

# The Mediating Role of Lifestyle Activities in the Association Between Social Deprivation and Cognition in Older Adulthood: Results From the Health and Retirement (HRS) Study

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## Abstract

**Objectives:** We aimed to investigate the mediating role of lifestyle activities in the association between social deprivation and cognition. **Methods:** To investigate, we analysed data of 3867 respondents (Mean Age: 73.37, SD: 5.57) in the U.S. Health and Retirement Study (HRS) using growth curve and path analysis, adjusted for demographic and health covariates. **Results:** Being in the high (vs. moderate) Social Deprivation Index group was associated with lower cognition scores ( $\beta = -2.63$ , [95 % CI:  $-2.90, -2.36$ ]). Conversely, higher (vs. lower) Lifestyle Index scores were associated with higher cognition scores ( $\beta = 1.17$ , [95 % CI:  $0.72, 1.63$ ]). In mediation analysis, the Lifestyle Index score explained 27 % of the association of So Dep Index group on cognition at the final follow-up. **Discussion:** While lifestyle activities did mediate the association between social deprivation and cognition, factors not investigated accounted for the majority of the variation. These may include systemic disadvantages.

## Keywords

socioeconomic status, longitudinal analysis, health and retirement study, dementia, inequality

## Introduction

There is great inter-individual variability in cognitive ageing. It has been shown that the degree of impairment experienced depends not only on genetic factors but also on a range of modifiable risk factors (Livingston et al., 2020). The level of socioeconomic (dis-)advantage a person experiences is one such factor. Socioeconomic status (SES), defined by education, income and/or occupation, has been found repeatedly to relate to cognitive health in older adults, in that higher SES is associated with better cognitive health (Lyu & Burr, 2016; Marden et al., 2017).

However, the SES construct has been criticised as being of limited relevance, particularly to older adults, who are less dependent on ongoing employment and income (Steptoe & Zaninotto, 2020). Indeed, additional facets of disadvantage not covered by the SES construct have been found to be relevant to cognition in this group. For instance, access to healthcare is increasingly important with older age and is directly associated with risk of cognitive impairment, which might be the result of more successful monitoring and management of risk factors such as cardiovascular risk (Mullins et al., 2021). Moreover, wealth in older adulthood

has been shown to be more strongly associated with dementia risk than education (Cadare et al., 2018) or income (Glei et al., 2022). Indeed, the significance of wealth has been found to increase with age, as accumulated resources are increasingly relied on and reflect financial security across the life course more comprehensively than income (Glei et al., 2022). There also is an association between cognition and neighbourhood quality, which likely reflects the access to important resources such as recreational spaces (Clarke et al., 2015).

The Social Deprivation Index was developed as a more comprehensive measure reflecting these additional domains (SoDep Index; Hofbauer & Rodriguez, 2021a). It has been shown that the SoDep Index score relates to cognitive functioning and decline (Hofbauer & Rodriguez, 2021,

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2021b), as well as dementia risk (Hofbauer & Rodriguez, 2023) in that those with higher scores experience poorer cognitive function and a higher risk of dementia. As resources fundamentally determine whether an individual is able to adhere to a lifestyle conducive to good health (Link & Phelan, 1995), one can expect the lifestyle behaviours of those more deprived to be less favourable to cognitive health than those of individuals low in social deprivation are. In the context of brain health, such favourable behaviours would include the participation in stimulating activity, resulting in the building or maintenance of a greater resistance to loss of cognitive functioning under age-related pathological load ('Cognitive Reserve Theory', Song et al., 2022), as well as factors relevant for cardiovascular health (e.g. physical activity; Livingston et al., 2020).

Indeed, previous research supports a gap in brain-healthy lifestyle behaviours between those with and without marked social deprivation. For instance, in U.S. adults of all ages, those with lower education have been found to engage in less physical and cognitive activity, which mediated the association with episodic memory (Liu & Lachman, 2019). Using the 'Lifestyle for BRAin health' (LIBRA) score, Deckers and colleagues (2019) showed in an older adult (50+ years) English sample that higher wealth was associated with a more brain-healthy lifestyle. The LIBRA score takes health risk/protective behaviours (smoking, physical inactivity, low-to-moderate alcohol use, healthy diet) and protective lifestyle activity (high cognitive activity) into account. Moreover, LIBRA assesses the presence of a number of high-risk conditions (e.g. coronary heart disease, diabetes). The LIBRA mediated around half of the difference in dementia risk between those highest and lowest in wealth (Deckers et al., 2019). Conversely, in an older adult German sample, the LIBRA score accounted for only around 13% of the variation in cognitive functioning explained by SES (Röhr et al., 2022). Thus, findings support the idea that lifestyle may play a mechanistic role in the association between socioeconomic disadvantage and cognition; yet, the size of the effect remains uncertain and warrants further investigation.

Moreover, it would be informative to expand the definition of brain-healthy activities. Since the LIBRA's construction, a number of activities have gained attention as protective of cognition, such as hobbies (Sala et al., 2019), social activities (Duffner et al., 2022; Sommerlad et al., 2019), and volunteering (Guiney & Machado, 2017). These may be particularly important to the older adult population, who may struggle with physical or cognitive activities, but still entertain hobbies suited to their capabilities. What is more, previous research has found some associations between socioeconomic indicators and participation in such broader lifestyle activities (Bone et al., 2022). Therefore, it is conceivable that these broader lifestyle activities may account for additional variance in the association between socioeconomic

disadvantage and cognition. Yet, a detailed look at participation frequency across activities and social deprivation status is lacking, as is a mediation analysis that includes such a wider range of lifestyle activities.

Specifically, it would be valuable to evaluate such a mediation longitudinally. Previous investigations largely assessed socioeconomic variables and lifestyle variables at the same measurement instance. For plausibility of causation in mediation analysis, it would be necessary to introduce time lags between measurement of the predictor, mediator, and outcome of interest (Cain et al., 2018). Using longitudinal data also allows for the investigation of the effect of lifestyle on not only cognitive status but also cognitive decline. Previous work has shown that social deprivation's association with cognition is limited to cognitive status with negligible effect on rate of decline (Hofbauer & Rodriguez, 2021, 2021b). If lifestyle activity were found to slow decline, this would be an important finding in terms of preventing impairment.

## Aims

Therefore, our first aim was to assess the association between social deprivation and participation in a wider range of lifestyle activities. Our second aim was to explore the role of social deprivation and lifestyle in cognition across time. Our third aim was to analyse whether lifestyle activities longitudinally mediate the association between social deprivation and cognitive function. We expect an association between social deprivation and a range of lifestyle activities, so that those higher in deprivation are less likely to partake in brain-healthy lifestyle activities. Further, we anticipate a negative association between social deprivation and cognition as well as a positive association between brain-healthy lifestyle activities and cognition. Finally, we expect the association between social deprivation and cognition to be partially mediated by lifestyle.

