Received: 5 October 2024 | Revised: 16 January 2025 | Accepted: 30 January 2025

DOI: 10.1002/dad2.70093

Alzheimer's & Dementia
Diagnosis, Assessment & Disease Monitoring

RESEARCH ARTICLE

Excessive sleep is associated with worse cognition, cognitive decline, and dementia in mild cognitive impairment

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Funding information
Vetenskapsrådet, Grant/Award Numbers: 2017-01613, 521-20138604, 2021-00178, 2021-01437

Abstract

INTRODUCTION: This study examines the link between daytime and nighttime excessive sleep and cognition, cognitive decline, and dementia in individuals with existing mild cognitive impairment (MCI).

METHODS: Using data from the Swedish longitudinal study Good Aging in Skåne, participants aged 60–102 years were retrospectively classified as MCI based on cognitive testing. The average follow-up time was 6.59 years. Mixed linear models assessed cross-sectional and longitudinal associations between excessive sleep patterns (napping ≥2 h or nighttime sleep ≥9 h) and multiple cognitive domains. Cox regressions estimated dementia risk for excessive sleep.

RESULTS: Of 4930 participants, 2052 (41%) had MCI. Excessive daytime napping and nighttime sleep were associated with worse cognition and cognitive decline. Excessive napping and nighttime sleep were also linked to higher dementia risk (hazard ratios: 1.75 and 1.86, respectively).

DISCUSSION: These findings suggest that excessive sleep in MCI is associated with further cognitive decline and dementia.

KEYWORDS
dementia, excessive napping, excessive sleep, long nighttime sleep, mild cognitive impairment, sleep duration

Highlights

- Excessive daytime napping and nighttime sleep are linked cognitive decline for those with MCI.
- Excessive sleep during the day or at night heighten dementia risk.
- Worse test scores across multiple cognitive domains were observed for excessive daytime nappers.
- Excessive sleep in MCI may be a warning sign for further cognitive decline.

1 | BACKGROUND

Emerging evidence shows that excessive sleep, both daytime napping and long nighttime sleep, is associated with worse cognition and cognitive decline across multiple cognitive domains and dementia onset in older adults.[1–4] Excessive sleeping patterns are common among those with mild cognitive impairment (MCI),[5] a major risk factor for dementia. Yet, research is limited whether excessive sleep leads to further cognitive decline in individuals with MCI. By improving sleeping habits in older adults already experiencing cognitive difficulties, further cognitive decline, including dementia onset, could be prevented.

Daytime napping has both been associated with positive cognitive outcomes and with an increased risk of cognitive decline and dementia.[4,6–9] Contradictions are partly due to variations in napping measures and duration, timing, frequency, nighttime sleep, intentionality, and cognitive status. Moreover, it remains uncertain whether excessive napping compensates for poor nighttime sleep or independently relates to cognitive impairment.[9] Subjective short or long nighttime sleep is similarly linked to worse memory, executive functioning, verbal fluency, perceptual speed, verbal short-term memory, and global cognition.[3,10–12] Short sleep is repeatedly linked to short-term and long-term negative cognitive outcomes; however, emerging evidence shows that excessive nighttime sleep is equally negatively associated.[3,13,14] Similarly, studies show worse cognition for individuals with excessive daytime napping but not for shorter daytime naps.[9,15,16] Therefore, sleeping excessively, irrespective of when during the 24-h day, could potentially serve as an indicator of cognitive deficits. While sleep disturbances increase the risk of cognitive impairment and dementia, the underlying mechanisms remain unclear. Current theories suggest a bidirectional relationship involving multiple factors. Neuronal degeneration in wake-promoting areas, tau tangles, and beta-amyloid accumulation, hallmarks of Alzheimer's disease, may play a role.[17,18] For instance, sleep disturbances, including excessive nighttime sleep, self-reported daytime sleepiness, and napping are associated with greater beta-amyloid accumulation.[19–21] Additionally, subclinical cerebrovascular disease could serve as an alternative explanation causing both sleep disturbances and other non-Alzheimer's dementias. Increased risk of vascular dementia is observed for individuals with daytime sleepiness, longer daytime naps, and disturbed sleep.[22–24] Individuals with amnestic MCI are at a higher risk for Alzheimer's, while those with non-amnestic MCI are prone to other dementias like vascular or Lewy bodies dementia. By linking MCI subtypes to excessive daytime or nighttime sleep, we can start to clarify whether excessive sleep is more related to memory-related or other forms of dementia.

Furthermore, studies indicate that cognitive function and sleep patterns vary with seasonal changes, with better cognitive performance, fewer dementia diagnoses, and less sleep occurring during lighter seasons.[25] Yet, the impact of seasonality on cognition and excessive sleep is rarely explored and warrants further investigation.

In this context, this work aims to investigate: (1) whether those with MCI and excessive sleep, including excessive daytime napping and excessive nighttime sleep, have worse cognition and faster cognitive decline in comparison to non-excessive sleepers and to inspect whether these associations are independent of health and lifestyle factors, insufficient nighttime sleep for excessive nappers, and seasonality; (2) potential patterns of cognitive impairment and decline for those with amnestic and non-amnestic MCI; and (3) risk of developing dementia for those with MCI and excessive sleep, examining daytime and nighttime sleep separately.

RESEARCH IN CONTEXT

1. **Systematic review**: A review of studies was conducted using databases EBSCOhost, including PubMed, to explore the relationship between excessive sleep patterns (daytime napping and nighttime sleep) and cognitive decline in mild cognitive impairment (MCI). Previous research links sleep disturbances with cognitive decline and dementia, but are limited in specifically addressing excessive sleep and cognition in those already experiencing cognitive impairment.
2. **Interpretation**: Our findings demonstrate that excessive daytime napping and excessive nighttime sleep are associated with worsened cognition and cognitive decline across several cognitive domains and an increased risk of dementia in individuals with MCI. These results add to the growing evidence that extreme sleep during the day and night may accelerate cognitive decline.
3. **Future directions**: Future research should investigate the underlying mechanisms linking excessive sleep with cognitive decline in MCI, such as neurodegenerative or cerebrovascular changes. Moreover, further studies are necessary to examine potential differences in nighttime and daytime sleep.

2 | METHODS

2.1 | Study population

Data were obtained from the "Good Aging in Skåne" (GÅS) study, which is a part of the larger "Swedish National Study on Aging and Care" (SNAC), ongoing since 2001.[26] The GÅS study includes individuals aged 60–102 years from five municipalities in southern Sweden, which are randomly selected from the Swedish population register. A new baseline cohort is added every sixth year. The participation rate ranges between 60% and 70%. Follow-up visits occur every third year for those aged 78 years and older, and every sixth year for those younger than 78 years.

Between 2001 and 2020, 5804 participants underwent baseline examinations using standardized procedures, including self-rated

questionnaires, cognitive testing directed by a trained test administer, and examinations by both physicians and nurses. The study received approval from the regional Ethics Committee of Lund University, and all participants provided written informed consent.

