

Title: Sleep problems, short sleep and a combination of both increase the risk of depressive symptoms in older people: a 6-year follow-up investigation from the English Longitudinal Study of Ageing

Subtitle: Self-reported sleep and future depressive symptoms in older age

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Abstract

Study Objectives: This study investigated whether sleep problems, sleep duration and a combination of short or long sleep with sleep problems were predictive of depressive symptoms 6 years later.

Methods: Participants were 4545 men and women aged 50 years or older from the English Longitudinal Study of Ageing. Sleep problems were indexed via self-report enquiring about the most frequent insomnia symptoms including difficulties falling asleep, waking up several times a night and waking up in the morning feeling tired. Sleep duration was ascertained by asking about average sleep in the weeknight. Depressive symptoms were measured with the Center for Epidemiologic Studies Depression scale.

Results: Sleep problems were predictive of elevated depressive symptoms at follow-up (odds ratio [OR] = 1.36, 95% confidence interval [CI] = 1.19-1.56). When explored separately, waking up in the morning feeling tired (OR = 1.71, 95% CI = 1.24-2.37) followed by difficulties falling asleep (OR = 1.49, 95% CI = 1.06-2.11) were also predictors of future depressive symptoms. Compared to optimal duration, short (OR = 1.90, 95% CI = 1.34-2.71) but not long sleep hours were also linked to elevated depressive symptoms. Participants reporting short sleep hours combined with high sleep problems also had an elevated risk of depressive symptoms 6 years later (OR = 1.85, 95% CI = 1.15-3.00). Long sleep combined with high sleep problems was not predictive of depressive symptoms.

Conclusions: Short and disturbed sleep as well as their combination increase the risk of future depressive symptoms in older adults.

Keywords: depressed mood, sleep duration and quality, older adults, longitudinal analysis.

1. Introduction

It has been estimated that by 2030 depression will be one of the three leading causes of disease burden worldwide [1]. Depression is common in older people and has been linked to higher risk of chronic medical conditions and poorer clinical outcomes, in particular cardiovascular disease, suicide, greater hospitalization as well as to cognitive decline and lower quality of life, to name but a few [2-4]. It has been estimated that clinically relevant depressive symptoms are found in between 8% to 16% of community-dwelling elders [3]. Both major depression and depressive symptoms increase markedly in people aged 70-85 years [2], which is noteworthy given the rapidly rising number of older people in developed countries [5]. These data make the issue of preventing depression pressing.

One possibility to reduce depression levels is to target potentially modifiable risk factors such as health behaviours including poor sleep. Indeed, aberrant sleep patterns in terms of sleep quality and duration increase future risk of depression and depressive symptoms. For example, a meta-analytic review of 21 studies found that non-depressed adults with insomnia symptoms (e.g. difficulties with falling or staying asleep) were over 2 times more likely to develop depression when compared with those who reported good sleep [6]. Sleep changes with age [7,8], and although the findings of this meta-analysis are informative, it did not explicitly focus on the link between sleep patterns and depression in older people, a research area where conflicting findings and gaps in knowledge still remain.

For example, a cross-sectional study reported that men aged 67 or older with disturbed sleep were over 3 times more likely to also report depressive symptoms [9]. However, another cross-sectional study of older adults (mean age 73.8 years), found that only the use of sleep medication but no other sleep complaints were linked to higher odds of depression [10].

In contrast, a number of prospective investigations in adults aged 50 years or older reported that disturbed sleep predicted depression at a 1- 2- and 5-year follow-up [11-13, respectively].

In addition, a longitudinal study of French elders revealed that insomnia complaints (defined as difficulties initiating sleep, difficulties maintaining sleep and early morning awakenings) were predictive of incident depressive symptoms 4 years later; when analysed separately difficulties initiating and maintaining sleep but not early morning awakenings also predicted future depression independently of each other [14]. However, data from a cohort of older Australian men showed that only difficulty falling asleep but not being awake in the night or early morning awakenings were predictive of incident depression 6 years later [15]. This is in line with evidence from the Wisconsin Sleep Cohort Study (participants' mean age = 54 years) [16] where, again, only difficulties falling asleep but not being awake in the night or waking up too early were prospectively associated with depressive symptoms.

