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The importance of social relationships in the process of cognitive ageing

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**The relationship between social
functioning and subjective memory
complaints in older persons:
a population-based
longitudinal cohort study**

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ABSTRACT

Background: Poor social functioning is associated with cognitive decline in older adults. It is unclear whether social functioning is also associated with subjective memory complaints (SMC). We investigated the association between social functioning and incident SMC and SMC recovery.

Design: Longitudinal cohort study (LifeLines).

Setting: General population in the north of the Netherlands.

Participants: 8762 older adults (aged ≥ 65 years) with good objective cognitive functioning at baseline (MMSE ≥ 26).

Measurements: Self-reported SMC were measured at baseline and after 1,5 years follow-up. Aspects of social functioning included marital status, household composition, social network size, social activity, quality of social relationships, social support, affection, behavioral confirmation, and status.

Results: Thirteen percent (513/3963) developed SMC during follow-up (incident SMC). Multivariate logistic regression analyses (adjusted for age, gender, education level, physical activity, alcohol use, smoking status, depression) showed that participants with better feelings of affection (OR: 0.93; 95%CI: 0.88-0.98) and behavioral confirmation (OR: 0.93; 95%CI: 0.88-0.99) had a lower risk of incident SMC. Thirty-four percent (1632/4799) reported recovery. Participants who were in a relationship (OR: 1.24; 95%CI: 1.04-1.47), lived in a larger household (OR: 1.26; 95%CI: 1.10-1.45), and had better feelings of affection (OR: 1.09; 95%CI: 1.05-1.13), behavioral confirmation (OR: 1.16; 95%CI: 1.11-1.21), and status (OR: 1.05; 95%CI: 1.01-1.10) recovered more often from SMC.

Conclusions: Social functioning is associated with incident SMC and SMC recovery over a follow-up period of 1.5 years. The association with SMC recovery further argues for the need of (large-scale) randomized controlled trials to prevent or slow-down cognitive decline.

INTRODUCTION

Subjective Memory Complaints (SMC) are very common in older persons¹. The prevalence of SMC among community-dwelling older persons is estimated to be between 25% and 50% and increases with age². SMC have a major impact on the everyday lives of older persons, as those with SMC report negative feelings and views of the self, an increase in the use of memory strategies and aids, and difficulty with cognitively demanding aspects of work and volunteer activities³. Furthermore, SMC are associated with various adverse outcomes⁴, including lower quality of life and well-being^{5,6} and difficulties with instrumental activities of daily living⁶. SMC are also shown to be a risk factor for nursing home admission⁷ and mortality⁸. Finally, this results in higher health care costs⁹.

SMC are also an important indicator and risk factor for the development of future cognitive decline, mild cognitive impairment (MCI) and dementia^{1,2,4}. In contrast, the association between SMC and current cognitive impairment is less clear^{1,10}. We know that the diagnostic performance of SMC on its own is described as modest and is not accurate enough to establish the presence of MCI (sensitivity: 37%, specificity: 87%) or dementia (sensitivity: 43%, specificity: 86%) by itself¹¹. However, SMC are often one of the first symptoms of cognitive decline and included in the criteria to diagnose MCI¹².

As SMC have a major impact on person's daily life and the society as a whole, it is important to identify potential modifiable risk factors underlying or causing SMC, in order to reduce SMC and subsequently its adverse effects on daily functioning^{13,14}. Furthermore, dementia has recently been identified as major public health priority and the focus in dementia research has shifted to prevention, rather than treatment of dementia¹⁵. There is increased consensus that dementia intervention programs should focus on the earliest stages of the disease, since the timing of therapeutic treatment of dementia may be too late in the disease process to substantively improve the outcome¹⁶. In light of the association between SMC and dementia, identifying risk factors associated with SMC may also contribute to the development of targeted dementia prevention strategies in its earliest stages before symptoms or pathology of dementia are even present¹⁶.

Various determinants, including demographic variables (i.e. older age, female sex, lower education level)^{2,17}, depression^{1,2,17}, neuroticism^{1,18}, less exercise¹⁷, and multimorbidity¹⁴, have shown to be associated with SMC. Another potentially important modifiable risk factor for SMC is poor social functioning. Poor social relationships, and in particular less social interaction, are an important risk factor for the development of dementia¹⁹. In addition, multiple aspects of social functioning predict cognitive decline at older age, including low social activity²⁰, low social engagement²¹, small social network size²², and loneliness²³. However, one should also acknowledge that people with

higher levels of social activity may also be more likely to be exposed to cognitively demanding situations in which cognitive impairments are more noticeable by others²⁴.