2.2 | Cognitive assessment

The cognitive testing procedure, detailed elsewhere,[27] involved 12 neuropsychological tests covering various cognitive domains. To assess cognitive levels, decline, and impairment for MCI diagnosis, five domains were examined. Memory was assessed with a 16-word recall and recognition test, and for MCI, additionally, a delayed five-item recall was used. Perceptual speed was measured using digit cancellation and pattern comparison tests. Verbal fluency was assessed through letter (A & F) and category (professions and animals) test. Executive functioning was measured using a modified Trail Making Test B (TMT-B) and digit span backwards. Global cognition was measured using the Mini-Mental State Examination (MMSE). Higher scores on all tests indicate better performance, except for TMT-B (time in seconds), where the opposite applies. To minimize re-test effects, three versions of the episodic memory, perceptual speed, and TMT-B tests were administered at each examination wave.

2.3 | MCI and dementia

MCI was determined using a modified version of the Mayo Clinic criteria, requiring cognitive impairment without dementia.[28,29] Objective impairment was assessed with cognitive testing, described above, and defined as one impaired test score, in at least one cognitive domain, indicated as below 7th percentile (1.5 SD below the mean) relative to a normative sample.[29] Further, two MCI subgroups were categorized, amnestic MCI, where the participant had at least one impaired test score in the memory domain and non-amnestic MCI, where there was least one impaired test score in the non-amnestic domains.

Dementia diagnosis was classified by the study physician according to the Diagnostic and Statistical Manual of Mental Disorders 4th edition,[30], supplemented by medical record reviews and Skåne Healthcare Register codes for Alzheimer's disease, mixed dementia, vascular dementia, Lewy body dementia, and frontotemporal dementia.

2.4 | Sleep parameters

Excessive daytime and nighttime sleep, respectively, were self-reported by questionnaire by the following two questions: (1) Do you feel tired and sleep for more than 2 h during the day? Yes or No (excessive daytime sleep); (2) On average, how many hours do you sleep per night? The answer was categorized as following: short sleep = < 6 h, normal sleep = 7–8 h, and long sleep = > 9 h (as per sleep recommendations for older adults).[31]

2.5 | Covariates

The following baseline covariates were considered: age, sex, years of education, cohabitation, retirement, use of hypnotics, depressive symptoms, physical activity, alcohol consumption, cardio- and cerebrovascular disease, hypertension, diabetes mellitus type I and II, and seasonality. Use of hypnotics (hypnotics as a necessity to sleep vs. not taking hypnotics to sleep), physical activity (active vs. sedentary), cohabitation (living with someone or not), and alcohol consumption (grams of alcohol per week) was self-reported using questionnaires. Retirement, years of education, and depressive symptoms were measured through interview by the test administrator. Depressive symptoms were assessed using the Montgomery Åsberg Depression Rating Scale.[32] Seasonality was defined by Sweden's light/dark periods: participants tested within 3 months of the lightest (June 21) or darkest (December 21) days were categorized accordingly.

Comorbidities, including hypertension, diabetes, and cardiovascular and cerebrovascular disease, were identified during the examination by the study physician. They were either self-reported, established through medical examination, or by reviewing medical records. To identify additional disease events and to fill in missing data, information from the Skåne Health Care Registry was implemented; in case of discrepancy between the study data and the registry, the study data was utilized. Cardiovascular and cerebrovascular disease included acute myocardial infarction, heart failure, ischemic heart disease, angina pectoris, presence of cardiac and vascular implants, heart failure, cardiac arrhythmias, cerebral infarction, nontraumatic intracranial hemorrhaged, occlusion, and stenosis of precerebral or cerebral arteries or transient cerebral ischemia.

2.6 | Statistical analyses

A series of linear mixed effects models, considering the dependency of repeated participant examinations, analyzed associations for excessive sleep and cognition. The main analyses included all types of MCI, and the sub-analyses were stratified for amnestic and non-amnestic MCI. Models were fit for each test score measuring either episodic memory, perceptual speed, verbal fluency, executive functioning, or global cognition, in combination with either excessive daytime napping or excessive nighttime sleep. To examine cross-sectional associations between excessive sleep and level of cognitive performance, baseline excessive daytime napping (yes or no)/hours of nighttime sleep (short sleep = < 6, normal sleep = 7–8, and long sleep = > 9) was included as a fixed effect. To examine longitudinal change cognition, a time-varying variable and excessive daytime/nighttime sleep interaction was included. Age, sex, education, test version, number of participant study-examinations, and the time between participant examinations (due to varying follow-ups for age groups) were included in the basic model. The fully adjusted model additionally included health covariates mentioned in Section 2.5. Models for excessive daytime napping were adjusted for nighttime sleep (≤ 5, 6–8, or ≥ 9 h of nighttime sleep),

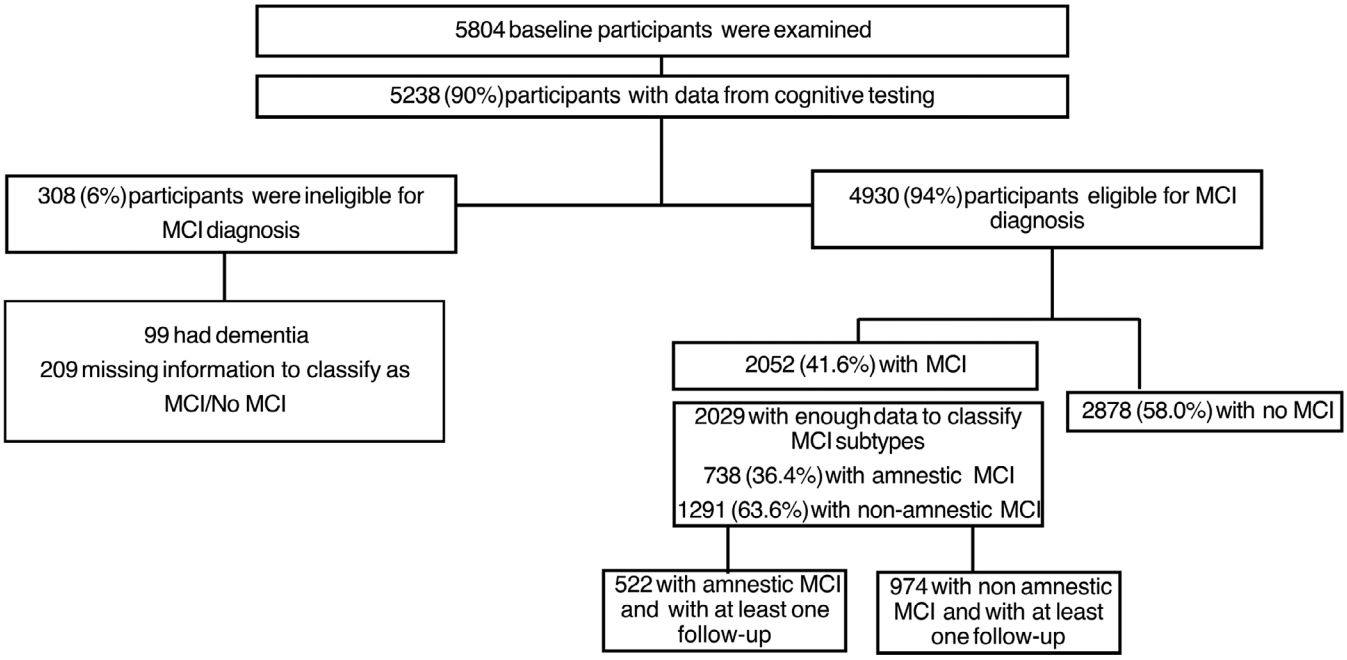

FIGURE 1 Flow chart of participant selection for mild cognitive impairment, drop-out, and eligibility for subtypes of mild cognitive impairment.

and an interaction between napping and nighttime sleep was included to inspect cognitive test performance for specific sleep groups, for example, excessive nappers with short nighttime sleep.