In addition to disturbances of sleep, meta-analytic evidence suggests that both short and long sleep duration also increase the risk of future depression [17]. However, there have been limited studies on this relationship in older people and findings are conflicting. Specifically, sleep duration measured objectively and subjectively was not related to depressive symptoms in older women from the Study of Osteoporotic Fractures [13]. In contrast, in the Wisconsin Sleep Study, short sleep duration predicted depressive symptoms approximately 4 years later [16]. Interestingly, recent analyses of data from the Nurses' Health Study also revealed that in women aged 65 years or older short (and long) sleep duration were predictive of depression at follow-up, however, after adjustment for sleep difficulties short sleep was no longer associated with an elevated depression risk [18].

In summary, there is growing evidence that disturbances of sleep predict future depression in older age. However, less is known about the contribution of distinct sleep problems (e.g. difficulties falling or staying asleep) towards greater risk of developing increased depression symptoms. It also remains relatively under-explored whether extremes of sleep duration (very short or long sleep) are predictive of future depression in ageing populations. Moreover, given that older adults who report sleep difficulties are also more likely to be sleeping short or long hours [19] it is important to explore whether there is a synergistic effect of disturbed sleep and extremes of sleep duration on depression risk. Finally, and importantly, understanding of the link between sleep and future depression is further constrained by a lack of prospective studies with longer follow-up periods based on representative samples of both men and women. We aimed to address these issues in analyses using data from nationally representative adults living in England, aged 50 years or older, namely the English Longitudinal Study of Ageing (ELSA). Specifically, we hypothesised that disturbed sleep would predict depressive symptoms 6 years later. We also hypothesised that adults reporting short and long sleep hours would have a higher risk of depressive symptoms at follow-up. Because of limited findings relating the contribution of separate sleep problems towards future depression and those regarding the synergistic influence of sleep problems and extremes of sleep duration we took an exploratory approach to test these research questions without forming any specific hypotheses.

2. Methods

2.1 Participants and procedures

This study uses data from ELSA [20]. ELSA is a multi-disciplinary prospective cohort study nationally representative of men and women aged 50 years and older living in England.

The study began in 2002 and participants have been seen biannually since then. Analyses described here are based on 4545 participants from waves 4 (2008-9) and 7 (2014-15) of ELSA. Data from wave 4 are used as baseline because sleep items were first introduced in this wave. In ELSA data are collected during a computer-assisted personal interview (CAPI) and a nurse visit a few days later (not described here). All data are collected in participants' homes. All participants provided written informed consent and ethical approval was granted by the National Research Ethics Service.

2.2. Measures

2.2.1 Sociodemographic variables

Age at baseline was categorised into four groups: "50-59", "60-69", "70-79" and "80+". Relationship status was categorised into "Married or cohabiting" or "Neither". Socio-economic status was estimated by total household wealth taking into account financial wealth (e.g., savings), the value of any property (less mortgage), and the value of any business assets and physical wealth (e.g., artwork), net of debt. Wealth is the most reliable indicator of socio-economic position in ELSA, and was divided into quintiles for these analyses.

2.2.2 Sleep measures

Sleep problems were measured with three questions referring to the most frequent insomnia symptoms, including: difficulties falling asleep, waking up several times a night and waking up in the morning feeling tired. These sleep items were derived from the Jenkins Sleep Problems Scale [21]. Participants answered these questions with regards to the past month. Items were rated on a 4-point Likert scale (anchored at 1 = "not during the past

month” to 4 = “three of more times a week”), and scores were averaged (range 1-4) with higher scores indicating more sleep problems. The Cronbach’s alpha at wave 4 for this analytical sample was 0.60.

Sleep duration was measured with an open-ended question asking participants about their sleep duration on an average weeknight. For the analyses described here sleep duration was categorised into “ ≤ 5 h” (short sleep duration), “ $>5-6$ h”, “ $>6-7$ ”, “ $>7-8$ ” (optimal sleep duration), and “ >8 ” (long sleep duration). These cut-off points are based on previous literature [9,17].

2.2.3 *Depressive symptoms*

Depressive symptoms were ascertained during the CAPI with a shortened version of the Center for Epidemiologic Studies Depression Scale (CES-D) devised for the Health and Retirement Study [22]. The CES-D has been validated for use in the elderly and carries very good psychometric properties [23,24]. The scale requires participants to give information on negative affect (e.g. feeling sad) and somatic complaints (e.g. having restless sleep) experienced in the past week. For the purpose of analyses described here the sleep item was removed from the CES-D so as to avoid the issue of shared variance with the sleep problems measure. As such, the scale consisted of 7 items rated with a “Yes” or “No” response. Items were totalled and ranged from 0 to 7 with higher scores being indicative of greater depressive symptoms. Using a validated cut-off point of 4 [22] we computed a binary variable to indicate presence or absence of elevated depressive symptoms. We used the standard cut-off value of 4 for the CES-D in order to obtain a more conservative estimate given the reduction of items in our adapted CES-D measure. A similar approach was also followed in a study by Jaussent et al. [14]. At baseline the Cronbach’s alpha for the scale in our sample was 0.79.