Only a few cross-sectional population-based studies have examined the association between social functioning (i.e. social activity, living alone, married, social support) and SMC^{12,24–26}. The results are contradictory. Only two out of four cross-sectional studies found a statistically significant association between poor social functioning (i.e. low social activity, living alone, poor social support) and SMC among persons aged 65 years and older^{12,25}. Lee et al (2014) found the opposite results in the same age group (n=741) (i.e. high social activity was associated with SMC). To our knowledge, only one longitudinal study has examined the association between social functioning and SMC at three year follow-up in 1416 community dwelling adults, aged 55 to 85 years and without subjective memory complaints at baseline¹³. Van den Kommer et al. (2014) only found a relation between lower frequency of visiting activities of organizations and SMC among participants aged 65 to 75 years. Associations between loneliness and social participation were not associated with incident SMC¹³.

Not much is known about the role of social functioning and recovery from SMC. Identification of factors underlying SMC recovery may offer important handles for the development of interventions or lifestyle programs to improve memory problems. Therefore, in our longitudinal study we examined the predictive value of social functioning on both incident SMC and SMC recovery among community dwelling people aged 65 years and older, without cognitive impairments at baseline.

METHODS

Study sample

The study sample was based on a sub-cohort of the LifeLines Cohort Study, including participants aged 65 years and older. LifeLines is a multi-disciplinary prospective population-based cohort study examining in a unique three-generation design the health and health-related behaviors of 167,729 persons living in the North of The Netherlands. It employs a broad range of investigative procedures in assessing the biomedical, socio-demographic, behavioral, physical and psychological factors which contribute to the health and disease of the general population, with a special focus on multi-morbidity and complex genetics. LifeLines is a facility that is open for all researchers. Information on application and data access procedure is summarized on www.lifelines.net. Details of the LifeLines study design are reported elsewhere^{27,28}. Briefly, the participant recruitment and baseline assessment started in 2006 and was finished in 2013 and was performed in 12 local research sites. Baseline assessment consisted of a physical examination, draw-

ing blood samples, collecting urine samples, and self-report questionnaires regarding demographics, health status, lifestyle and psychosocial aspects. About 1.5 years after the baseline measurement, a follow-up questionnaire was administered. For this study, we selected all participants that were 65 years and older with a score of 26 or above on the Mini-Mental State Examination (MMSE) at baseline ($n=12,391$). We applied a cut-off of 26 points instead of the traditional cut-off of 24 points²⁹, to ensure persons with objective cognitive impairment at baseline are excluded.

Measurements

Subjective Memory Complaints (SMC)

SMC was assessed in the self-report questionnaire at baseline and again 1.5 years later with the question, "Do you have complaints about your memory?". This question was answered on a 3-point scale, coded as: 1) no; 2) sometimes; 3) yes. Subsequently the outcome was dichotomized in 1) no SMC and 2) yes SMC (categories sometimes and yes combined). *Incident SMC* was defined as the number of people with SMC at 1.5 years follow-up and who had no SMC at baseline, divided by the number of people who had no SMC at baseline. *Recovery of SMC* was defined as the number of people who had no SMC at 1.5 year follow-up and with SMC at baseline, divided by the number of people with SMC at baseline.

Social functioning

The following social functioning variables were examined: marital status (i.e. being in a relationship (no=1, yes=2)), household composition (i.e. number of people living in the household, including oneself), social network size (number of people one has contact with over a period of two weeks (small=1, large=2)), social activity (i.e. involvement in activities where one meets other people (very low=1, low=2, medium=3, high=4)^{30,31}, quality of social relationships (i.e. appreciation of ones relationship with other people (very poor=1, poor=2, fair=3, good=4))^{30,31}, social support (i.e. perceived support from partner, family, work, and friends (very poor=1, poor=2, fair=3, good=4))^{30,31}, and feelings of affection, behavioral confirmation, and status (i.e. subscales of social well-being of the Social Production Function Instrument Measuring Level of Need Satisfaction (SPF-IL)^{32,33}), higher scores indicate better social well-being, with a possible range on each scale of 3-12). The questions regarding social activity, quality of social relationships, and social support were derived from the social domain of the INTERMED for the Elderly Self-Assessment (IM-E-SA), which has been shown to be a valid and reliable tool for the assessment of health care needs in elderly populations^{30,31}. The SPF-IL has been shown to be a valid and reliable instrument for the assessment of social well-being³². Details of the social functioning variables can be found in Supplemental material A and in the online LifeLines data catalogue at [www.lifelines.net].