Risk of incident dementia for excessive daytime and nighttime sleep, respectively, was investigated using Cox proportional hazard regression models, with excessive sleep, sex, age, and education as explanatory variables. Dementia diagnosis was modeled as a time-varying covariate. Participants with baseline dementia were excluded. Restricted mean survival time (RMST) was used was used to estimate average time to event, which can provide robust estimates even with censored data.[33] Analyses included 2052 with MCI. All statistical analyses were two-sided, with $p = 0.05$ as the threshold for statistical significance. The statistical analyses were performed using SPSS 29. Plots and RMST for Cox regression were graphed in R using survminer package.

3 | RESULTS

Of the 5804 participants who were included in the study, a total of 4930 were eligible for MCI diagnosis, 2052 (41.6%) met the criteria for MCI, 738 (36.4%) were of the amnestic, and 1291 (63.6%) were of the non-amnestic type, see Figure 1. Out of those with MCI, 11.4% reported napping for 2 h or more during the day, and 8.28% reported sleeping for 9 h or more per night, whereas 30.1% reported sleeping for 6 h or less per night. The mean average time for follow-up for was 6.59 years for participants with MCI.

On inspection of the descriptives (Tables 1 and 2), excessive daytime nappers and excessive nighttime sleepers were older, less educated, used more hypnotics, had depressive symptoms, lived alone, retired, had diabetes, had a sedentary lifestyle, had cerebrovascular or cardiovascular disease, or had hypertension in comparison to those without excessive sleeping habits. Excessive nighttime sleepers seemed to consume less alcohol in comparison to those sleeping 7–8 h per night, whereas excessive daytime nappers consumed more in comparison to those without excessive napping. In addition, most of excessive nappers and non-excessive nappers reported sleeping for a normal duration at nighttime (6–8 h); however, the excessive napping group had a higher percentage of individuals reporting sleeping for shorter and longer durations at night. Both groups of excessive sleepers performed seemingly worse on all cognitive tests in comparison to non-excessive sleepers.

3.1 | Mixed models

3.1.1 | Excessive daytime napping

Table 3 presents the mixed linear model estimates for cross-sectional and longitudinal associations. Results presented in this section are contrasted to non-excessive daytime nappers. Napping for 2 or more hours during the day was significantly associated to worse performance across all cognitive domains: episodic memory, perceptual speed, verbal fluency, executive functioning, and global cognition. These associations remained significant after adjusting for health and lifestyle factors, with only slight reductions in effect sizes, except for perceptual speed (digit cancellation), which lost significance in fully adjusted models.

None of the beta-coefficient estimates for the interaction terms napping and nighttime sleep were significant.

Most associations from the main analyses persisted in the sub-analyses, showing worse cognition in multiple domains for both

TABLE 1 Baseline descriptives for MCI and excessive daytime napping

Parameter	MCI *N* = 2052		Amnestic MCI *N* = 738		Non-amnestic MCI *N* = 1291	
	Excessive nappers, *n* = 233	No excessive nappers, *n* = 1793	Excessive nappers, *n* = 87	No excessive nappers, *n* = 628	Excessive nappers, *n* = 136	No excessive nappers, *n* = 1136
Age, M (SD)	70.3 (11.3)	69.1 (9.83)	71.6 (12.3)	68.3 (9.17)	69.2 (9.83)	68.3 (6.69)
Sex, female, *n* (%)	116 (49.8)	981 (54.7)	43 (49.4)	330 (52.5)	63 (46.3)	629 (55.4)
Education, M (SD)	10.4 (4.18)	11.1 (4.04)	10.0 (3.93)	10.9 (3.91)	10.8 (4.36)	11.3 (4.07)
Average follow-up time in years, M (SD)	4.79 (4.78)	6.91 (5.32)	4.20 (4.82)	6.96 (5.39)	5.45 (4.81)	7.05 (5.24)
Hypnotic usage, *n* (%)						
Yes	60 (25%)	256 (14.3)	28 (32.2)	100 (15.9)	24 (17.6)	149 (12.1)
No	173 (75%)	1537 (83.7)	59 (67.8)	528 (84.1)	112 (82.4)	987 (86.9)
Depressive symptoms, *n* (%)						
Yes	11 (4.9)	27 (1.5)	6 (9.20)	10 (1.97)	4 (2.99)	17 (1.52)
No	210 (95.1)	1720 (98.5)	76 (90.8)	598 (98.3)	130 (97.1)	1103 (98.5)
Cohabitation, *n* (%)						
Yes	131 (56.2)	1105 (61.7)	42 (48.8)	370 (59.2)	82 (61.2)	724 (63.9)
No	101	685	44 (51.2)	255 (40.8)	52 (38.8)	409 (36.1)
Retired, *n* (%)						
Yes	149 (66.8)	984 (56.2)	75 (77.3)	396 (61.2)	91 (68.9)	607 (53.6)
No	74 (33.2)	767 (43.8)	22 (22.7)	251 (38.8)	41 (31.1)	525 (46.4)
Hypertension, *n* (%)						
Yes	101 (43.3)	591 (32.9)	45 (51.7)	198 (31.5)	84 (61.8)	198 (20.7)
No	132	1202	42 (48.3)	430 (68.4)	52 (38.8)	757 (79.3)
Cardiovascular or cerebrovascular disease, *n* (%)						
Yes	114 (48.9)	571 (32.8)	45 (51.7)	217 (34.6)	61 (44.9)	335 (29.5)
No	119 (51.1)	1222 (68.2)	42 (48.3)	411 (65.4)	75 (55.1)	801 (70.5)
Diabetes, *n* (%)						
Yes	39 (16.7)	162 (9.0)	19 (18.4)	57 (8.5)	21 (15.2)	110 (9.6)
No	194 (83.3)	1631 (91.0)	84 (81.6)	611 (91.5)	117 (84.8)	1034 (90.4)
Physically active, *n* (%)						
Yes	171 (73.4)	1577 (88.0)	64 (62.1)	555 (85.0)	106 (76.8)	1023 (89.6)
No, sedentary	62 (26.6)	215 (12.0)	39 (37.9)	100 (15.0)	32 (23.2)	119 (10.4)
Alcohol, grams per week, M (SD)	33.1 (87.5)	38.9 (69.8)	26.8 (83.2)	34.3 (60.9)	35.1 (103.7)	37.0 (79.5)
Nighttime sleep duration, hours, *n* (%)						
0–5	34 (14.6)	151 (8.4)	9 (10.3)	62 (9.9)	23 (16.9)	92 (8.19)
6–8	155 (66.5)	1512 (84.6)	59 (67.8)	516 (82.7)	92 (67.6)	958 (85.3)
9 +	44 (18.9)	125 (0.07)	19 (21.8)	46 (7.37)	21 (15.4)	73 (6.50)
Neuropsychological tests, M (SD)						
Episodic memory, M (SD)						
Free recall (0–16)	5.59 (2.60)	6.23 (2.48)	4.13 (2.55)	4.46 (2.06)	6.75 (2.04)	7.25 (2.12)
Recognition (0–16)	9.96 (3.47)	10.9 (3.37)	7.54 (3.50)	8.52 (3.52)	11.61 (2.44)	12.3 (2.43)
Perceptual speed, M (SD)						
Digit cancellation	15.36 (4.70)	16.8 (4.72)	15.2 (5.10)	16.9 (4.50)	15.2 (4.41)	16.8 (4.78)
Pattern comparison	11.62 (4.16)	13.38 (4.31)	10.1 (3.98)	13.3 (4.21)	11.9 (3.10)	13.4 (4.30)