## Method

### Sample

We used data from the longitudinal Health and Retirement Study (HRS). Commencing in 1992, the HRS aims at generating data that allow the investigation of demographic, economic, health and psychological aspects of ageing. Interviews are conducted bi-annually. The study population is a representative sample of US Americans over the age of 50 and their partners (Fisher & Ryan, 2017). We accessed publicly available longitudinal and wave-wise data provided by the RAND Corporation. Specifically, we used data collected between 2010 and 2018 as the lifestyle items have been kept constant from 2010 forward. We included respondents who, at baseline (i.e. in 2010), were at least 50 years old, were not institutionalised, and completed cognitive testing and all social deprivation items. Further, respondents were included

only if they completed all lifestyle items in one of the next two subsequent waves (i.e., either in 2012 or 2014). Data from two waves was used as the HRS employs a rotating administration of lifestyle variables, with only about half of the sample questioned on these at each instance (Smith et al., 2017). Finally, respondents needed to have participated in at least one additional cognitive assessment beyond baseline, with their final cognitive assessment conducted after the lifestyle assessment (i.e., either in 2016 or 2018). By purposefully sampling with time lags, we ensured that the order of measurements was appropriate for longitudinal mediation analysis (Cain et al., 2018). This resulted in an analysis sample of  $n = 3867$  (see Supplemental Figure 1). At baseline, included respondents had a mean age of 73.37 (SD: 5.57) years. On average, they were followed for 7.49 (SD: 0.87) years (see Table 1).

### Social Deprivation Index (SoDep Index) Score

The SoDep Index was calculated based on responses at baseline (i.e., in 2010). Details on the construction of the SoDep Index are reported elsewhere (Hofbauer & Rodriguez, 2021a). In short, domains included in the index are education (in years), job stability (ever having held a job for 5+ years), health insurance status (uninsured/medicare only/employer or business-based/other), self-rated neighbourhood safety (excellent to poor), income (sum of all sources of income including government transfers), and wealth (sum of all wealth components other than primary residence less all debt components). Wealth and income were adjusted for household size. Scoring was reversed so that a higher SoDep Index Score indicates greater deprivation. Domain scores were weighted according to weights determined at index construction (Hofbauer & Rodriguez, 2021a). For the purpose of group comparison, we subdivided respondents into (1) those with extremely low SoDep Index scores (20<sup>th</sup> percentile), (2) those with extremely high SoDep Index scores (80<sup>th</sup> percentile). These percentiles are commonly operationalised as indicating 'high' and 'low' socioeconomic position (e.g., Stenberg et al., 2019). The remaining participants were considered to have a moderate SoDep Index score (21<sup>st</sup>–79<sup>th</sup> percentile).

### Lifestyle Index Score

The Lifestyle Index score was calculated based on lifestyle activities recorded (on a rotating basis) either in 2012 or 2014. We selected the following relevant dimensions: (1) health/risk behaviours, (2) cognitively stimulating activities, (3) social activities, and (4) other meaningful activities. *Health/risk behaviours* are behaviours with a well-established impact to cognitive health, namely smoking, drinking alcohol and vigorous physical activity (Livingston et al., 2020). Corresponding items were selected from the core HRS questionnaire. Items on the remaining three dimensions were selected

from the psychosocial and lifestyle questionnaire (Smith et al., 2017). In line with previous findings, *cognitively stimulating activities* included were adult education attendance (Hatch et al., 2007), reading, writing (Duffner et al., 2022; Kochhann et al., 2018), and playing games (Cegolon & Jenkins, 2022). *Social activities* included were active participation in non-religious organisations or clubs (Lee & Kim, 2016), volunteering (Guiney & Machado, 2017), and activities with children in the family/neighbourhood (Krzechowska et al., 2021). Finally, we included *other meaningful activities* that have shown some association with cognition: spending time on a hobby (Sala et al., 2019), praying (Hosseini et al., 2019), and household activities (Shuen Yee et al., 2021). In total, we thus included 13 activities (see Table 2).

We used structural equation modelling (SEM) using *lavaan* in R to build the index. Specifically, this SEM is a confirmatory factor analysis in which all lifestyle activity items loaded onto a single latent 'lifestyle' variable. This approach to combining indicators into a compound measure has the advantage providing a weighting for each indicator without researchers making any a priori decisions about their relative importance. It is commonly used in health and social sciences to reduce dimensionality, avoid issues of multicollinearity among indicators, and achieve an intuitively interpretable score (e.g., Ivaldi et al., 2016; Yanuar et al., 2010). For the construction of the index, we initially included all lifestyle activity indicators. We reverse coded smoking and drinking alcohol so that a higher Lifestyle Index score would indicate a 'healthier' lifestyle.

We made stepwise adjustments to the SEM, removing variables with loadings  $< .04$  in each step (see Supplemental Table 1). We evaluated fit using multiple indices (Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR)). Given a CFI  $> 0.95$ , a RMSEA of  $< 0.06$  and a SRMR  $< 0.05$  adjustments were not necessary after the fourth iteration (Hooper et al., 2008). The final Lifestyle Index score for each participant is a weighted summary of the frequency at which respondents attend educational/training courses (weight: 0.57), read (weight: 0.42), do writing (weight: 0.53), participate in non-religious organisations or clubs (weight: 0.53), volunteer (weight: 0.62), and spend time on a hobby/project (weight: 0.41).

### Cognitive Outcome

Cognitive testing in the HRS consists of a battery of tests (word recall, serial 7s, counting backwards, naming, orientation). This testing is administered to first-hand respondents only, never to proxy respondents (Ofstedal et al., 2005). In the word recall task, respondents were asked to reproduce a list of 10 words, once immediately and after a 5 min delay. Each correctly recalled word was worth one point at each instance (range: 0–20). In the serial 7s test, respondents had to subtract