Covariates

Age, gender, education level, lifestyle characteristics and depression were taken into account as covariates based on their association with social and cognitive functioning. Educational level was categorized as low, middle and higher education level. Lifestyle variables included physical activity, alcohol use, and smoking status. Physical activity was measured with the Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH)³⁴ and was dichotomized (no/yes) as complying with the Dutch Standard for Healthy Exercise (i.e. adults 55 years and older, require at least thirty minutes of moderately intensive exercise at least five days a week³⁵). Alcohol use was measured with the first two questions of the Alcohol Use Disorder Identification Test³⁶. We classified alcohol consumption into three categories; no drinking, moderate alcohol use and problematic alcohol use. Problematic alcohol use was defined as taking 5 or more units on a typical drinking day irrespective of the frequency of drinking, or 3 or more units on a typical drinking day at least 4 or more days a week. Moderate alcohol use was defined as any alcohol use not being problematic use. Smoking status was defined as never smoker=1, past smoker=2, and current smoker=3. Depression was measured with the Mini International Neuropsychiatric Interview (MINI). The MINI is a valid and reliable semi-structured psychiatric interview among others assessing depressive disorder (no=0, yes=1)³⁷.

In order to describe the study sample, we report baseline information on ethnicity, number of cardiovascular conditions (i.e. diabetes mellitus, myocardial infarction, arrhythmia, heart failure, stroke, or high blood pressure) and difficulties in activities of daily living (ADL).

Statistical methods

First, characteristics of the study sample are described by displaying percentages for categorical variables, the mean (SD) for normally distributed continuous variables and the median (IQR) for not normally distributed continuous variables. Results are shown for the total sample and stratified by SMC group at baseline (i.e. no and yes).

With univariate logistic regression analyses the association between each predictor and covariate with incident SMC was assessed. In addition, interaction terms for age, gender, education level, depression, and each social functioning variable with each social functioning variable were calculated. Subsequently, multivariate logistic regression analysis was applied to examine the predictive value of each different measure of social functioning with incident SMC as the dependent variable, adjusted for age, gender, education level, physical activity, alcohol use, smoking status, and depression. This was repeated with SMC recovery as dependent variable.

Patterns of missing values were assessed and multiple imputations were applied, using the fully conditional specification approach³⁸. In total 12.451 (8%) out of a total of

151,861 values were missing and 4,677 cases (52%) had missing values on at least one variable. The number of missing values per variable ranged from 0% for age and gender to 37% for social activities. Therefore, 52 datasets were created with 10 iterations for each dataset³⁹. Using the outcome for imputation of missing predictor values has been shown to give more reliable results⁴⁰. Therefore, the imputation model included the nine determinant variables, the seven covariates, and the outcome. However, missing values on the outcome itself were not imputed, because this adds noise to the estimates^{39,41}. IBM SPSS statistics software version 22 was used for the statistical analysis. Significance levels were set at $p < 0.05$ and all tests were two-tailed.

RESULTS

Study sample

The LifeLines Cohort Study is an ongoing longitudinal cohort study. At the time of the follow-up measurement (approximately 1.5 years after the baseline measurement), data was available for 9,032 participants aged 65 years and older (72%) with a complete first follow-up assessment. Participants with a MMSE score < 26 ($n = 62$), missing values on the MMSE ($n = 37$), or missing values on the outcome (i.e. SMC at baseline ($n = 79$) or at follow-up ($n = 92$)), were excluded from data analyses, leaving 8,762 participants in our final dataset (see Figure 1).

Table 1 shows the baseline characteristics of the study population, stratified for the presence of SMC at baseline, with 55% ($n = 4,799$) of the participants reporting SMC. Differences between participants with and without SMC were small for all variables (i.e. $\leq 5\%$). However, participants with SMC are twice as often depressed (6%) compared to participants without SMC (3%) and they more often (63%) have one or more cardiovascular conditions compared to those without SMC (58%).