(Continues)

TABLE 1 (Continued)

Parameter	MCI N = 2052		Amnestic MCI N = 738		Non-amnestic MCI N = 1291	
	Excessive nappers, n = 233	No excessive nappers, n = 1793	Excessive nappers, n = 87	No excessive nappers, n = 628	Excessive nappers, n = 136	No excessive nappers, n = 1136
Verbal fluency, M (SD)						
Categories	13.3 (5.19)	15.9 (5.21)	12.5 (5.23)	15.9 (5.32)	13.9 (4.95)	16.14 (5.14)
Letters	9.15 (4.53)	10.9 (4.61)	8.63 (3.91)	10.8 (4.69)	9.45 (4.75)	11.1 (4.55)
Executive functioning, M (SD)						
Digit span backward	4.16 (1.68)	4.70 (1.87)	3.88 (1.60)	4.94 (1.80)	4.36 (1.76)	4.63 (1.93)
Trail Making Test B	42.9 (35.3)	34.1 (24.9)	48.9 (49.45)	32.6 (21.9)	40.3 (24.9)	34.7 (25.7)
Global cognitive function, M (SD)						
MMSE	24.8 (3.76)	26.3 (2.96)	24.0 (3.82)	26.3 (2.75)	26.0 (3.32)	26.6 (2.67)

Abbreviations: MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination.

amnestic and non-amnestic MCI subtypes (Table 4). However, no significant differences were found in the recognition test for either MCI subtype. Moreover, amnestic excessive nappers showed worse performance on executive functioning and global cognition, whereas this was not observed for non-amnestic MCI. Finally, poorer performance was not observed for digit cancellation in the amnestic group.

Excessive nappers showed faster decline in episodic memory (word recall), observed for both amnestic and non-amnestic MCI subtypes. However, for amnestic MCI, this association lost significance in the fully adjusted model ($p = 0.081$). Additionally, the sub-analysis revealed a new longitudinal association, with non-amnestic nappers showing a decline in global cognition. Moreover, amnestic excessive nappers performed better over time on the word fluency test compared to non-excessive amnestic nappers.

3.1.2 | Excessive nighttime sleep

Table 3 presents the mixed linear model estimates for cross-sectional and longitudinal associations in individuals with MCI and excessive nighttime sleep (≥9 h). All results presented below are contrasted with those who report sleeping 7–8 h per night (normal sleepers). In the main analyses, worse performance on the executive functioning test TMT-B, the perceptual speed test digit cancellation, and global cognition (MMSE) was observed for excessive nighttime sleepers. No other significant associations with worse performance were found. Faster decline for excessive nighttime sleepers was observed for performance on verbal fluency categories and global functioning. Significant cross-sectional and longitudinal results remained after adjusting for covariates.

No significant cross-sectional or longitudinal differences were detected for cognitive performance for those with baseline short nighttime sleep versus normal nighttime sleep (data not shown). Neither amnestic nor non-amnestic excessive nighttime sleepers performed worse on TMT-B on global functioning as in the main analyses (Table 4). The perceptual speed association was only seen in the amnestic MCI group. Sub-analyses revealed that the steeper decline in global functioning (MMSE) was driven by the non-amnestic group, while faster decline in verbal fluency (categories) only occurred in amnestic MCI. New findings showed non-amnestic excessive nighttime sleepers performed significantly better on memory recognition but had a steeper decline in executive functioning.

3.2 | Risk of dementia

The mean expected time to dementia was 8.15 and 9.35 years for excessive nappers and non-excessive nappers, respectively. Nineteen of 245 (7.8%) with MCI and who reported sleeping ≥2 h during the day were later diagnosed with dementia and 119 of 1851 (6.4%) with MCI who did not report excessive daytime napping were later diagnosed with dementia. Excessive nappers had a higher hazard ratio (HR) 1.75 (95% confidence interval [CI]: 1.07–2.88), $p < 0.05$ of being diagnosed with dementia compared to those reporting no excessive napping. Twenty-two of 181 (12.2%) with MCI and reported to sleep for 9 h or more per night were later diagnosed with dementia, whereas 78/1283 (6.1%) with MCI who reported sleeping for 7–8 h later developed dementia. Those reporting sleeping for 9 h or longer per night had a higher HR 1.86 (95% CI: 1.15–3.02) for developing dementia compared to those reporting sleeping 7–8 h per night. See Figure 2A and 2B for visual plots of risk for dementia.

4 | DISCUSSION

Our results show an associative pattern for worse cognition and cognitive decline in multiple domains and heightened risk for dementia for individuals with MCI reporting excessive sleeping. Generally, excessive daytime napping was cross-sectionally associated with all cognitive domains and some longitudinal associations were observed for