2.2.4 Health-related measures

The presence of chronic illness was assessed during the CAPI. Those who responded positively to this question were further requested to report whether their condition limited their activities. Answers were categorised into “yes” for limiting long-standing illness and “no” for its absence. Height and weight were assessed by a nurse and were used to calculate body mass index (BMI, kg/m²). Physical activity was indexed by asking whether respondents participated in mild, moderate and vigorous physical activity. The possible answers were “hardly ever or never”, “one to three times a month”, “once a week”, and “more than once a week”. In the analyses described here, physical activity was categorised into “moderate or vigorous physical activity at least once a week” and “moderate or vigorous physical activity less than once a week”. Information on smoking was obtained by asking participants if they currently smoked and responses were categorised into “Yes” and “No”. Alcohol consumption was measured by asking respondents how many times they had an alcoholic drink in the last 12 months. For these analyses we grouped responses into “5-6 days or almost every day”, “1-4 days a week”, “1-2 times a month or up to every other month”, “2 times a year, or never”. Participants gave information on depression treatment by indicating whether in the previous two years they had taken depression medication (in this analytical sample N = 111), had counselling (N = 14) or both (N = 54)). Due to a small number of cases in the two latter categories answers were categorised into “Depression medication, counselling or both” and “None”.

2.3 Statistical approach

The analytic sample of 4545 is based on participants who provided complete data at baseline on sleep measures, covariates (detailed below) and depressive symptoms at both baseline and follow-up. Covariates were selected a priori and included age, sex, relationship status, wealth, presence of a limiting long-standing illness, BMI, smoking, alcohol consumption, physical activity, depressive symptoms at baseline and depression treatment. We selected these covariates since they are related to sleep and depression measures [4,17, 25, 26]. All statistical analyses described here were adjusted for the same covariates. The prospective association between baseline sleep problems and elevated depressive symptoms was tested with logistic regression analysis. To explore the contribution of separate sleep items (difficulties falling asleep, waking up several times a night and waking up in the morning feeling tired) to elevated depressive symptoms at follow-up we entered them simultaneously into logistic regression analysis. The prospective association between sleep duration categories and depressive symptoms was tested with adjusted logistic regression analysis where optimal sleep duration (>7-8 h) was the reference category.

To test whether participants reporting short or long sleep duration and who also reported elevated sleep problems at baseline had an increased risk of depressive symptoms at follow-up, when compared with those reporting short or long sleep but low sleep problems, we ran a logistic regression analysis. For the purpose of this analysis we performed a median split on sleep problems (low/high). When we tried to compute a variable distinguishing between short sleepers (≤ 5 h) with low and high sleep problems (from now on referred to as short sleep/low sleep problems and short sleep/high sleep problems) this resulted in a small number of cases in the former category ($N = 86$), so we grouped together participants reporting ≤ 5 h and $>5-6$ h (short sleep duration has been defined as 6 or fewer hours

previously [27,28]). This resulted in 439 participants in the short sleep/low sleep problems category and 1005 participants in the short sleep/high sleep problems category. For long sleep duration (>8 h) we computed a variable distinguishing between participants sleeping long hours with low sleep problems (long sleep/low sleep problems; N = 181) and long sleep hours with high sleep problems (long sleep/high sleep problems; N = 110).

Results for logistic regressions are shown as odds ratio (OR) and 95% confidence intervals (CI) and *P*-values (given in text only). All analyses were performed in SPSS v21.

3. Results

3.1 Participants characteristics

Participants' characteristics are shown in Table 1. The majority of the sample was aged 60 to 69 years and there were more women than men. Over 70% of participants were either married or cohabiting and there were more participants in the wealthiest quintiles. In terms of health-related variables 13% of participants were current smokers, approximately 40% reported consuming alcohol 1 to 4 days per week and only about 1/3 engaged in moderate or vigorous physical activity more than once per week. Nearly 30% of the analytical sample had a long-standing illness that was limiting, and 8.7% had elevated depressive symptoms. More participants reported sleeping short hours (12.3%) than long (6.4%).