**Table 1.** Sample Characteristics.

| Demographic aspect          | Total                 | SoDep index group   |                   |                      | p-value <sup>1)</sup> |
|-----------------------------|-----------------------|---------------------|-------------------|----------------------|-----------------------|
|                             |                       | Low                 | Moderate          | High                 |                       |
| N                           | 3867                  | 774                 | 2319              | 774                  |                       |
| Follow-up time (Yrs)        |                       |                     |                   |                      | .656                  |
| Mean (SD)                   | 7.49 (0.87)           | 7.46 (0.89)         | 7.49 (0.87)       | 7.52 (0.86)          |                       |
| Range                       | 6–8                   | 6–8                 | 6–8               | 6–8                  |                       |
| Gender                      |                       |                     |                   |                      | <.001                 |
| Male                        | 1607 (41.56 %)        | 416 (53.75 %)       | 944 (40.71 %)     | 247 (31.91 %)        |                       |
| Female                      | 2260 (58.44 %)        | 358 (46.25 %)       | 1375 (59.29 %)    | 527 (68.09 %)        |                       |
| Age                         |                       |                     |                   |                      | .662                  |
| Mean (SD)                   | 73.37 (5.57)          | 72.8 (5.53)         | 73.49 (5.59)      | 73.57 (5.52)         |                       |
| Range                       | 61–101                | 64–93               | 61–93             | 63–101               |                       |
| Race                        |                       |                     |                   |                      | <.001                 |
| White                       | 3333 (86.19 %)        | 730 (94.32 %)       | 2078 (89.61 %)    | 525 (67.83 %)        |                       |
| Black                       | 413 (10.68 %)         | 28 (3.62 %)         | 185 (7.98 %)      | 200 (25.84 %)        |                       |
| Other                       | 121 (3.13 %)          | 16 (2.07 %)         | 56 (2.41 %)       | 49 (6.33 %)          |                       |
| Yrs of education            |                       |                     |                   |                      | <.001 <sup>2)</sup>   |
| Mean (SD)                   | 12.92 (2.88)          | 16.29 (1.01)        | 12.86 (1.67)      | 9.74 (3.25)          |                       |
| Range                       | 0–17                  | 12–17               | 8–17              | 0–17                 |                       |
| Marriage status             |                       |                     |                   |                      | <.001                 |
| Married/Partnered           | 2552 (65.99 %)        | 612 (79.07 %)       | 1598 (68.91 %)    | 342 (44.19 %)        |                       |
| Separated/Divorced          | 374 (9.67 %)          | 41 (5.3 %)          | 207 (8.93 %)      | 126 (16.28 %)        |                       |
| Widowed                     | 837 (21.64 %)         | 99 (12.79 %)        | 472 (20.35 %)     | 266 (34.37 %)        |                       |
| Never married               | 107 (2.77 %)          | 22 (2.84 %)         | 45 (1.94 %)       | 40 (5.17 %)          |                       |
| No. of chronic conditions   |                       |                     |                   |                      | <.001                 |
| Mean (SD)                   | 2.22 (1.31)           | 1.9 (1.22)          | 2.21 (1.28)       | 2.6 (1.38)           |                       |
| Range                       | 0–7                   | 0–7                 | 0–7               | 0–7                  |                       |
| CES-D score                 |                       |                     |                   |                      | <.001 <sup>2)</sup>   |
| Mean (SD)                   | 1.04 (1.65)           | 0.62 (1.29)         | 0.9 (1.49)        | 1.86 (2.1)           |                       |
| Range                       | 0–8                   | 0–8                 | 0–8               | 0–8                  |                       |
| Baseline cognition          |                       |                     |                   |                      | <.001                 |
| Mean (SD)                   | 22.82 (4.30)          | 25.17 (3.42)        | 23.07 (3.81)      | 19.75 (4.7)          |                       |
| Range                       | 4–35                  | 12–35               | 8–35              | 4–35                 |                       |
| Follow-up cognition         |                       |                     |                   |                      | <.001                 |
| Mean (SD)                   | 21.1                  | 23.62               | 21.31             | 17.91                |                       |
| Range                       | 0–35                  | 3–35                | 0–35              | 0–32                 |                       |
| Income (US Dollars)         |                       |                     |                   |                      | <.001 <sup>2)</sup>   |
| Median (IQR)                | 39,240 (44,594)       | 93,471 (87,580)     | 39,276 (33,021)   | 17,454 (16,527)      |                       |
| Range                       | 0–2,140,728           | 10,856–2,140,728    | 600–549,656       | 0–297,936            |                       |
| Wealth (US Dollars)         |                       |                     |                   |                      | <.001 <sup>2)</sup>   |
| Median (IQR)                | 263,000 (554,000)     | 921,000 (1,123,750) | 274,000 (413,379) | 13,050 (77,900)      |                       |
| Range                       | –1,165,000–20,466,180 | 21,500–20,466,180   | 600–12,301,697    | –1,165,000–1,266,000 |                       |
| Health insurance status     |                       |                     |                   |                      | <.001                 |
| Uninsured                   | 9 (0.23 %)            | 1 (0.13 %)          | 2 (0.09 %)        | 6 (0.78 %)           |                       |
| Medicare only               | 2134 (55.18 %)        | 282 (36.43 %)       | 1374 (59.25 %)    | 478 (61.76 %)        |                       |
| Employer/Own-business based | 472 (12.21 %)         | 63 (8.14 %)         | 208 (8.97 %)      | 201 (25.97 %)        |                       |
| Other                       | 1252 (32.38 %)        | 428 (55.3 %)        | 735 (31.69 %)     | 89 (11.5 %)          |                       |
| Job held for 5+ Yrs         |                       |                     |                   |                      | <.001                 |
| Yes                         | 3640 (94.13 %)        | 751 (97.03 %)       | 2216 (95.56 %)    | 673 (86.95 %)        |                       |
| No                          | 227 (5.87 %)          | 23 (2.97 %)         | 103 (4.44 %)      | 101 (13.05 %)        |                       |
| Neighbourhood safety        |                       |                     |                   |                      | <.001                 |
| Excellent                   | 1481 (38.3 %)         | 484 (62.53 %)       | 881 (37.99 %)     | 116 (14.99 %)        |                       |
| Very good                   | 1351 (34.94 %)        | 220 (28.42 %)       | 912 (39.33 %)     | 219 (28.29 %)        |                       |
| Good                        | 731 (18.9 %)          | 63 (8.14 %)         | 410 (17.68 %)     | 258 (33.33 %)        |                       |
| Fair                        | 250 (6.46 %)          | 6 (0.78 %)          | 101 (4.36 %)      | 143 (18.48 %)        |                       |
| Poor                        | 54 (1.4 %)            | 1 (0.13 %)          | 15 (0.65 %)       | 38 (4.91 %)          |                       |

Abbreviations: CES-D, Center for Epidemiologic Studies Depression; No.: Number; SoDep: Social Deprivation; Yrs.: Years.

Note. <sup>1)</sup> Categorical variables were compared by  $\chi^2$  testing. Continuous variables were compared by one-way ANOVA. <sup>2)</sup> Due to violations of the normality assumption, Kruskal-Wallis testing was employed.

7s from 100 in five consecutive steps (range: 0–5). The counting backwards task required counting backwards from 20 to 10. A score of two or one was assigned for a successful first or second attempt, respectively (range: 0–2). In the naming task, respondents had to name two objects after description (range: 0–2). In addition, they were asked the day of the week, month, day, and year (range: 0–4), and the President and Vice-President (range: 0–2). The total cognition score, which is the sum of these sub-test scores, thus ranges between 0–35. Where scores for respondents were missing, RAND provides imputations. No imputations are made for non-respondents, including in cases where proxies were interviewed (Mccammon et al., 2022). At baseline in 2010, cognitive testing scores were available for all respondents. At the follow-ups in 2012, 2014, 2016, and 2018, cognitive testing data were available for 99.41%, 99.74%, 99.50%, and 74.65% of respondents, respectively.

### Covariates

Time-invariant covariates used were gender and race. Age, marital status, number of chronic health conditions, and the Center for Epidemiologic Studies Depression (CES-D) Scale score were used as time-variant covariates.