TABLE 2 Descriptives for MCI and excessive nighttime sleep

Parameter	MCI, *N* = 2052			Amnestic MCI, *N* = 738			Non-amnestic MCI, *N* = 1291		
	Short sleep, *n* = 618	Normal sleep, *n* = 1240	Long sleep, *n* = 170	Short sleep *n* = 239	Normal sleep, *n* = 414	Long sleep, *n* = 66	Short sleep, *n* = 381	Normal sleep, *n* = 798	Long sleep, *n* = 94
Age, M (SD)	67.9 (9.87)	67.3 (9.47)	74.1 (11.6)	68.5 (10.1)	67.9 (9.91)	74.1 (11.5)	67.4 (9.62)	66.4 (8.71)	72.4 (10.9)
Sex, female, *n* (%)	359 (58.0)	640 (51.6)	99 (58.2)	134 (56.0)	213 (51.4)	40 (60.6)	225 (59.1)	416 (52.1)	52 (55.3)
Education, years, M (SD)	10.8 (4.03)	11.3 (4.11)	9.74 (3.64)	10.7 (3.97)	11.0 (3.86)	10.1 (4.18)	10.9 (4.11)	11.5 (4.14)	10.2 (3.59)
Average follow-up time in years, M (SD)	6.37 (5.17)	7.01 (5.36)	5.26 (5.07)	6.35 (5.37)	6.98 (5.46)	4.90 (4.87)	6.57 (4.95)	7.14 (5.32)	5.71 (5.26)
Hypnotics, *n* (%)									
Yes	139 (29.0)	143 (13.0)	32 (18.8)	59 (24.7)	57 (12.3)	13 (19.6)	79 (20.7)	80 (10.0)	14 (14.9)
No	479 (71.0)	1097 (87%)	138 (81.2)	180 (75.3)	357 (86.2)	53 (80.4)	302 (79.3)	718 (90.0)	80 (75.1)
Depressive symptoms, *n* (%)									
Yes	14 (2.33)	19 (1.58)	5 (3.05)	7 (3.04)	6 (1.50)	3 (4.62)	8 (2.13)	12 (1.50)	1 (1.10)
No	587 (97.67)	1186 (74.2)	159 (96.9	223 (96.0	393 (98.5)	62 (95.4)	368 (97.9)	776 (98.5)	90 (98.9)
Cohabitation, *n* (%)									
Yes	339 (55.1)	810 (65.4)	86 (51.2)	129 (54.9)	255 (61.6)	30 (46.9)	209 (55.1)	541 (68.1)	54 (58.1)
No	276 (44.9)	429 (34.6)	82 (48.8)	106 (55.1)	159 (38.4)	34 (53.1)	170 (44.8)	253 (31.9)	39 (41.9)
Retired, *n* (%)									
Yes	357 (57.8)	666 (54.3)	139 (83.2)	147 (57.4)	232 (57.6)	51 (78.5)	205 (54.2)	410 (52.0)	75 (83.3)
No	261 (42.2)	560 (45.2)	28 (16.8)	88 (37.4)	171 (42.4)	14 (21.5)	173 (45.8)	378 (48.0)	15 (16.7)
Hypertension, *n* (%)									
Yes	224 (36.2)	406 (32.7)	65 (38.2)	79 (33.1)	138 (33.3)	30 (45.4)	142 (37.3)	257 (32.3)	34 (36.2)
No	394 (63.8)	834 (77.3)	105 (42.8)	160 (76.9)	276 (66.7)	36 (54.6)	239 (62.7)	541 (67.7)	60 (43.8)
Alcohol, grams per week, M (SD)	31.7 (64.3)	38.1 (81.1)	27.5 (74.8)	34.4 (68.8)	38.1 (67.8)	22.5 (39.9)	31.4 (62.3)	40.4 (89.8)	31.3 (92.1)
Cardiovascular or cerebrovascular disease, *n* (%)									
Yes	216 (34.9)	389 (31.4)	83 (48.8)	95 (39.7)	137 (33.1)	34 (51.1)	124 (32.8)	235 (29.4)	39 (41.5)
No	402 (65.1)	851 (68.6)	87 (51.2)	144 (60.3)	277 (76.9)	32 (48.9)	257 (77.2)	563 (70.6)	55 (58.5)
Diabetes, *n* (%)									
Yes	81 (12.9)	104 (8.3)	22 (12.6)	26 (10.9)	49 (9.7)	7 (10.6)	55 (14.4)	60 (7.5)	13 (13.8)
No	546 (87.1)	1156 (91.7)	153 (87.4)	213 (89.1)	374 (90.3)	59 (89.2)	326 (85.6)	738 (92.5)	81 (86.2)
Physically active, *n* (%)									
Yes	532 (86.2)	1082 (87.4)	134 (79.3)	198 (84.3)	355 (86.0)	46 (70.8)	337 (88.5)	704 (88.7)	79 (84.0)
No, sedentary	85 (13.8)	156 (12.6)	35 (20.7)	37 (15.7)	58 (14.0)	19 (29.2)	44 (11.5)	90 (11.3)	15 (16.0)
Neuropsychological tests, M (SD)									
Episodic memory, M (SD)									
Free recall (0–16)	6.10 (2.58)	6.27 (2.45)	5.48 (2.48)	4.17 (1.98)	4.58 (2.14)	4.40 (2.45)	7.31 (2.15)	7.19 (2.10)	6.67 (2.07)
Recognition (0–16)	10.9 (3.41)	10.9 (3.35)	10.1 (3.69)	8.27 (3.47)	4.58 (2.14)	7.37 (3.40)	12.4 (2.37)	12.1 (2.48)	12.2 (2.39)
Perceptual speed, M (SD)									
Digit cancellation	16.8 (4.78)	16.8 (4.69)	14.7 (4.64)	16.8 (4.23)	17.1 (4.75)	14.8 (4.33)	16.8 (5.02)	16.7 (4.60)	14.9 (5.04)
Pattern comparison	12.9 (4.14)	13.48 (4.27)	11.6 (5.10)	12.7 (3.62)	13.4 (4.34)	11.8 (5.39)	13.2 (3.35)	13.5 (4.17)	11.6 (4.82)
Verbal fluency, M (SD)									
Categories	15.5 (5.19)	15.9 (5.29)	14.2 (5.28)	15.3 (5.24)	15.8 (5.46)	14.4 (5.7)	15.7 (5.06)	16.1 (5.22)	14.6 (5.04)
Letters	10.7 (4.94)	10.8 (4.45)	9.83 (4.78)	10.3 (4.66)	10.7 (4.62)	10.2 (4.93)	10.9 (5.03)	10.9 (4.35)	14.6 (5.03)

(Continues)

TABLE 2 (Continued)

Parameter	MCI, *N* = 2052			Amnestic MCI, *N* = 738			Non-amnestic MCI, *N* = 1291		
	Short sleep, *n* = 618	Normal sleep, *n* = 1240	Long sleep, *n* = 170	Short sleep *n* = 239	Normal sleep, *n* = 414	Long sleep, *n* = 66	Short sleep, *n* = 381	Normal sleep, *n* = 798	Long sleep, *n* = 94
Executive Functioning, M (SD)									
Digit span backwards	4.56 (1.86)	4.72 (1.83)	4.35 (1.93)	4.57 (1.88)	4.97 (1.77)	4.55 (1.81)	4.55 (1.93)	4.63 (1.86)	4.55 (2.13)
Trail making test B	35.9 (27.0)	33.2 (23.3)	48.2 (42.8)	37.9 (31.4)	30.8 (18.6)	45.4 (44.9)	35.1 (24.7)	34.3 (24.9)	45.5 (36.9)
Global cognitive function, M (SD)									
MMSE	26.0 (2.94)	26.3 (2.99)	24.9 (3.94)	25.6 (3.07)	26.3 (2.80)	24.9 (3.83)	26.5 (2.71)	26.6 (2.73)	26.1 (3.07)

Abbreviations: MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination.

excessive nighttime sleepers. Most associations were observed for excessive napping and remained significant after adjustments for lifestyle and health-related factors. Further cognitive decline in excessive nappers and nighttime sleepers with MCI was confirmed, exhibiting a 75% increased risk of incident dementia for excessive nappers and 86% for excessive nighttime sleepers compared to non-excessive sleepers.