Table 1. Baseline characteristics of study participants

Variable	Mean (SD)/N (%)
Age	
50-59 years	1336 (29.4)
60-69 years	1872 (41.2)

70-79 years	1089 (24.2)
80+ years	239 (5.3)
Sex	
Men	2063 (45.4)
Women	2482 (54.6)
Relationship status	
Married or cohabiting	3334 (73.4)
Neither	1211 (26.6)
Wealth quintiles	
Poorest quintile	615 (13.5)
2 nd quintile	822 (18.1)
3 rd quintile	921 (20.3)
4 th quintile	1008 (22.2)
Richest quintile	1179 (25.9)
Current smoking status	
Yes	592 (13.0)
No	3953 (87.0)
Alcohol consumption	
5-6 days or almost every day	1072 (23.6)
1-4 days a week	1861 (40.9)
1-2 times a month or up to every other month	846 (18.6)
2 times a year or never	766 (16.9)
Moderate or vigorous physical activity	
Less than once per week	3063 (67.4)
At least once per week	1482 (32.6)
BMI (kg/m²)	
	28.3 (5.2)
Limiting long-standing illness	
Yes	1341 (29.5)
No	3204 (70.5)
Depressive symptoms (CES-D ≥ 4)	
Yes	394 (8.7)
No	4151 (91.3)
Depression treatment	
Depression medication, counselling or both	179 (3.9)
None	4366 (96.1)
Sleep disturbance	
	2.3 (0.9)
Sleep duration	
≤ 5 h	560 (12.3)

>5-6 h	884 (19.4)
>6-7 h	1530 (33.7)
>7-8 h	1280 (28.2)
>8 h	291 (6.4)

SD = standard deviation; BMI = body mass index; CES-D = Center for Epidemiologic Studies Depression Scale.

3.2 Baseline sleep measures and covariates

Sleep problems were unrelated to age but were more prevalent in women ($P < 0.001$), respondents who were neither married nor cohabiting ($P < 0.001$), those from lower wealth quintiles ($P < 0.001$), current smokers ($P = 0.04$), those who consumed alcohol less frequently ($P < 0.001$) and engaged in moderate or vigorous physical activity less than once a week ($P < 0.001$), as well as in respondents with higher BMI ($P < 0.001$). Unsurprisingly, those who reported having a limiting long standing illness ($P < 0.001$), elevated depressive symptoms ($P < 0.001$) and undergoing treatment for depression ($P < 0.001$) also had higher sleep problems. Sleep duration was significantly associated with age ($P < 0.001$); for example short (≤ 5 h) as well as long (> 8 h) hours were most prevalent in respondents aged 60-69 years, while those in the 80+ years category were least likely to report these sleep durations. Women were more likely to report both short and long sleep ($P < 0.001$) than men. Participants who were not married or cohabiting were more likely to be short sleepers ($P < 0.001$), and there was a positive association with wealth ($P < 0.001$) whereby wealthier participants were more likely to sleep more optimal sleep hours. Current smokers ($P = 0.004$), participants with higher BMI ($P = 0.003$), those who were less likely to consume alcohol ($P < 0.001$) and engage in moderate or vigorous activity at least once a week ($P < 0.001$), as well as those who had a limiting long standing illness ($P < 0.001$) were more likely to report short sleep duration. Similarly, participants who had elevated depressive symptoms

($P < 0.001$) and were receiving depression treatment ($P = 0.039$) were also more likely to be short sleepers.

3.3 Sleep problems and depressive symptoms

As shown in Table 2, sleep problems were associated with increased odds of elevated depressive symptoms 6 years later (OR = 1.36, 95% CI = 1.19-1.56, $P < 0.001$), independently of covariates. When we entered the three sleep items simultaneously into logistic regression analysis difficulty falling asleep less than once a week, when compared with not during the past month, was predictive of higher odds of depressive symptoms (OR = 1.49, 95% CI = 1.06-2.11, $P = 0.023$). Waking in the morning feeling tired once or twice a week (OR = 1.43, 95% CI = 1.00-2.03, $P = 0.049$) and 3 or more times a week (OR = 1.71, 95% CI = 1.24-2.37, $P = 0.001$) also predicted depressive symptoms at follow-up. However, waking several times a night was not prospectively associated with depressive symptoms independently of the remaining two sleep items.