### Analysis

All analyses were conducted using R (Version 4.2.2.) in RStudio (Rstudio Team, 2020). Unless otherwise indicated, we used the significance level  $\alpha < .05$ .

**Comparison of Lifestyle Indicators by SoDep Index Group.** Using population weights in the data provided by RAND, we estimated the prevalence of each frequency of activity per SoDep Index group at baseline. Subsequently, using  $\chi^2$  tests with Rao-Scott correction, we compared activity frequencies between SoDep Index groups. When cell sizes were too small to achieve reliable  $\chi^2$  estimates, adjusted Wald testing was used. We used the Bonferroni-adjusted significance level of  $\alpha < .004$  ( $\alpha < .05/13$ ). No post-hoc testing was used, as the high number of comparisons would have rendered results highly susceptible to Type II error.

**Association of Lifestyle Index and SoDep Index Group with Cognitive Status and Decline.** We conducted growth curve modelling using the *nlme* package in R. All models included a random intercept and slope allowing for the initial cognitive status and the association between time and cognitive score to vary randomly. Age was used as the time variable and re-centred at 50. Given a significant quadratic association between age and cognitive score, we included the quadratic age term in the model. The first model included the age terms and SoDep Index group as predictors. The second model further included Lifestyle Index score. In the third model, we included the interaction between Lifestyle Index score and the

squared age term to test the association between Lifestyle Index score and cognitive change over time. A fourth model included demographic covariates (gender, race, marriage status). The final fifth model included demographic covariates as well as health covariates (chronic conditions, CES-D score).

**Mediation Analysis.** Path modelling was completed using *lavaan* in R. The main exposure was the SoDep Index group (measured in 2010) and the Lifestyle Index score (measured in 2012/2014) was the mediator. The outcome of interest was the cognitive function at last assessment ('follow-up cognition', in 2016/2018). The model was designed specifically to test the following paths: (1) the direct path from baseline SoDep Index group to follow-up cognition, (2) the indirect path from baseline SoDep Index group via the Lifestyle Index score to follow-up cognition, and (3) the direct path from Lifestyle Index score to follow-up cognition. We report standardized coefficients. We took the product of coefficients approach to mediation (Mackinnon & Dwyer, 1993). We evaluated the bootstrap confidence interval (5000 samples) to determine the significance of the indirect effects (Hayes & Scharkow, 2013). Follow-up cognition was additionally predicted by baseline cognition. Covariates at follow-up were controlled for and predicted by the corresponding baseline predictor (e.g., a path from chronic conditions at baseline to chronic conditions at follow-up was included; see Supplemental Table 2). We assessed model fit according to CFI, RMSEA and SRMR. Given an insufficient model fit, we consulted modification indices and let CES-D score at follow-up be additionally predicted by of chronic conditions at follow-up. This resulted in satisfactory model fit (see Supplemental Table 2).

## Results

### Descriptive Analysis and Comparison of Lifestyle Activities by SoDep Index Group

SoDep Index groups did not differ in age at baseline and follow-up duration. However, compared to those in the low/moderate SoDep Index group those in the high SoDep Index group were more likely to be female, non-White, and not married/partnered. They had higher baseline CES-D scores and more baseline chronic conditions. Moreover, they exhibited lower cognitive function at both baseline and follow-up, compared to those in the moderate/high SoDep Index group (see Table 1). Chi-square comparison of the weighted frequencies of lifestyle activities (see Table 2) indicated that SoDep Index groups differed in the frequency of all 13 activities. Those in the high SoDep index group were most frequently smoking and least frequently partaking in vigorous physical activity. They were also drinking alcohol least frequently. Further, those in the high SoDep Index group participated less frequently in education/training courses, in reading books/magazines/newspapers, and in doing writing.