4.1 | Excessive daytime napping

Our results align with research showing that excessive daytime napping and daytime sleepiness are accompanied with worse episodic memory, verbal fluency, perceptual speed, executive functioning, and global cognition in cognitively healthy older adults.[1,4,6,9,12,34] Few prior studies on excessive napping examine cognitive decline in terms of distinct cognitive measures or in relation to MCI. We demonstrated accelerated memory decline in excessive nappers, independent of lifestyle covariates and nighttime sleep. Napping can act as a compensatory mechanism for lost nighttime sleep, which could prove beneficial for cognitive functioning. Moreover, excessive nappers who also sleep for longer durations at nighttime may be of worse health with severer cognitive impairment. Adjustments for these subgroupings (interaction terms) showed no significant differences for cognitive test performance. Other studies also show worse cognition for excessive daytime sleep independent of insufficient nighttime sleep.[4,9] Interestingly, one study showed naps lasting ≥2 h were linked to future cognitive impairment, but only in those with normal nighttime sleep (6–8 h), not in short or long sleepers.[9] Differences in baseline cognitive health, applied nap measurement, sex, and sleep duration cutoff may explain differences between our results. Additionally, poor nighttime sleep effectivity, insomnia, and sleep fragmentation can lead to daytime napping, suggesting poor sleep quality rather than duration may better signify inadequate restorative sleep.[35] Moreover, excessive daytime sleepiness, often stemming from insufficient nighttime sleep, is a major contributing factor for prolonged sleep during the day; however, we lack information to determine daytime sleepiness. Further studies are warranted to explore the role of nighttime sleep, daytime sleepiness on excessive napping.

We additionally showed excessive napping increases dementia risk for cognitively impaired individuals. Convincing evidence highlights nap duration's importance, for instance, nappers ≥120 min/day were 66% more likely to develop cognitive impairment over 12 years compared to short nappers (30 min/day).[9] In a similar study, nappers of ≥ 60 versus < 60 min/day were at a 40% increased risk for Alzheimer's disease.[4] Finally, a recent intervention study found that taking 20-min early afternoon naps improved cognition and quality of life in participants with MCI.[36]

4.2 | Excessive nighttime sleep

We showed worse perceptual speed and executive functioning and accelerated cognitive decline in verbal fluency and global cognition for excessive nighttime sleepers. These results align with a previous meta-analysis where excessive nighttime sleep was cross-sectionally associated with multiple cognitive domains and longitudinally with aggregated measures of cognition.[37] As many others, we found an increased all-cause dementia risk for those with excessive nighttime sleep.[38–40] Moreover, an increased risk for all-cause dementia was displayed for those with MCI and self-reported prolonged sleep duration (>9 h).[13]

4.3 | Sub-analyses

Sub-analyses revealed that both amnestic and non-amnestic MCI are linked to worse cognition and decline, indicating excessive sleep is associated with various cognitive impairments. Memory decline in non-amnestic MCI and non-memory decline in amnestic MCI were unexpected. Conceptually, those with amnestic MCI are at a higher risk for dementias like Alzheimer's disease; hence, greater memory decline would be expected in amnestic excessive sleepers compared to non-amnestic MCI. Potential explanations include that the same cognitive tests were used to categorize subtypes of MCI, which were also used as outcome measures. Hence, a decline in the same domain would have to be substantial to be detectable. Moreover, the amnestic group contained individuals with impaired test scores in non-amnestic domains.

TABLE 3 Mixed model β-coefficient estimates for cross-sectional and longitudinal associations for participants with MCI, excessive daytime napping, and excessive nighttime sleep and cognitive domain

	Cognitive domain								
	Episodic memory		Verbal fluency		Perceptual speed		Executive functioning		Global cognition
	Recall	Recognition	Categories	Letters	Digit cancellation	Pattern comparison	Digit span backward	TMT-B	MMSE
Parameter	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)
Cross-sectional associations excessive napping									
Basic model	**−0.42 (−0.78; −0.07)**	**−0.55 (−1.12; −0.01)**	**−1.82 (−2.60; −1.06)**	**−1.82 (−2.59; −1.06)**	**−0.55 (−1.08; −0.01)**	**−1.25 (−1.78; −0.72)**	**− 0.52 (−0.80; −0.24)**	**6.89 (2.71; 11.1)**[a]	**−1.07 (−1.61; −0.53)**
Fully adjusted model	**−0.42 (−0.78, −0.06)**	**−0.50 (−1.04; −0.05)**	**−1.49 (−2.28; −0.70)**	**−1.49 (−2.28; −0.70)**	−0.49 (−1.04: 0.04)	**−1.05 (−1.59; −0.51)**	**− 0.50 (−0.79; −0.21)**	**6.99 (2.83; 11.14)**[a]	**−0.83 (−1.36; −0.30)**
Cross-sectional associations excessive nighttime sleep									
Basic model	−0.02 (−0.38; 0.34)	−0.03 (−0.57; 0.52)	0.00 (−0.75; 0.76)	−0.12 (−0.82; 0.57)	−0.57 (−1.22; 0.08) ($p = 0.08$)	−0.18 (−0.72; 0.36)	− 0.08 (−0.37; 0.20)	**5.04 (0.72; 9.36)**[a])	−0.52 (−1.08; 0.02) ($p = 0.58$)
Fully adjusted model	−0.04 (−0.41; 0.32)	−0.12 (−0.77; 0.44)	0.01 (−0.76; 0.79)	−0.18 (−0.89; 0.53)	**−0.66 (−1.32: −0.01)**	−0.15 (−0.70; 0.40)	− 0.13 (−0.42; 0.15)	**5.54 (1.23; 9.84)**[a])	**−0.63 (−1.16; −0.10)**
Longitudinal associations excessive napping									
Basic model	**−0.08 (−0.14; −0.09)**	−0.02 (−0.13; 0.09)	−0.01 (−0.15; 0.08)	−0.04 (−0.15; 0.08)	−0.02 (−0.13; 0.09)	−0.01 (−0.08; 0.09)	−0.01 (0.06; 0.04)	0.27 (−0.56; 1.09)[a]	−0.02(−0.12; 0.08)
Fully adjusted model	**−0.08 (−0.14; −0.01)**	− 0.03 (−0.14; 0.08)	−0.02 (−0.14; 0.10)	−0.02 (−0.14; 0.10)	−0.03 (−0.14; 0.08)	−0.00 (−0.08; 0.09)	−0.01 (−0.06; 0.04)	0.30 (−0.53; 1.12)[a]	−0.02 (−0.12; 0.07)
Longitudinal associations excessive nighttime sleep									
Basic model	−0.02 (−0.10; 0.06)	−0.07 (−0.20; 0.06)	**−0.19 (−0.33; −0.05)**	−0.01 (−0.12; 0.13)	−0.02 (−0.14; 0.10)	−0.08(−0.18; 0.02)	−0.04 (−0.10; 0.02)	0.21 (−0.61; 1.04)[a]	**−0.12 (−0.24; −0.00)**
Fully adjusted model	0.01 (−0.08; 0.09)	− 0.05 (−0.19; 0.08)	**−0.16 (−0.30; 0.03)**	−0.03 (−0.09; 0.15)	−0.00 (−0.12; 0.12)	−0.07 (−0.17; 0.04)	−0.04 (−0.10; 0.02)	0.26 (−0.56; 1.09)[a]	**−0.07 (−0.18; −0.04)**