3.4 Sleep duration and depressive symptoms

In comparison with optimal sleep duration (>7-8 h) participants sleeping short hours (≤ 5 h) had higher odds of depressive symptoms as follow-up (OR = 1.90, 95% CI = 1.34-2.71, $P < 0.001$), independently of covariates, but other sleep categories were not linked to future depressive symptoms (see Table 2).

3.5 Sleep duration combined with sleep problems and depressive symptoms

As shown in Table 2, in our analysis exploring whether participants sleeping short hours/high sleep problems had higher odds of elevated depressive symptoms, when compared

with short hours/low sleep problems, we found that indeed these participants were nearly twice as likely to suffer from depressive symptoms at follow-up (OR = 1.85, 95% CI = 1.15-3.00, $P = 0.012$). In contrast, there was no difference in depressive symptoms at follow-up between long sleepers with and without high sleep problems at baseline (OR = 2.30, 95% CI = 0.86-6.16, $P = 0.097$) (see Table 2).

Table 2 Prospective associations between sleep measures and depressive symptoms

	Percent	Adjusted odds ratio ^a (95%CI)
Sleep problems	–	1.36 (1.19-1.56)
Difficulties falling asleep		
Not during the past month	41.5%	Reference
Less than once a week	15.4%	1.49 (1.06-2.11)
Once or twice a week	11.2%	0.91 (0.62-1.35)
3 or more times a week	31.9%	1.25 (0.91-1.72)
Waking several times a night		
Not during the past month	15.2%	Reference
Less than once a week	5.6%	0.80 (0.46-1.37)
Once or twice a week	15.2%	1.06 (0.70-1.61)
3 or more times a week	64.1%	1.17 (0.83-1.66)
Waking up in the morning feeling tired		
Not during the past month	29.8%	Reference
Less than once a week	11.7%	1.08 (0.73-1.58)
Once or twice a week	16.8%	1.43 (1.00-2.03)
3 or more times a week	41.8%	1.71 (1.24-2.37)
Sleep duration		
≤ 5 h	17.9%	1.90 (1.34-2.71)
>5-6 h	8.6%	1.26 (0.88-1.79)
>6-7 h	6.5%	1.21 (0.87-1.68)
>7-8 h	6.0%	Reference
>8 h	8.3%	1.18 (0.71-1.96)
Short sleep duration^b & sleep problems combined		
Short sleep/low sleep problems	13.6%	Reference
Short sleep/high sleep problems	86.4%	1.85 (1.15-3.00)

Long sleep duration & sleep problems**combined**

Long sleep/low sleep problems	37.5%	Reference
Long sleep/high sleep problems	62.5%	2.30 (0.86-6.16)

^a Adjusted for age, sex, relationship status, wealth, presence of limiting long-standing illness, BMI, smoking, alcohol consumption, physical activity, depressive symptoms at baseline and depression treatment.

^b defined as ≤ 6 hours.

4. Discussion

In our study we report that in older men and women sleep problems were associated with elevated depressive symptoms 6 years later, independently of a range of confounders. We also found that when explored simultaneously in a multivariate analysis, waking up in the morning feeling tired and to some extent difficulties falling asleep were predicative of depressive symptoms, but no such association was detected for waking up several times a night. Our data further revealed that short sleep duration was associated with a significantly increased likelihood of depressive symptoms at follow-up. Finally, our analyses showed that individuals reporting short hours/high sleep problems were nearly two times more likely to report elevated depressive symptoms than those in the short hours/low sleep problems category. Neither long sleep duration nor long sleep/high sleep problems were related to depressive symptoms at follow-up. These findings lend partial support towards our hypotheses that sleep problems and extremes of sleep duration do increase future risk of depressive symptoms in older men and women.

Our finding that having sleep problems is prospectively associated with an increased risk of depressive symptoms is in line with past studies of older people [11-14,18]. With respect to our results relating separate sleep items we found that having difficulties falling asleep less than once a week, compared with not in the last month, was associated with