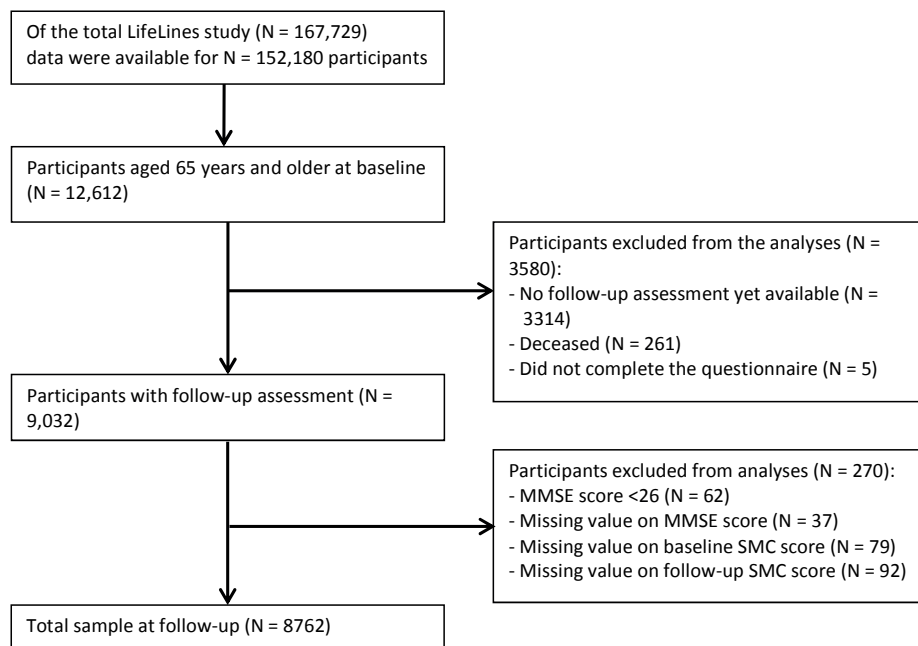


Figure 1. Study sample.

Table 1. Baseline characteristics of study sample^a.

	Total (N = 8762)	No SMC at baseline (N = 3963)	Yes SMC at baseline (N = 4799)
Characteristics	%	%	%
Age (yrs), mean (SD)	70 (4.4)	69 (4.1)	70 (4.5)
Gender (female)	52%	50%	54%
Education level ^b			
Low	58%	59%	58%
Middle	20%	20%	20%
High	22%	21%	22%
Marital status (in a relationship) ^b			
Yes	83%	86%	82%
No	17%	14%	18%
Household composition ^b , mean (SD)	1.83 (0.47)	1.86 (0.45)	1.81 (0.48)
Social network size ^b			
Small (0-5)	16%	16%	16%
Large (≥6)	84%	84%	84%
Social activity ^b			
Very low	10%	10%	11%
Low	41%	39%	43%
Medium	11%	12%	11%
High	37%	39%	35%
Quality of social relationships ^b			

Table 1. Baseline characteristics of study sample^a. (continued)

	Total (N = 8762)	No SMC at baseline (N = 3963)	Yes SMC at baseline (N = 4799)
Very poor	14%	15%	13%
Poor	1%	0%	1%
Fair	8%	6%	10%
Good	77%	79%	76%
Social support^b			
Very poor	3%	2%	3%
Poor	5%	5%	5%
Fair	6%	5%	7%
Good	86%	88%	85%
SPF-IL^b, mean (SD)			
Affection	9.35 (1.69)	9.51 (1.69)	9.21 (1.68)
Behavioral confirmation	9.26 (1.63)	9.45 (1.64)	9.10 (1.61)
Status	6.13 (1.68)	6.27 (1.73)	6.01 (1.63)
Complies with the norm of physical activity^b			
Yes	66%	66%	67%
No	34%	34%	33%
Alcohol use^b			
No alcohol use	21%	22%	20%
Moderate alcohol use	69%	68%	70%
Problematic alcohol use	10%	10%	10%
Smoking status^b			
Never smoker	39%	41%	37%
Past smoker	53%	51%	55%
Current smoker	8%	8%	8%
Depression^b			
No depression	96%	97%	94%
Depression	4%	3%	6%
Ethnicity			
Dutch	96%	96%	96%
Other	4%	4%	4%
Number of cardiovascular conditions^c			
No condition	40%	42%	37%
1 condition	38%	37%	39%
2 conditions	18%	17%	19%
≥3 conditions	5%	4%	5%
Number of difficulties in ADL			
No difficulties	99%	99%	99%
≥1 difficulty	1%	1%	1%
SMC at follow-up			
No	58%	87%	34%
Yes	42%	13%	66%

SMC: subjective memory complaints; SD: standard deviation; SPF-IL: Social Production Function Instrument Measuring Level of Need Satisfaction; ADL: activities of daily living.

^aThe percentage is reported, unless otherwise indicated.

^bMissings are imputed.

^cDiabetes mellitus, myocardial infarction, arrhythmia, heart failure, stroke, or high blood pressure.

Social functioning as predictor for incident SMC

In total, 514 out 3.963 (13%) participants had incident SMC at follow-up. The results of the uni- and multivariate logistic regression analyses are presented in Table 2. No statistically significant interaction terms were found and were therefore not included in the table. In general, the results of the uni- and multivariate logistic regression analyses did not differ at lot. In addition, the association between covariates and incident SMC remained the same after including any social functioning variable to the multivariate model. A statistically significant association was found in the multivariate analyses between the two subscales affection and behavioral confirmation of the SPF-IL questionnaire and incident SMC (OR: 0.93; 95% CI: 0.88-0.98, and OR: 0.93; 95% CI: 0.88-0.99, respectively). Based on the multivariate logistic regression analyses, we found that (older) age increases the odds of incident SMC.