**Table 2.** Estimated Weighted Prevalence for Lifestyle Indicators by Social Deprivation Index Group.

| Lifestyle indicator                                                                                                         | SoDep index group    |                      |                      | p-value <sup>1)</sup> |
|-----------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|----------------------|-----------------------|
|                                                                                                                             | Low                  | Moderate             | High                 |                       |
| Health/Risk Behaviours                                                                                                      |                      |                      |                      |                       |
| Smoking <sup>a</sup>                                                                                                        |                      |                      |                      | .0002                 |
| Non-smoker                                                                                                                  | 47 % (43–51 %)       | 44 % (41.7–46.3 %)   | 41.3 % (37.3–45.4 %) |                       |
| Past smoker                                                                                                                 | 49.4 % (45.4–53.4 %) | 49.6 % (47.3–52 %)   | 49.1 % (44.9–53.3 %) |                       |
| Past and current smoker                                                                                                     | 3.6 % (2.1–5.1 %)    | 6.4 % (5.2–7.6 %)    | 9.6 % (6.8–12.3 %)   |                       |
| Drinking alcohol                                                                                                            |                      |                      |                      | <.0001                |
| Every day                                                                                                                   | 14.6 % (11.8–17.4 %) | 7 % (5.8–8.2 %)      | 3.7 % (2–5.5 %)      |                       |
| Several times a week                                                                                                        | 28.2 % (24.6–31.9 %) | 17.9 % (16.1–19.7 %) | 8.7 % (6.1–11.3 %)   |                       |
| Once week                                                                                                                   | 15.5 % (12.5–18.4 %) | 11.3 % (9.9–12.8 %)  | 7.9 % (5.6–10.2 %)   |                       |
| Less than once a week                                                                                                       | 41.7 % (37.8–45.6 %) | 63.8 % (61.5–66 %)   | 79.7 % (76.1–83.2 %) |                       |
| Vigorous activity (e.g. running, jogging, swimming, cycling, aerobics, gym workout, tennis, digging with a spade or shovel) |                      |                      |                      | <.0001                |
| Every day                                                                                                                   | 2.9 % (1.5–4.3 %)    | 1.9 % (1.3–2.4 %)    | 0.9 % (0.2–1.6 %)    |                       |
| Several times a week                                                                                                        | 36.3 % (32.5–40.2 %) | 23.2 % (21.2–25.2 %) | 12.9 % (10.1–15.7 %) |                       |
| Once a week                                                                                                                 | 11.8 % (9.1–14.5 %)  | 11.2 % (9.7–12.6 %)  | 8.2 % (6.1–10.2 %)   |                       |
| 1–3 times a month                                                                                                           | 9.7 % (7.3–12.2 %)   | 8.7 % (7.4–10.1 %)   | 5.9 % (3.9–7.9 %)    |                       |
| Less than once a month                                                                                                      | 39.2 % (35.4–43.1 %) | 55.0 % (52.7–57.3 %) | 72.1 % (68.5–75.8 %) |                       |
| Cognitive activity                                                                                                          |                      |                      |                      | <.0001 <sup>3)</sup>  |
| Educational/training course                                                                                                 |                      |                      |                      |                       |
| Every day                                                                                                                   | 0.5 % (–0.2–1.1 %)   | 0.0 % (0.0–0.0 %)    | 0.1 % (–0.1–0.3 %)   |                       |
| Several times a week                                                                                                        | 2.3 % (1.2–3.5 %)    | 0.8 % (0.4–1.2 %)    | 0.7 % (0.1–1.3 %)    |                       |
| Once a week                                                                                                                 | 2.8 % (1.7–4 %)      | 2.0 % (1.3–2.7 %)    | 1.0 % (0.3–1.7 %)    |                       |
| 1–3 times a month                                                                                                           | 12.9 % (10.2–15.7 %) | 4.2 % (3.3–5.1 %)    | 2.5 % (1.4–3.7 %)    |                       |
| Less than once a month                                                                                                      | 81.5 % (78.4–84.6 %) | 93 % (91.8–94.2 %)   | 95.6 % (94.1–97.1 %) |                       |
| Read books/magazines/newspapers                                                                                             |                      |                      |                      | <.0001                |
| Every day                                                                                                                   | 79.9 % (76.6–83.3 %) | 66.8 % (64.6–69 %)   | 44.6 % (40.5–48.8 %) |                       |
| Several times a week                                                                                                        | 15.1 % (12.1–18.2 %) | 16.8 % (15.1–18.5 %) | 19.0 % (15.7–22.2 %) |                       |
| Once a week                                                                                                                 | 1.5 % (0.5–2.5 %)    | 3.7 % (2.9–4.6 %)    | 9.5 % (6.8–12.1 %)   |                       |
| 1–3 times a month                                                                                                           | 2.2 % (1.1–3.4 %)    | 8.0 % (6.6–9.3 %)    | 13.3 % (10.5–16 %)   |                       |
| Less than once a month                                                                                                      | 1.2 % (0.4–1.9 %)    | 4.7 % (3.7–5.7 %)    | 13.7 % (10.9–16.5 %) |                       |
| Do writing (e.g. letters, stories, or journal entries)                                                                      |                      |                      |                      | <.0001                |
| Every day                                                                                                                   | 8.5 % (6.3–10.8 %)   | 4.5 % (3.5–5.4 %)    | 3.2 % (1.8–4.5 %)    |                       |
| Several times a week                                                                                                        | 10.4 % (8.1–12.6 %)  | 4.6 % (3.7–5.6 %)    | 4.0 % (2.4–5.5 %)    |                       |
| Once a week                                                                                                                 | 7.2 % (5.2–9.3 %)    | 3.7 % (2.9–4.5 %)    | 3.5 % (2.0–5.0 %)    |                       |
| 1–3 times a month                                                                                                           | 24.5 % (21–28 %)     | 17.2 % (15.4–18.9 %) | 10.8 % (8.3–13.4 %)  |                       |
| Less than once a month                                                                                                      | 49.3 % (45.3–53.3 %) | 70.1 % (68–72.2 %)   | 78.5 % (75.2–81.9 %) |                       |
| Play games <sup>b</sup>                                                                                                     |                      |                      |                      | <.001                 |
| Every day                                                                                                                   | 31.6 % (28–35.3 %)   | 26.9 % (24.9–29 %)   | 21.3 % (18.0–24.6 %) |                       |
| Several times a week                                                                                                        | 13.3 % (10.7–15.9 %) | 15.7 % (14–17.5 %)   | 12.9 % (10.1–15.7 %) |                       |
| Once a week                                                                                                                 | 7.4 % (5.3–9.4 %)    | 7.5 % (6.3–8.7 %)    | 6.4 % (4.0–8.8 %)    |                       |
| 1–3 times a month                                                                                                           | 12.4 % (9.6–15.2 %)  | 15.7 % (14.0–17.4 %) | 15.0 % (11.8–18.2 %) |                       |
| Less than once a month                                                                                                      | 35.3 % (31.5–39.2 %) | 34.1 % (31.9–36.3 %) | 44.3 % (40.2–48.5 %) |                       |
| Social activities                                                                                                           |                      |                      |                      | <.0001 <sup>3)</sup>  |
| Attend non-religious organisations/clubs <sup>c</sup>                                                                       |                      |                      |                      |                       |
| Every day                                                                                                                   | 1.8 % (0.7–2.8 %)    | 0.8 % (0.4–1.2 %)    | 0.4 % (0.0–0.8 %)    |                       |
| Several times a week                                                                                                        | 13.6 % (10.9–16.3 %) | 7.6 % (6.3–8.9 %)    | 1.7 % (0.8–2.6 %)    |                       |
| Once a week                                                                                                                 | 12.4 % (9.8–15.0 %)  | 8.1 % (6.9–9.4 %)    | 4.8 % (3.2–6.5 %)    |                       |
| 1–3 times a month                                                                                                           | 35.7 % (31.8–39.6 %) | 25.1 % (23.0–27.1 %) | 15.5 % (12.1–18.9 %) |                       |
| Less than once a month                                                                                                      | 36.6 % (32.8–40.4 %) | 58.4 % (56.1–60.7 %) | 77.6 % (73.9–81.3 %) |                       |
| Volunteer <sup>d</sup>                                                                                                      |                      |                      |                      | <.0001                |

(continued)