Note: Comparison of estimates from the basic adjusted model and the fully adjusted model. Basic model controlling for age, sex, education, test version, time between examinations, and number of examinations. Fully adjusted model controlling for age, sex, education, test version, short, normal, long nighttime sleep, time between examinations, and number of examinations, cohabitation, alcohol consumption, physical inactivity, retirement, depressive symptoms, diabetes, cardiovascular and cerebrovascular-disease, hypertension, and light or dark season. β-coefficient estimates are based on test scores for those who report sleeping 2 h or more during daytime in contrast to those who do not report excessive napping, and for excessive nighttime sleeping, estimates are based on test scores for those sleeping 9 h or more in contrast to those who report sleeping 7–8 h per night. Longitudinal β-coefficient estimates are expected to decline on tests scores over 1 year.

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination; TMT-B, Trail Making Test B.

All bold estimates are signtificant at the $p > 0.05$ level or below.

[a]These estimates are based on speed tests, where a positive estimate, that is, taking longer time to complete the test, is equal to a poorer performance.

TABLE 4 Mixed model β-coefficient estimates from fully adjusted models for cross-sectional and longitudinal associations for participants with amnestic and non-amnestic MCI, excessive napping, and excessive nighttime sleep and cognitive domain

	Cognitive domain								
	Episodic memory		Verbal fluency		Perceptual speed		Executive functioning		Global cognition
	Recall	Recognition	Categories	Letters	Digit cancellation	Pattern comparison	Digit span backwards	TMT-B	MMSE
Parameter	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)	Est. (95% CI)
Cross-sectional associations napping									
Amnestic	0.04 (−0.46; −0.53)	−0.27 (−1.10; 0.55)	**−1.93 (−3.09; −0.76)**	**−1.54 (−2.63; −0.46)**	0.06 (−0.89; 1.01)	**−0.99 (−1.79; −0.18)**	**−0.77 (−1.18; −0.35)**	**13.0 (5.61; 20.4)**[a]	**−1.10 (−1.94; −0.25)**
Non-amnestic	−0.12 (−0.47; 0.23)	0.42 (−0.92; 0.85)	**−1.40 (−2.24; −0.57)**	**−1.10 (−1.87; −0.33)**	**−0.74 (−1.44: −0.04)**	**−0.65 (−1.23; −0.08)**	−0.22 (−0.54; 0.10)	0.29 (−3.79; 4.37)[a]	−0.17 (−0.73; 0.39)
Excessive nighttime sleep									
Amnestic	−0.16 (−0.37; 0.71)	−0.30 (−1.58; 0.26)	−0.12 (−1.14; 1.37)	−0.16 (−1.34; 1.00)	**−1.8 (−2.84; −0.78)**	−0.27 (−1.14; 0.61)	−0.23 (−0.69; 0.22)	6.44 (−1.84; 14.7)[a]	−0.70 (−1.57; 0.24)
Non-amnestic	0.19 (−0.23; 0.62)	**0.68 (0.07; 1.28)**	0.03; (−0.97; 1.03)	−0.23 (−1.15; 0.69)	−0.68 (−1.63: 0.27)	0.03 (−0.66; 0.73)	0.12 (−0.27; 0.52)	1.96 (−2.91; 6.83)[a]	0.22 (−0.43; 0.88)
Longitudinal associations napping									
Amnestic	−0.10 (−0.22; 0.03)	0.03 (−0.17; 0.22)	0.06 (−0.14; 0.26)	**0.25 (0.05; 0.49)**	−0.08 (−0.24; 0.08)	0.07(−0.07; 0.21)	−0.06 (−0.02; 0.14)	−0.73 (2.07; 0.61)[a]	0.05 (−0.12; 0.23)
Non-amnestic	**−0.09 (−0.17; −0.01)**	−0.10 (−0.22; 0.03)	−0.08 (−0.22; 0.07)	−0.07 (−0.20; 0.06)	−0.07 (−0.19; 0.05)	−0.05 (−0.16; 0.05)	−0.05 (−0.12; 0.01)	0.78 (−2.18; 1.77)[a]	**−0.14 (−0.25; −0.03)**
Longitudinal associations excessive nighttime sleep									
Amnestic	−0.11 (−0.23; 0.02)	−0.12 (−0.36; 0.13)	**−0.32 (−0.55; −0.09)**	0.03 (−0.19; 0.24)	0.04 (−0.16; 0.23)	−0.09 (−0.27; 0.08)	−0.03 (−0.07; 0.12)	−0.47 (−2.04; 1.09)[a]	0.03 (−0.17; −0.24)
Non-amnestic	0.09 (−0.22; 0.05)	−0.06 (−0.20; 0.09)	−0.05 (−0.22; 0.12)	0.04 (−0.11; 0.19)	−0.02 (−0.16; 0.13)	−0.05 (−0.17; 0.08)	**−0.08 (−0.16; 0.01)**	0.12 (−1.05; 1.30)[a]	**−0.15 (−0.28; −0.02)**

Note: Fully adjusted model controlling for age, sex, education, test version, time between examinations, and number of examinations, cohabitation, alcohol consumption, physical inactivity, retirement, depressive symptoms, diabetes, cardiovascular and cerebrovascular-disease, hypertension, and light or dark season. β-coefficient estimates are based on test scores for those who report sleeping 2 h or more during daytime in contrast to those who do not report excessive napping, and for excessive nighttime sleeping, estimates are based on test scores for those sleeping 9 h or more in contrast to those who report sleeping 7–8 h per night. Longitudinal β-coefficient estimates are expected to decline on tests cores over 1 year.

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination; TMT-B, Trail Making Test B.

All bold estimates are significant at the $p < 0.05$ level or below.

[a]These estimates are based on speed tests, where a positive estimate, that is, taking longer time to complete the test, is equal to a poorer performance.