Social functioning as predictor for SMC recovery

In total, 1.632 out 4.799 (34%) participants recovered from SMC at follow-up. The results of the uni- and multivariate logistic regression analyses are presented in Table 3. No statistically significant interaction terms were found and were therefore not included in the table. Several social functioning factors were found to be associated with SMC recovery in the multivariate analyses, including being in a relationship (OR: 1.24; 95% CI: 1.04-1.47), household composition (OR: 1.26; 95% CI: 1.10-1.45), and affection, behavioral confirmation, and status (SPF-IL subscales) (OR: 1.09; 95% CI: 1.05-1.13, OR: 1.16; 95% CI: 1.11-1.21, and OR: 1.05; 95% CI: 1.01-1.10, respectively). With exception of social network size, the results of the uni- and multivariate logistic regression analyses were almost equal. In addition, the association between covariates and incident SMC remained the same after including any social functioning variable to the multivariate model. Based on the multivariate logistic regression analyses, we found that (older) age and having a depression decreases the odds of SMC recovery.

Table 2. Univariate and multivariate logistic regression analysis of the association of baseline social functioning with incident SMC (514 out of 3.963 participants developed incident SMC after 1.5 year follow-up).

	Univariate		Multivariate	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Covariates^a				
Age	1.04 (1.02-1.06)	<0.01	1.04 (1.02-1.06)	<0.01
Gender (reference male)				
Female	0.83 (0.69-1.00)	0.05	0.87 (0.71-1.07)	0.19
Education level (reference high)				
Low	0.93 (0.73-1.18)	0.55	0.94 (0.73-1.22)	0.66
Middle	1.13 (0.85-1.51)	0.41	1.14 (0.85-1.53)	0.39
Physical activity^b (reference yes)				
No	1.13 (0.93-1.38)	0.21	1.15 (0.94-1.40)	0.18
Alcohol use (reference no)				
Moderate alcohol use	1.08 (0.85-1.36)	0.53	1.11 (0.87-1.42)	0.42
Problematic alcohol use	1.17 (0.83-1.66)	0.38	1.19 (0.81-1.73)	0.38
Smoking status (reference never)				
Past smoker	1.07 (0.88-1.30)	0.48	1.00 (0.82-1.24)	0.97
Current smoker	1.07 (0.74-1.55)	0.71	1.03 (0.71-1.50)	0.89
Depression (reference no)				
Yes	1.27 (0.74-2.20)	0.39	1.35 (0.78-2.34)	0.29
Predictors in separate logistic regression analyses adjusted for covariates above^c				
Marital status (in a relationship; reference yes)				
No	0.88 (0.67-1.16)	0.37	0.87 (0.65-1.16)	0.34
Household composition	1.12 (0.92-1.38)	0.27	1.15 (0.93-1.42)	0.20
Social network size (reference ≥6)				
0-5	1.23 (0.97-1.57)	0.09	1.24 (0.97-1.58)	0.09
Social activity (reference high)				
Very low	0.96 (0.54-1.72)	0.89	0.92 (0.50-1.69)	0.78
Low	1.01 (0.66-1.54)	0.97	0.99 (0.64-1.55)	0.98
Medium	0.76 (0.40-1.44)	0.40	0.73 (0.38-1.41)	0.35
Quality of social relationships^d (reference yes)				
No	1.05 (0.39-2.82)	0.92	1.04 (0.37-2.94)	0.94
Social support^e (reference yes)				
No	1.23 (0.50-3.02)	0.64	1.27 (0.49-3.31)	0.63
SPF-IL				
Affection	0.92 (0.88-0.98)	<0.01	0.93 (0.88-0.98)	0.01
Behavioral confirmation	0.93 (0.88-0.98)	0.01	0.93 (0.88-0.99)	0.02
Status	0.96 (0.91-1.02)	0.17	0.95 (0.89-1.00)	0.07

SMC: subjective memory complaints; OR; odds ratio; CI: confidence interval; SPF-IL: Social Production Function Instrument Measuring Level of Need Satisfaction.

^a Adjusted in the multivariate mode for all other covariates, but not for social functioning variables.

^b Complies with the norm of at least thirty minutes of moderately intensive exercise at least five days a week.

^c Adjusted for all covariates but not for other social functioning variables.

^d I have enough contacts with other people and can get along well with them.

^e I get enough support.

Table 3. Univariate and multivariate logistic regression analysis of the association of baseline social functioning with SMC recovery (1.632 out of 4.799 participants recovered from SMC after 1.5 year follow-up).