**Table 2. (continued)**

| Lifestyle indicator                            | SoDep index group    |                      |                      | p-value <sup>1)</sup> |
|------------------------------------------------|----------------------|----------------------|----------------------|-----------------------|
| Every day                                      | 2.3 % (1.1–3.6 %)    | 1.5 % (0.9–2.1 %)    | 1.5 % (0.6–2.5 %)    |                       |
| Several times a week                           | 9.7 % (7.5–11.9 %)   | 6.6 % (5.5–7.8 %)    | 3.3 % (1.7–4.9 %)    |                       |
| Once a week                                    | 12.3 % (9.7–15 %)    | 7.3 % (6.0–8.5 %)    | 3.8 % (2.4–5.3 %)    |                       |
| 1–3 times a month                              | 24.5 % (21.0–28.0 %) | 17.2 % (15.4–19 %)   | 10.9 % (8.4–13.3 %)  |                       |
| Less than once a month                         | 51.1 % (47.1–55.1 %) | 67.4 % (65.2–69.6 %) | 80.5 % (77.2–83.7 %) |                       |
| Activities w. children in family/neighbourhood |                      |                      |                      | <.0001                |
| Every day                                      | 3.5 % (1.8–5.2 %)    | 3.5 % (2.6–4.3 %)    | 5.9 % (3.8–8 %)      |                       |
| Several times a week                           | 7.4 % (5.4–9.5 %)    | 9.2 % (7.8–10.6 %)   | 7.4 % (5.3–9.5 %)    |                       |
| Once a week                                    | 8.3 % (6.1–10.6 %)   | 6.0 % (5.0–7.0 %)    | 6.8 % (4.5–9.1 %)    |                       |
| 1–3 times a month                              | 34.5 % (30.7–38.3 %) | 30.8 % (28.6–33 %)   | 22.4 % (18.9–25.9 %) |                       |
| Less than once a month                         | 46.3 % (42.3–50.2 %) | 50.5 % (48.1–52.8 %) | 57.5 % (53.4–61.7 %) |                       |
| Other meaningful activity                      |                      |                      |                      |                       |
| Pray privately                                 |                      |                      |                      | <.0001                |
| Every day                                      | 37.9 % (34.0–41.7 %) | 46.8 % (44.5–49.1 %) | 48.1 % (43.9–52.2 %) |                       |
| Several times a week                           | 12.6 % (9.9–15.3 %)  | 14.4 % (12.8–16.1 %) | 13.1 % (10.0–16.2 %) |                       |
| Once a week                                    | 2.3 % (1.0–3.7 %)    | 3.2 % (2.4–4.0 %)    | 1.5 % (0.7–2.4 %)    |                       |
| 1–3 times a month                              | 11.7 % (9.3–14.2 %)  | 12.6 % (11.0–14.2 %) | 11.0 % (8.6–13.5 %)  |                       |
| Less than once a month                         | 35.4 % (31.6–39.3 %) | 23.0 % (21.0–25.0 %) | 26.3 % (22.5–30.0 %) |                       |
| Household activities <sup>e</sup>              |                      |                      |                      | <.0001                |
| Every day                                      | 26.2 % (22.6–29.7 %) | 25.3 % (23.3–27.3 %) | 23.4 % (19.6–27.1 %) |                       |
| Several times a week                           | 29.7 % (26.0–33.4 %) | 29.9 % (27.8–32.1 %) | 20.3 % (16.9–23.6 %) |                       |
| Once a week                                    | 12.1 % (9.5–14.7 %)  | 11.9 % (10.4–13.4 %) | 10.8 % (8.5–13.2 %)  |                       |
| 1–3 times a month                              | 23.0 % (19.7–26.3 %) | 21.5 % (19.6–23.5 %) | 26.9 % (23.2–30.6 %) |                       |
| Less than once a month                         | 9.0 % (6.9–11.2 %)   | 11.3 % (9.9–12.7 %)  | 18.6 % (15.5–21.8 %) |                       |
| Spend time on hobby/project <sup>f</sup>       |                      |                      |                      | <.0001                |
| Every day                                      | 8.8 % (6.5–11.2 %)   | 8.4 % (7.1–9.7 %)    | 7.3 % (5.2–9.5 %)    |                       |
| Several times a week                           | 22.3 % (18.8–25.7 %) | 12.9 % (11.4–14.5 %) | 9 % (6.2–11.7 %)     |                       |
| Once a week                                    | 7.4 % (5.3–9.6 %)    | 6.7 % (5.5–7.9 %)    | 3.2 % (1.7–4.7 %)    |                       |
| 1–3 times a month                              | 24.6 % (21.2–28 %)   | 21.9 % (19.9–23.9 %) | 16.3 % (13.4–19.2 %) |                       |
| Less than once a month                         | 36.9 % (33.1–40.7 %) | 50.1 % (47.8–52.4 %) | 64.2 % (60.2–68.2 %) |                       |

Abbreviations: CES-D, Center for Epidemiologic Studies Depression; SoDep: Social Deprivation, sth.: something; w.: with.

Note. <sup>1)</sup> Frequencies were compared using  $\chi^2$  testing. <sup>2)</sup> Adjusted Wald statistic used due to small cell sizes, <sup>a</sup> Combines responses to items on past and current smoking, <sup>b</sup> Combines responses to items on card and other games and word games, <sup>c</sup> Combines responses on items on the attendance of meetings of non-religious organisations and on participation in sport/social/other clubs, <sup>d</sup> Combines responses on items on volunteering with young people and other kinds of volunteering, <sup>e</sup> Combines responses on items on car/home/garden maintenance and cooking/baking, <sup>f</sup> Combines responses on items on hobbies/projects and cloth making/knitting/embroidering.

Additionally, they were less frequently engaged in attending non-religious organisations and clubs, volunteering, in activities with children in the family/neighbourhood, and playing games. Finally, they reported the lowest frequency of household activities and time spend on hobbies but the highest of praying.

### Association of SoDep Index Group and Lifestyle Index with Cognitive Status and Decline

Table 3 presents the results of the growth curve models. Compared to being in the moderate SoDep Index group, being in the low SoDep Index group was associated with better cognitive performance ( $\beta = 1.97$ , [95 % CI: 1.70, 2.24],  $p < .001$ ) and being in the high SoDep Index group was associated with poorer cognitive performance ( $\beta = -3.43$ , [95

% CI:  $-3.70$ ,  $-3.16$ ],  $p < .001$ , ‘Model 1’). These associations persisted after adding the Lifestyle Index score to the model; yet, coefficients were reduced, which is indicative of partial mediation (‘Model 2’).

The Lifestyle Index score was positively associated with cognitive performance ( $\beta = 1.90$ , [95 % CI: 1.63, 2.16],  $p < .001$ ). To illustrate, as lifestyle activity weights range between 0.41 and 0.62 (see Supplemental Table 1) one may roughly equate a unit increase in Lifestyle Index with two units increase on a lifestyle items’ frequency scale (see Table 2), provided that item is included in the index. This could, for instance, signify that a respondent attends a club not only 1–3 times a month but several times a week or reads not once a week but daily. A significant interaction between Lifestyle Index score and the squared age term took a positive value near zero ( $\beta = 0.00$ , [95 % CI: 0.00, 0.00],  $p = .010$ ) indicating

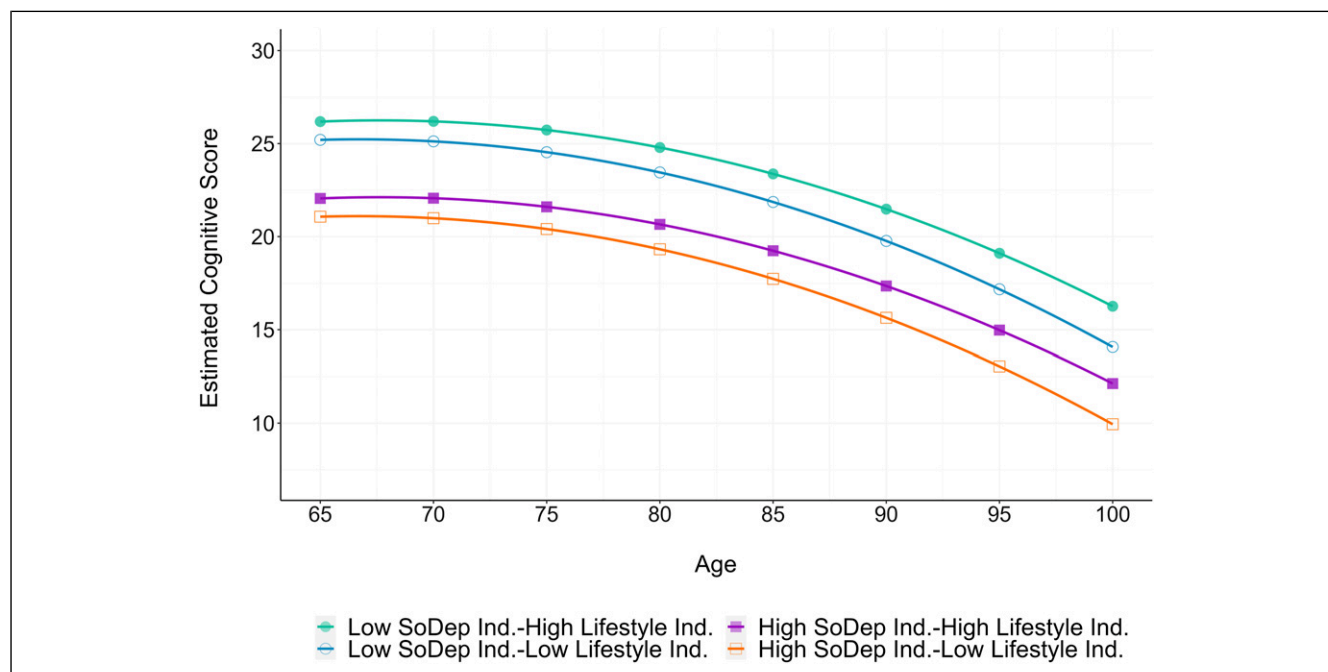
**Table 3.** Results From Growth Models of the Associations Between SoDep Index Group, Lifestyle Index Score and Cognitive Scores.

