serum 25(OH)D concentration, and risk of paediatric MS, adjusting for sex, age, race, birth season, child's skin colour, mother's education, tobacco smoke exposure, being overweight and antibodies against EBV VCA as covariates, and including all study participants.

Model 2 tests the same associations as in Model 1, adjusting for the same covariates, but restricts the dataset to children with MS onset within 4 months prior to enrolment in the study, and their matched controls.

Model 3 tests the same associations as in Model 1, adjusting for the same covariates, but restricts the dataset to children with MS onset within 2 months prior to enrolment in the study, and their matched controls.

Results are presented as adjusted odds ratios (AOR) with 95% confidence intervals (95%CI).

EBV VCA=Epstein Barr virus viral capsid antigen, UVR=ultraviolet radiation, 25(OH)D=25-hydroxyvitamin D.