	Univariate		Multivariate	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Covariates^a				
Age	0.98 (0.97-0.99)	0.01	0.98 (0.97-0.99)	<0.01
Gender (reference male)				
Female	1.03 (0.92-1.17)	0.58	0.99 (0.86-1.13)	0.84
Education level (reference high)				
Low	1.10 (0.94-1.28)	0.23	1.12 (0.95-1.32)	0.16
Middle	0.95 (0.78-1.15)	0.60	0.95 (0.78-1.16)	0.64
Physical activity^b (reference yes)				
No	1.07 (0.94-1.22)	0.31	1.07 (0.93-1.22)	0.34
Alcohol use (reference no)				
Moderate alcohol use	0.91 (0.78-1.06)	0.22	0.89 (0.76-1.04)	0.15
Problematic alcohol use	0.87 (0.69-1.09)	0.22	0.85 (0.66-1.10)	0.22
Smoking status (reference never)				
Past smoker	0.97 (0.85-1.10)	0.58	0.97 (0.84-1.11)	0.62
Current smoker	0.87 (0.69-1.11)	0.27	0.87 (0.67-1.12)	0.27
Depression (reference no)				
Yes	0.54 (0.39-0.74)	<0.01	0.52 (0.37-0.72)	<0.01
Predictors in separate logistic regression analyses adjusted for covariates above^c				
Marital status (in a relationship; reference no)				
Yes	1.25 (1.07-1.47)	0.01	1.24 (1.04-1.47)	0.02
Household composition	1.26 (1.11-1.44)	<0.01	1.26 (1.10-1.45)	<0.01
Social network size (reference 0-5)				
≥6	1.21 (1.02-1.43)	0.03	1.16 (0.98-1.38)	0.10
Social activity (reference very low)				
Low	1.09 (0.78-1.52)	0.61	1.08 (0.75-1.55)	0.68
Medium	1.14 (0.58-2.23)	0.70	1.15 (0.56-2.35)	0.71
High	1.27 (0.85-1.89)	0.25	1.25 (0.81-1.94)	0.31
Quality of social relationships^d (reference no)				
Yes	1.19 (0.58-2.47)	0.63	1.14 (0.52-2.49)	0.74
Social support^e (reference no)				
Yes	1.39 (0.65-2.98)	0.40	1.28 (0.57-2.87)	0.55
SPF-IL				
Affection	1.11 (1.07-1.15)	<0.01	1.09 (1.05-1.13)	<0.01
Behavioral confirmation	1.18 (1.13-1.22)	<0.01	1.16 (1.11-1.21)	<0.01
Status	1.05 (1.01-1.09)	0.02	1.05 (1.01-1.10)	0.01

SMC: subjective memory complaints; OR; odds ratio; CI: confidence interval; SPF-IL: Social Production Function Instrument Measuring Level of Need Satisfaction.

^a Adjusted in the multivariate mode for all other covariates, but not for social functioning variables.

^b Complies with the norm of at least thirty minutes of moderately intensive exercise at least five days a week.

^c Adjusted for all covariates but not for other social functioning variables.

^d I have enough contacts with other people and can get along well with them.

^e I get enough support.

DISCUSSION

Our study shows that various aspects of social functioning are associated with change in SMC over time. People with better feelings of affection and behavioral confirmation reported less often SMC during follow-up (incident SMC). People who are in a relationship, live in a larger household, and have better feelings of affection, behavioral confirmation, and status reported more often SMC recovery. Remarkably, affection and behavioral confirmation of the SPF-IL questionnaire are the most consistent predictors with regard to SMC.

One of the hypotheses to explain the association between social functioning and SMC is the *stress-buffering hypothesis*, which suggests that a supportive social environment prevents or modulates negative responses to stressful events⁴². Stress has been associated with cognitive decline and the development of Alzheimer's disease due to structural changes in the hippocampus⁴³. It is known that better feelings of affection and behavioral confirmation are both related to better subjective well-being, including higher levels of life satisfaction. Furthermore, better feelings of behavioral confirmation are positively related to positive affect (i.e. feeling excited, enthusiastic, alert, inspired), and negatively to negative affect (i.e. feeling sad, upset, afraid, nervous, scared)³³. Affection, behavioral confirmation, and status are considered three basic human social needs in life, and the lack of fulfillment of these needs causes stress⁴⁴. Therefore, better feelings of affection and behavioral confirmation may lead to a more positive appraisal of a situation, thereby reducing stress and preventing a negative subjective evaluation of one's memory. Another theory explaining the association between social functioning and SMC is the *cognitive reserve theory*, which suggests that stimulating environments can build resilience to cognitive ageing⁴⁵. The concept of cognitive reserve suggests that social interaction affects brain structure and results in more efficient use of brain networks⁴⁵. As a result, people may also report less memory complaints. Both the structure of the social network (i.e. being in a relationship and living in a larger household) and a good appraisal of the quality of social network (better feelings of affection and behavioral confirmation) could contribute to a stimulating and active environment, and thereby explain the higher odds of SMC recovery found in the present study.