greater odds of depressive symptoms 6 years later. However, it is noteworthy that difficulties falling asleep experienced more frequently, for example, one or twice a week, were not related to future depressive symptoms in our study. We can only speculate the reason for this finding. It is plausible that only experiencing difficulty falling asleep once a week is particularly troublesome when compared to someone who has difficulty consistently. On the other hand, in our data the relationship between more severe difficulties with falling sleep and depressive symptoms may have been confounded by other variables. Indeed, while over 30% of respondents with elevated depressive symptoms at follow-up reported difficulties falling asleep three or more times a week at baseline, this association was not statistically significant in a multivariate analysis (see Table 2). Data from France [14] Australia [15] and the US [16] suggest that struggling with falling asleep may have a particularly adverse impact on future depression risk in the elderly; therefore further work is needed to replicate these findings in other cohorts. We also found that feeling tired upon waking up, or in other words having non-refreshing sleep, once or twice a week as well as three or more times a week, again compared with not in the past month, were associated with greater depressive symptoms risk. It is difficult to relate this finding to extant data since none of the studies cited here have measured this sleep complaint in their investigations. In our data waking up several times a night was unrelated to future depressive symptoms. This is in line with findings reported in older Australian men [15] and the Wisconsin Sleep Cohort study [16], but contradicts results from older French adults [14]. Taken together, while there is growing evidence suggesting that difficulty falling asleep increases the risk of depressive symptoms in older adults, more research is warranted to test the plausible impact of other insomnia symptoms.

There is limited literature relating sleep duration with future risk of depression in the elderly, and using large representative data from community-dwelling older men and women we showed that short sleep duration is associated with an increased risk of elevated depressive symptoms 6 years later. This supports findings from the Wisconsin Sleep Cohort Study [16] and to some extent from the Nurses' Health Study [18]. Albeit meta-analytic [17] and very recent evidence [18] suggests that long sleep duration increases the risk of depression, our investigation of ELSA data does not support this finding. Notably, there are published data that also do not support the link between long sleep and increased depression risk [13]. Plausible reasons for this discrepancy of findings linking long sleep hours with future depression risk may be differences in sleep measurement (objective vs. subjective), the choice of confounders, as well as differences in studied populations (e.g. both sexes vs. male or female only).

Finally, we found that in our data older adults who reported short sleep/high sleep problems at baseline were nearly two times more likely to have elevated depressive symptoms 6 years later than those in the short sleep/low sleep problems category. However, notably, this association was not a stronger predictor of future depressive symptoms than either short sleep or sleep problems considered on its own. To date, to the best of our knowledge, little attention has been given to exploring the plausible combined effect of disturbed and short or long sleep on future risk of depression. However, a synergistic effect of disturbed and short sleep has been reported in the literature relating sleep measures with cardiovascular disease [29,30] as well as in clinical populations where the risk of incidence of depression was highest in participants with persistent insomnia and objective short sleep duration than among insomniacs with normal sleep hours [31]. More studies are needed to

corroborate our finding that in the elderly the combination of short and disturbed sleep has a more adverse impact on depression risk than either of these sleep measures alone.

In contrast to short sleep hours long sleep experienced together with high sleep problems at baseline was not linked to future depressive symptoms in our data. This may in part be explained by the fact long sleep itself was not associated with depressive symptoms 6 years later. Furthermore, analysis of covariance showed that when compared with optimal sleep duration (>7-8 h) long sleepers did not report significantly higher sleep problems at baseline (data not shown).

Our findings and those of studies cited here clearly suggest that aberrant sleep patterns increase the risk of milder forms of depression as well as major depressive episode in the elderly. The precise mechanisms that may be translating unhealthy sleep into symptoms of depression are complex and still not fully understood. For example, electroencephalogram (EEG) abnormalities (e.g. prolonged time spent in rapid eye movement (REM) sleep) and hypothalamic-pituitary-adrenal (HPA) axis hyperactivity, which is tightly linked to impaired sleep continuity and reduction or loss of slow-wave sleep (SWS) have been implicated [see 32 for a review]. Disturbed and curtailed sleep, if prolonged, has been found to increase levels of low-grade inflammation, which is another plausible pathway that may increase risk of depression in poor sleepers [see 33 for a review]. It is also important to highlight that insomnia symptoms and depression share a number of overlapping risk factors including advancing age, female sex, being single, divorced or widowed (vs. married) or adverse economic circumstances, which makes studying the aetiological pathway between these two conditions challenging.

Our study has a number of strengths. We used a large and well-described cohort of community-dwelling older men and women from England [20]. The results described here

are prospective with participants being followed for 6 years. We were able to show that sleep measures at baseline are predictive of future depressive symptom after adjustment for a range of confounders including baseline depressive symptoms and depression treatment. Because a large number of data are collected as part of ELSA, which includes information on psychological and socio-economic factors, leisure activities, health behaviours and physical health indicators this reduces the possibility that participants were aware of our interests in sleep and depressive symptoms described here.