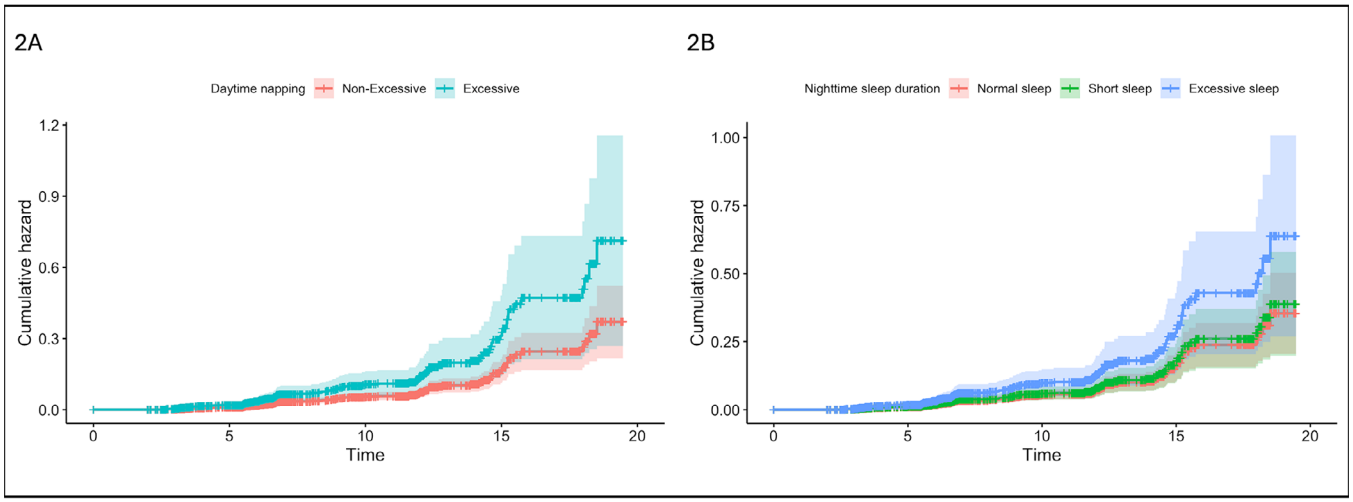

FIGURE 2 Plots show cumulative hazard functions for excessive daytime napping (A) and excessive nighttime sleep (B). Individuals who napped for ≥2 h per day had a 1.75-fold increased risk of dementia compared to those who did not report excessive napping. Individuals reporting sleeping for ≥9 h per night had a 1.86-fold increased risk of dementia compared to those reporting sleeping for 7–8 h.

Nevertheless, further investigation may elucidate whether excessive sleep is a risk marker for certain cognitive impairments.

We offer several explanations to our main results. First, individuals reporting excessive sleep are probably more advanced in their cognitive decline trajectory, suggesting potential reversed causality. A bidirectional relationship has been proposed between cognitive impairment and excessive sleep.[4] Notably, the average age of our MCI participants was 68 years, with excessive nappers progressing to dementia within 8.15 years, indicating that excessive sleep patterns emerge early in dementia development. Second, there could be unknown underlying factors causing both excessive sleep and worse cognition. For instance, subclinical cerebrovascular disease, displayed as silent infarcts or micro bleeds, is prevalent in older adults and in MCI and can lead to major cerebrovascular events such as stroke, which has a direct bearing on cognition.[41–43] A bidirectional association between cerebrovascular risk factors and sleep disturbances has been reported.[44] Moreover, self-reported napping (≥ 60 min) is associated with an increased risk of stroke.[45] Obstructive sleep apnea is a common condition among older individuals and has been linked to sleep disruption, cognitive impairment, and dementia.[46,47] Moreover, it can induce ischemia, increasing the risk of cerebral small vessel disease and negatively affecting cognition. Unfortunately, our study lacked information about diagnosis of sleep apnea. Degeneration of wake-promoting neurons, associated with tau-tangels, a key feature of Alzheimer's disease, could explain daytime sleepiness and napping.[4,48] It is possible, especially in our amnestic group, that existing Alzheimer-related pathologies were already present causing both sleep and further cognitive impairments. Additionally, recent evidence shows circadian sleep-wake disorders prior to dementia diagnosis causing excessive sleepiness and daytime napping.[49]

Mutual results for excessive daytime and nighttime sleep were cross-sectional and were seen for executive functioning and global cognition. This suggests that excessive sleep during the day versus at night targets different neuropsychological areas. However, a recent meta-analysis linked > 12.5 h daily sleep (night and day) to an elevated risk of all-cause cognitive disorder or AD.[40] Further research on total daily sleep's impact on cognition is warranted.

4.4 | Strengths and limitations

Strengths include a large sample size of MCI participants, standardized procedures of data-gathering, and cognitive testing enabling fair comparability across examinations. Dementia diagnosis was complemented via medical journal and reporting diagnosis is mandatory by law in Sweden. Also, this study contributes to research on excessive sleep patterns in individuals with MCI and how they correlate with further cognitive decline, where research is lacking. Additionally, adjustments were made for important health related covariates, including rare and novel covariates nighttime sleep, seasonality, and retirement.

Limitations include the excessive napping group was compared to individuals who did not report napping for ≥2 h during the day. Hence, this group contained individuals who both never napped and extensional nappers, that is, those who were napping closer to 2 h, perhaps attenuating effects and dampening effect sizes. Similarly, having a cut-off of 10 h or more may have been a better cutoff to detect cognitive decline.[11] There may have been power issues in the sub-analyses due to small number of returning participants with MCI and excessive sleep. Additionally, the same tests to distinguish objective cognitive impairment, a criterion for MCI, were used as outcome measures. Since these individuals are already impaired, their additional cognitive decline would have to be substantial to detect. Although inaccurate inferences are a potential problem due to multiple testing, the majority of the significant estimates were in the expected direction, reducing the probability of merely representing chance findings.

4.5 | Conclusion

Our findings show that excessive sleep, both day and night, is linked to worsened cognition and higher dementia risk in MCI. While no clear patterns emerged between MCI subtypes and excessive sleep, we highlight that future research should distinguish between different types of cognitive impairments. Our results suggest a bidirectional link between cognition and excessive sleep, where further investigation is warranted to explore whether excessive sleep is a compensatory response to cognitive decline or a contributing factor, concluding that excessive sleep is a robust independent marker of further cognitive decline.

AUTHOR CONTRIBUTIONS

Marieclaire Overton, Sölve Elmståhl, and Shireen Sindi study contributed to the conception and design of the study. Marieclaire Overton and Rani Basna performed the statistical analysis. All authors interpreted the results and critically revised the manuscript.

ACKNOWLEDGMENTS

The authors thank the GÅS-participants and GÅS-team members for collecting the data. The project Good Aging in Skåne, part of the Swedish National Study on Aging and Care (www.snac.org) was supported by the Swedish Ministry of Health and Social Affairs, the County of Region Skåne, and the Swedish Research Council under Grant No. 2017-01613; 521-2013 8604, 2021-00178, and 2021-01437. The study was approved by the regional ethics committee of Lund University (LU 744-00) and written consent from all participants was obtained, and in case of cognitively impaired individuals, consent was obtained from closest relative or guardian.

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to report. Author disclosures are available in the supporting information.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Overton M, Sindi S, Basna R, Elmståhl S. Excessive sleep is associated with worse cognition, cognitive decline, and dementia in mild cognitive impairment. *Alzheimer's Dement*. 2025;17:e70093.
https://doi.org/10.1002/dad2.70093