Our study has contributed on various aspects to the current knowledge in the literature. Firstly, to our knowledge, this is the first study that not only investigated the association between social functioning and incident SMC, but also SMC recovery. This provides relevant information which can be used for developing prevention strategies for SMC and possibly the earliest stages of dementia. Only one other study investigated the longitudinal relation between social functioning and incident SMC and found only an

association between the frequency of visiting activities of organizations and SMC at three year follow-up¹³. This could indicate that only specific types of social activities may be related to SMC. In our study, social activity was measured as an overall variable of social activity including various aspects (e.g. (volunteer) work, study/courses, shopping, exercise/sports, visiting people or being visited). Studies often apply an overall measure of social activity, including multiple aspects in one variable (e.g.^{12,26}). Future research should investigate whether specific social activities are associated with SMC. Our study did not find associations in the opposite direction (i.e. higher levels of social activity are associated with higher risk of SMC), as was hypothesized by Trouton et al. (2006)²⁴.

Besides demographic variables such as older age, female sex and lower education level, depression is found to be one of the strongest predictors of SMC^{1,2}. Previous research has shown that depression is also associated with worse social functioning⁴⁶. As depression is associated with both SMC and social functioning, depression is an important potential confounder in the association between social functioning and SMC. Although we found a positive association between depression and SMC recovery, the association between social functioning and SMC remains present and of the same magnitude after controlling our analyses for depression. Furthermore, the interaction between depression and the various social functioning variables were not statistically significant, indicating that the association between social functioning and SMC is independent of depression.

Our study has several strengths. First, we included a large sample of older adults, broadly representative for the population of the North of the Netherlands⁴⁷. Second, whereas other studies only included a few social functioning aspects in relation to SMC^{12,13,24–26}, we investigated a broad range of social functioning aspects, which gives more insight into what aspects of social functioning are important in relation with SMC. Third, we applied a longitudinal study design, which minimizes the risk of reverse causation between SMC and social functioning. In addition, as we selected participants with relatively good cognitive functioning (MMSE score ≥ 26), the likelihood that the baseline assessments of social functioning is influenced by impaired baseline cognition (measurement error) is small.

Our study has also some limitations. Firstly, our follow-up period of 1.5 year might be too short to find strong effects. Second, a relatively high proportion of 55% of our sample reported SMC at baseline. Although this percentage is not uncommon compared to other population based studies who used the same question¹, two aspects should be considered. Firstly, we dichotomized our answer categories (no, sometimes, yes) into “sometimes” and “yes”, versus “no” as only a small percentage of the participants

answered “yes” (4% at baseline; 2% at follow-up). Others, for example, have applied four answer categories and dichotomized between “no” and “sometimes but is no problem”, versus “yes, is a problem” and “yes, it is a serious problem”⁴⁸. Secondly, we used a single question in the assessment of SMC. Participants might have interpreted the question differently. For example, some participants may think of someone’s memory complaints (e.g. a recently forgotten appointment), whereas others may think of someone’s current memory ability (e.g. a recent memory success). Although a single question is the most frequently used way to assess SMC in the literature^{1,11,49}, the advantage of using long multi-item questionnaires is that it will give more insight in the severity and the content of the memory complaints, and also yields larger effect sizes compared to short subjective memory measures (i.e. 10 items or viewer)^{1,10}. For future research, a more extensive validated questionnaire and a clear definition of SMC is recommended⁴⁹. Furthermore, it should be mentioned that in the LifeLines Cohort Study, two out of the three original items of the behavioral confirmation subscale of the SPF-IL questionnaire were slightly adapted compared to the original behavioral confirmation items. Particularly among older adults (aged 65 years and over), including these two original items resulted in many missing values and relatively poor psychometric properties (Cronbach’s alpha: 0.58³³). Therefore, the original items (“do people find you reliable?” and “do you feel useful to others?”) were adapted to: “When you are at school, at work, with family, at an association or in church, do you feel like you belong?” and “Do others appreciate the things you do?” (see Supplemental material A), which resulted in better psychometric properties (Cronbach’s alpha: 0.76) (personal communication N. Steverink).