However, our conclusions are tempered by a number of limitations that need to be borne in mind. First of all sleep was measured with self-report that is prone to affect and memory biases [34] as well as inaccuracies when compared with objective sleep indicators [35]. An objective sleep measure such as actigraphy would have been preferable but it is often impractical or financially prohibitive in large studies like ELSA. Sleep disorders such as sleep apnoea are not assessed in ELSA but all analyses were adjusted for the presence of a limiting long-standing condition as well age, sex, BMI and smoking that are known risk factors for sleep apnoea [36]. Our analyses were adjusted for a range of covariates including socio-demographic factors, health behaviours, limiting long-standing illness as well as depression treatment that are relevant to sleep and depressive symptoms, but we did not adjust for sleep medication since it is not collected in ELSA. Finally, in our study we measured depressive symptoms with the CES-D; albeit the scale has been validated for use in the elderly and has excellent psychometric properties this measure captures depression symptoms and not clinical depression per se.

In conclusion, our study found that sleep problems predicted elevated depressive symptoms at a 6-year follow-up. When explored separately, waking up in the morning feeling tired and to some extent difficulties falling asleep were both predictors of future

depressive symptoms. We further found that older men and women reporting short sleep duration had an increased risk of depressive symptoms at follow-up. Similarly, those reporting a combination of both short sleep hours and high sleep problems also had a higher risk of future depressive symptoms, when compared with short sleepers with low sleep problems. Finally, long sleep hours and long sleep hours combined with high sleep problems were not predictive of depressive symptoms. Taken together, our study adds to the growing evidence that in older men and women deleterious sleep patterns increase the risk of future depressive symptoms.

References

- [1] Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *Plos Med* 2006: e442.
- [2] Alexopoulos GS. Depression in the elderly. *The Lancet* 2005; 365: 1961-1970.
- [3] Blazer DG. Depression in late life: review and commentary. *J Gerontol A Biol Sci Med Sci* 2003; 58: 249-265.
- [4] Fiske A, Wetherell JL, Gatz M. Depression in older adults. *Annu Rev Clin Psychol* 2009; 5: 363-389.
- [5] Oeppen J, Vaupel JW. Broken limits to life expectancy. *Science* 2002; 296: 1029-1031.
- [6] Baglioni C, Battagliese G, Feige B, Spiegelhalder K, Nissen C, Voderholzer U, Lombardo C, Riemann D. Insomnia as a predictor of depression: a meta-analytic evaluation of longitudinal epidemiological studies. *J Affect Disord* 2011; 135: 10-19.
- [7] Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep* 2004; 27: 1255-1274.
- [8] Crowley K. Sleep and sleep disorders in older adults. *Neuropsychol Rev* 2011; 21: 41-53.
- [9] Paudel ML, Taylor BC, Diem SJ, Stone KL, Ancoli-Israel S, Redline S, Ensrud KE. Association between depressive symptoms and sleep disturbances in community-dwelling older men. *J Am Geriatr Soc* 2008; 56: 1228-1235.
- [10] Potvin O, Lorrain D, Belleville G, Grenier S, Prévaille M. Subjective sleep characteristics associated with anxiety and depression in older adults: a population-based study. *Int J Geriatr Psychiatry* 2014; 29: 1262-1270.

- [11] Roberts RE, Shema SJ, Kaplan GA, Strawbridge WJ. Sleep complaints and depression in an aging cohort: a prospective perspective. *Am J Psychiatry* 2000; 157: 81-88.
- [12] Livingston G, Blizard B, Mann A. Does sleep disturbance predict depression in elderly people? A study in inner London. *Br J Gen Pract* 1993; 43: 445-448.
- [13] Maglione JE, Ancoli-Israel S, Peters KW, Paudel ML, Yaffe K, Ensrud KE, Stone KL. Subjective and objective sleep disturbance and longitudinal risk of depression in a cohort of older women. *Sleep* 2014; 37: 1179-1187.
- [14] Jaussent I, Bouyer J, Ancelin ML, Akbaraly T, Pérès K, Ritchie K, Besset A, Dauvilliers Y. Insomnia and daytime sleepiness are risk factors for depressive symptoms in the elderly. *Sleep* 2011; 34: 1103-1110.
- [15] Almeida OP, Alfonso H, Yeap BB, Hankey G, Flicker. Complaints of difficulty to fall asleep increase the risk of depression in later life: the health in men study. *J Affect Disord* 2011; 134: 208-216.
- [16] Szklo-Coxe M, Young T, Peppard PE, Finn LA, Benca RM. Prospective associations of insomnia markers and symptoms with depression. *Am J Epidemiol* 2010: kwp454.
- [17] Zhai L, Zhang H, Zhang D. Sleep duration and depression among adults: a meta-analysis of prospective studies. *Depress Anxiety* 2015; 32: 664-670.
- [18] Chang S-C, Pan A, Kawachi I, Okereke OI. Risk factors for late-life depression: a prospective cohort study among older women. *Prev Med* 2016; 91: 144-151.
- [19] Ohayon MM. Interactions between sleep normative data and sociocultural characteristics in the elderly. *J Psychosom Res* 2004; 56: 479-486.
- [20] Steptoe A, Breeze E, Banks J, Nazroo J. Cohort profile: the English longitudinal study of ageing. *Int J Epidemiol* 2013; 42: 1640–1648.