|                                                  | Model 1                 | Model 2                  | Model 3                 | Model 4                 | Model 5                 |
|--------------------------------------------------|-------------------------|--------------------------|-------------------------|-------------------------|-------------------------|
| (Intercept)                                      | 21.19 [21.19, 22.12]*** | 21.19 [20.26, 22.13] *** | 21.26 [20.33, 22.20]*** | 21.70 [20.71, 22.67]*** | 21.88 [20.90, 22.87]*** |
| Age                                              | 0.32 [0.25, -0.39]***   | 0.32 [0.25, 0.39]***     | 0.31 [0.24, 0.38]***    | 0.32 [0.25, 0.40]***    | 0.34 [0.26, 0.41]***    |
| Age <sup>2</sup>                                 | -0.01 [-0.01, -0.01]*** | -0.01 [-0.01, -0.01]***  | -0.01 [-0.01, -0.01]*** | -0.01 [-0.01, -0.01]*** | -0.01 [-0.01, -0.01]*** |
| Low SoDep index group                            | 1.97 [1.70, 2.24]***    | 1.47 [1.20, 1.74]***     | 1.47 [1.20, 1.74]***    | 1.54 [1.28, 1.81]***    | 1.50 [1.23, 1.76]***    |
| High SoDep index group                           | -3.43 [-3.70, -3.16]*** | -3.03 [-3.30, -2.76]***  | -3.03 [-3.30, -2.76]*** | -2.74 [-3.01, -2.47]*** | -2.63 [-2.90, -2.36]*** |
|                                                  |                         | Cog.Score                | Cog.Score               | Cog.Change <sup>d</sup> | Cog.Change <sup>d</sup> |
| Lifestyle index score                            |                         | 1.90 [1.63, 2.16]***     | 1.43 [0.99, 1.87]***    | 0.00 [0.00, 0.00]**     | 1.17 [0.72, 1.63]***    |
| Gender: Male <sup>a</sup>                        |                         |                          |                         | -0.88 [-1.09, -0.67]*** | -0.90 [-1.11, -0.69]*** |
| Race: Black/African American <sup>b</sup>        |                         |                          |                         | -1.92 [-2.25, -1.59]*** | -1.89 [-2.21, -1.56]*** |
| Race: Other <sup>b</sup>                         |                         |                          |                         | -1.01 [-1.57, -0.45]*** | -1.03 [-1.59, -0.47]*** |
| Marriage status: Widowed <sup>c</sup>            |                         |                          |                         | 0.01 [-0.18, 0.18]      | 0.06 [-0.13, 0.24]      |
| Marriage status: Divorced/Separated <sup>c</sup> |                         |                          |                         | -0.02 [-0.30, 0.27]     | 0.03 [-0.25, 0.31]      |
| Marriage status: Never Married <sup>c</sup>      |                         |                          |                         | -0.21 [-0.75, 0.33]     | -0.21 [-0.74, 0.32]     |
| No. of chronic conditions                        |                         |                          |                         |                         | -0.17 [-0.23, -0.11]*** |
| CES-D score                                      |                         |                          |                         |                         | -0.09 [-0.12, -0.05]*** |
| AIC                                              | 95865.16                | 95671.95                 | 95682.17                | 95412.06                | 95366.37                |
| BIC                                              | 95935.49                | 95750.10                 | 95768.12                | 95544.89                | 95514.82                |

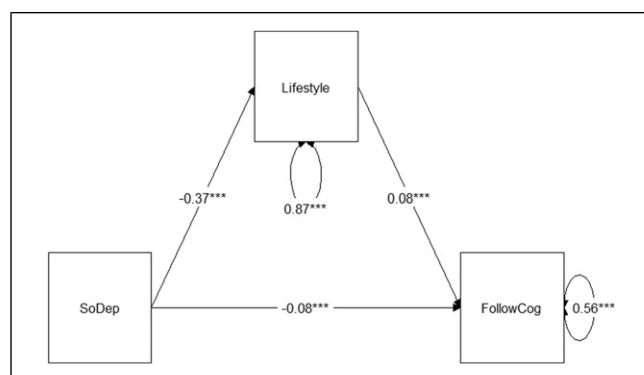
Abbreviations: AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; Cog.: Cognitive; SoDep: Social Deprivation; \*\*\* $p < .001$ .

Note. Model 1 – Conditional growth curve model with SoDep Index group as predictor; Model 2 – Conditional growth curve model with SoDep Index group and Lifestyle Index as predictors; Model 3 – Conditional growth curve model with SoDep Index group and Lifestyle Index as predictors incl. the interaction of Age x Lifestyle Index; Model 4 – Adjusted conditional growth curve model with SoDep Index group and Lifestyle Index as predictors incl. the interaction of Age x Lifestyle Index incl. covariates. Values in square brackets are the 95 % Confidence Intervals. <sup>a</sup> Gender: Female is the reference level. <sup>b</sup> Race: White/Caucasian is the reference level. <sup>c</sup> Marriage Status: Married/Partnered is the reference level, <sup>d</sup> that is the interaction Lifestyle Index x Age<sup>2</sup>.





**Figure 1.** Estimated cognitive scores based on the adjusted growth curve model. Abbreviations: Lifestyle Ind: Lifestyle Index score, SoDep Ind.: Social Deprivation Index score. Note: Cognitive scores estimated using model coefficients of Model 5 (see Table 3). Scores estimated for a hypothetical individual with (1) a low Social Deprivation index score and a high Lifestyle index score, (2) a low Social Deprivation index score and a low Lifestyle index score, (3) a high Social Deprivation index score and a high Lifestyle index score, and (3) a high Social Deprivation index score and a low Lifestyle index score. As a 'low' score, we chose the respective index score marking the 20<sup>th</sup> percentile; as a 'high' score the index score marking the 80<sup>th</sup> percentile. For all estimations, we kept categorical covariates at the reference level (gender: female; marriage status: married/partnered) and used the average values for the number of chronic conditions and EURO-D score.