In summary, our results show that worse social functioning is associated with incident SMC and that better social functioning is associated with SMC recovery over a follow-up period of 1.5 years. Improving one’s social functioning could be an important tool to reduce memory complaints. Our findings may have implications for clinical practice in an ageing population, and contribute to the development of SMC and dementia prevention strategies in its earliest stages. As a next step, large-scale randomized controlled trials are needed to investigate whether improvements in social functioning can delay the onset of SMC.

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Supplemental material A. Social functioning assessment.

Social functioning variable	Question	Possible responses	Categories used in the analyses
Marital status	"What is your marital status?"	<ol style="list-style-type: none"> 1) Married/registered partnership 2) Cohabiting 3) Single 4) Widow/widower 5) Divorced 6) Other 7) In a serious relationship, not cohabiting Continuous variable	Being in a relationship <ol style="list-style-type: none"> 1) No (responses 3, 4, or 5) 2) Yes (responses 1, 2, or 7)
Household composition	"How many people live in your home, including yourself? NB: this concerns the place where you live most days of the week"	Continuous variable	Original responses
Social network size	"With on average how many different people do you have contact over a period of two weeks?"	Continuous variable	<ol style="list-style-type: none"> 1) Small (0 to 5 contacts) 2) Large (≥ 6 contacts)
Social activity	"Are you involved in activities where you meet where other people, such as (voluntary) work, study/courses, shopping, exercise/sports, visiting people or being visited by people?"	<ol style="list-style-type: none"> 1) I am engaged in (almost) no activities during which I meet other people 2) I am usually engaged in the same activity, during which I always meet the same people 3) I am engaged in a different activity every week, during which I meet quite a few people 4) I am engaged in several activities per week, during which I meet many people 	Original responses renamed as: <ol style="list-style-type: none"> 1) Very low 2) Low 3) Medium 4) High

Supplemental material A. Social functioning assessment. (continued)

Social functioning variable	Question	Possible responses	Categories used in the analyses
Quality of social relationships	"How is your relationship with other people?"	<ol style="list-style-type: none"> 1) Contacts with other people or friendships often end in fights; I feel miserable because of that, and sometimes lonely 2) I did not succeed in establishing or maintaining contacts or friendships 3) I have contact with other people, but sometimes there is tension between us 4) I have enough contacts with other people and can get along well with them 	<p>Original responses renamed as:</p> <ol style="list-style-type: none"> 1) Very poor 2) Poor 3) Fair 4) Good <p>Subsequently, due to the commonly answered fourth option (77%), we dichotomized this variable into "I have enough contacts with other people and can get along well with them"</p> <ol style="list-style-type: none"> 1) no (responses 1 through 3) 2) yes (response 4).
Social support	"How do you feel about the support from your partner, family, work, friends?"	<ol style="list-style-type: none"> 1) I get far too little support 2) I need more support 3) I need a little more support 4) I get enough support 	<p>Original responses renamed as:</p> <ol style="list-style-type: none"> 1) Very poor 2) Poor 3) Fair 4) Good <p>Subsequently, due to the commonly answered fourth option (86%), we dichotomized this variable into "I get enough support"</p> <ol style="list-style-type: none"> 1) no (responses 1 through 3), 2) yes (response 4).
SPF-IL affection subscale <i>The SPF-IL affection subscale represents the concept of the love one gets for who one is as a person, regardless of one's assets or actions</i>	<p>"Do people pay attention to you?"</p> <p>"Do people help you if you have a problem?"</p> <p>"Do you feel that people really love you?"</p>	<ol style="list-style-type: none"> 1) Never 2) Sometimes 3) Often 4) Always 	<p>Sumscore of the responses on the three questions. Possible range: 3-12.</p>

Supplemental material A. Social functioning assessment. (continued)

Social functioning variable	Question	Possible responses	Categories used in the analyses
SPF-IL behavioral confirmation subscale <i>The SPF-IL behavioral confirmation subscale represents the concept of the feeling to have done "the right thing" in the eyes of relevant others.</i>	"There are situations in which we deal with groups of people, for example at home, at work or during our leisure time. Do others appreciate your role in the group?" "When you are at school, at work, with family, at an association or in church, do you feel like you belong?" "Do others appreciate the things you do?"	1) Never 2) Sometimes 3) Often 4) Always	Sumscore of the responses on the three questions. Possible range: 3-12.
SPF-IL status subscale <i>The SPF-IL status subscale represents the concept of social approval given on the basis of the command over scarce resources relative to others (e.g. money and education).</i>	"Do people think you do better than others?" "Do people find you an influential person?" "Are you known for the things you have accomplished?"	1) Never 2) Sometimes 3) Often 4) Always	Sumscore of the responses on the three questions. Possible range: 3-12.

SPF-IL: Social Production Function Instrument Measuring Level of Need Satisfaction.