- [21] Jenkins CD, Stanton BA, Niemcryk SJ, Rose RM. A scale for the estimation of sleep problems in clinical research. *J Clin Epidemiol* 1988; 41: 313-321.
- [22] Steffick DE. Documentation of affective functioning measures in the Health and Retirement Study. Ann Arbor, MI: HRS Health Working Group; 2000.
- [23] Irwin M, Artin KH, Oxman MN. Screening for depression in the older adult: criterion validity of the 10-item Center for Epidemiological Studies Depression Scale (CES-D). *Arch Intern Med* 1999; 159: 1701–1704.
- [24] Lyness JM, Noel TK, Cox C, King DA, Conwell Y, Caine ED. Screening for depression in elderly primary care patients. A comparison of the Center for Epidemiologic Studies-Depression Scale and the Geriatric Depression Scale. *Arch Intern Med* 1997; 157: 449–454.
- [25] Arber S, Bote M, Meadows R. Gender and socio-economic patterning of self-reported sleep problems in Britain. *Soc Sci Med* 2009; 68: 281-289.
- [26] Stranges S, Dorn JM, Shipley MJ, Kandala NB, Trevisan M, Miller MA, Donahue RP, Hovey KM, Ferrie JE, Marmot MG, Cappuccio FP. Correlates of short and long sleep duration: A cross-cultural comparison between the United Kingdom and the United States-the Whitehall II study and the Western New York Health study. *Am J Epidemiol* 2008; 168: 1353-1364.
- [27] Gehrman P, Seelig AD, Jacobson IG, Boyko EJ, Hooper TI, Gackstetter GD, Ulmer CS, Smith TC. Predeployment sleep duration and insomnia symptoms as risk factors for new-onset mental health disorders following military deployment. *Sleep* 2013; 36: 1009-1018.
- [28] Yokoyama E, Kaneita Y, Saito Y, Uchiyama M, Matsuzaki Y, Tamaki T, Munezawa T, Ohida T. Association between depression and insomnia subtypes: a longitudinal study on the elderly in Japan. *Sleep*, 2010; 33: 1693-1702.

- [29] Hoevenaar-Blom MP, Spijkerman AM, Kromhout D, van den Berg JF, Verschuren WM. Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: the MORGEN study. *Sleep* 2011; 34: 1487-1492.
- [30] Chandola T, Ferrie JE, Perski A, Akbaraly T, Marmot MG. The effect of short sleep duration on coronary heart disease risk is greatest among those with sleep disturbance: a prospective study from the Whitehall II cohort. *Sleep* 2010; 33:739-744.
- [31] Fernandez-Mendoza J, Shea S, Vgontzas AN, Calhoun SL, Liao D, Bixler EO. Insomnia and incident depression: role of objective sleep duration and natural history. *J Sleep Res* 2015; 24:390-398.
- [32] Staner L. Comorbidity of insomnia and depression. *Sleep Med Rev* 2010; 14: 35-46.
- [33] Irwin MR. Why sleep is important for health: a psychoneuroimmunology perspective. *Psychology* 2015; 66: 143-172.
- [34] Krystal AD, Edinger JD. Measuring sleep quality. *Sleep Med* 2008; 9: S10-S17.
- [35] Jackowska M, Dockray S, Hendrickx H, Steptoe A. Psychosocial factors and sleep efficiency: discrepancies between subjective and objective evaluations of sleep. *Psychosom Med* 2011; 73: 810-816.
- [36] Punjabi NM. The epidemiology of adult obstructive sleep apnea. *Proc Am Thorac Soc* 2008; 5: 36-143.