**Figure 2.** Path diagram showing paths between social deprivation and cognition as mediated by lifestyle with standardised coefficients. Abbreviations: SoDep: Social Deprivation Index group, Lifestyle: Lifestyle Index score; FollowCog: Cognitive score at last follow-up; \*\*\* $p < .001$ . Note: Paths involving covariates are not displayed. Refer to Supplemental Table 2 for coefficient estimates. Curved arrows indicate the error variance.

that higher Lifestyle Index scores were associated with a negligible attenuation in cognitive decline over time ('Model 3'). All effects survived adjustment for demographic covariates ('Model 4') and for additional health-related covariates ('Model 5').

Figure 1 shows the predicted cognitive performance across time for four respondent types: (1) someone in the high SoDep Index group with a high Lifestyle Index score, (2) someone in the high SoDep Index group with a low Lifestyle Index score, (3) someone in the low SoDep Index group with a high Lifestyle Index score, and (4) someone in the low SoDep Index group with a low Lifestyle Index score.

### Mediation Analysis

Fit indices of the path model of the mediation effect of lifestyle in the association between social deprivation and follow-up cognition indicated good model fit ( $CFI: 0.98$ ,  $RMSEA: 0.05$ ,  $SRMR: 0.04$ ). Figure 2 shows the path diagram with standardised coefficients (full model output in Supplemental Table 3). There was a significant direct associations between SoDep Index group as well as the Lifestyle Index score and follow-up cognition, and a significant indirect association of SoDep Index group via Lifestyle Index Score. As the bootstrapped confidence interval of the indirect path coefficient excludes zero (Std.  $\beta = -0.03$ , [95 % CI:  $-0.04, -0.02$ ],  $p < .001$ ), we can conclude that the effect of SoDep Index group was partially mediated by Lifestyle Index score. The total effect of SoDep Index group on follow-up cognition was significant and negative (Std.  $\beta = -0.11$ , [95 %

CI:  $-0.14, -0.09$ ],  $p < .001$ ). Thus, the indirect effect via Lifestyle Index Score accounted for 27% of the total effect of SoDep Index group on follow-up cognition.

## Discussion

In this work, we set out to assess the association between social deprivation and participation in a broader range of lifestyle activities, evaluate the association between social deprivation and lifestyle behaviours with cognition across time, and to assess whether the lifestyle activities mediate the association between social deprivation and cognitive function.

We found that those with higher social deprivation are less likely to frequently engage in a range of stimulating activities (e.g., reading, volunteering) but more likely to frequently engage in some health risk behaviours (e.g. smoking, physical inactivity). This expands on previous findings of lifestyle disparities based on wealth and SES (Deckers et al., 2019; Röhr et al., 2022). Reasons for reduced engagement with stimulating activities may include lack of access to the appropriate environments (e.g. lack of spaces for physical exercise) and lack of social capital (i.e. lower social cohesion and trust) (Chen & Miller, 2013). Stress may also be relevant, particularly to engagement in health risk behaviours, as perceived stress has been shown to be associated with such behaviours in individuals in deprived neighbourhoods (Algren et al., 2018). While the frequency of alcohol consumption was lower in those with higher deprivation, this may mask a higher probability of engaging in high-risk drinking (i.e. high intake in a single instance), as has been found previously (Beard et al., 2019).

As observed previously (Hofbauer & Rodriguez, 2021, 2021b), social deprivation was negatively associated with cognitive function in longitudinal growth curve models. This association was attenuated when adding the lifestyle indicator. In line with previous results (Sommerlad et al., 2019), lifestyle activity participation was positively associated with cognitive status in longitudinal growth curve analysis. While there also was an association of higher Lifestyle Index scores with slowed cognitive decline, the size of this effect was negligible. This is reminiscent of the associations between education and cognition (Lövdén et al., 2020) and social deprivation and cognition (Hofbauer & Rodriguez, 2021, 2021b), which are notable for the level but not the rate of change of functioning. Taken together, this indicates that life experiences may influence the risk of significant cognitive decline only in as far as they influence the likelihood of reaching a threshold for notable impairment.

We found a partial mediation of the association between social deprivation status and cognition via lifestyle. This highlights lifestyle aspects as promising intervention targets. Indeed, multicomponent lifestyle intervention trials have successfully reduced cognitive decline in healthy (Ngandu

et al., 2015) and at-risk (Andrieu et al., 2017) individuals. However, it is important to note the magnitude of the observed mediation; the indirect effect via lifestyle made up only 27% of the total effect of social deprivation on follow-up cognition. This underlines that, rather than focusing too heavily on individual lifestyle, broader social context needs to be considered (Daly, 2023). The exposure to multiple, converging risk factors likely is responsible for a large proportion of variance in health outcomes associated with socioeconomic status (Evans & Kim, 2010). Thus, guidelines for the prevention of cognitive decline and dementia need to go beyond individual behaviour and acknowledge the role of deprivation in cognitive health (Daly, 2023).

Strengths of the present analysis include the large, extensively described sample with longitudinal data on a timeline suitable for causal interpretation of mediation analysis. Still, there are limitations to our results. By selecting only respondents who completed at least two cognitive tests and were not institutionalised at baseline, we likely ended up with an analysis sample that was healthier than the overall sample and healthier than the general older population. This may have led us to underestimate the associations between SoDep Index group and Lifestyle Index Score on cognition. Further, as the Lifestyle Index contains cognitive activities (adult education, reading, and writing) there is a risk of circularity in our analysis. However, this is mitigated by the fact that follow-up cognition was measured after the lifestyle assessment.

## Conclusion

In conclusion, our results emphasize an association between higher social deprivation and lower cognitive function that persists when accounting for lifestyle activities. A greater participation in lifestyle activities is associated with better cognition and mediates the effect of social deprivation on cognition. While lifestyle thus remains an interesting target for interventions, the effects of systematic disadvantages should be explored further and addressed in efforts to prevent cognitive decline.

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## Author Contributions

Lena M. Hofbauer and Francisca S. Rodriguez contributed equally to conception of this work. Data preparation and analysis were performed by Lena M. Hofbauer and checked by Francisca S. Rodriguez. The first draft of the manuscript was written by Lena M. Hofbauer and both authors commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

## Ethics Approval

This work is based on secondary analysis of data without any identifying information and does as such not require ethical approval. The original data collection by the Health and Retirement Study (HRS) was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the University of Michigan Institutional Review Board.

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## Data Availability Statement

The data used in this work are publicly available from Health and Retirement Study (HRS) and the RAND Corporation at <https://hrs.isr.umich.edu/data-products>.

## Supplemental Material

Supplemental material for this article is available online.

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