



Original Article

Insomnia symptoms and short sleep duration predict trajectory of mental health symptoms



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ARTICLE INFO

Article history:

Received 20 July 2018

Received in revised form

14 September 2018

Accepted 4 October 2018

Available online 25 October 2018

Keywords:

Insomnia
Sleep duration
Prognosis
Depression
Anxiety

ABSTRACT

Objectives: We evaluated whether insomnia symptoms and short or long sleep duration, alone or in combination, are robustly associated with subsequent trajectory of mental health symptoms.

Methods: Participants were 2598 individuals (15 to 94 years of age) with elevated mental health symptoms at baseline (2013–14). Associations of baseline insomnia symptoms and sleep duration with two-year trajectory of mental health were estimated and adjusted for multiple potential confounders. Outcomes included recovery (well at both follow-up timepoints), intermittent symptoms (unwell at one follow-up timepoint), and chronic symptoms (unwell at each follow-up timepoint).

Results: Adjusted for age and sex, baseline insomnia symptoms predicted intermittent (OR 1.43, 95% CI 1.15–1.80) and chronic (OR 2.16, 95% CI 1.77–2.68) trajectories of mental health symptoms. Short sleep duration (<6 h and ≥6 to <7 h) only predicted a chronic trajectory (ORs 1.70–2.06). Associations were attenuated but significant after confounder adjustment. Those who experienced both insomnia and short (<7 h) sleep duration had the greatest risk of chronic mental health symptoms (OR 2.35, 95% CI 1.60–3.45).

Conclusion: A focus on just sleep duration or insomnia symptoms in those with elevated mental health symptoms will not be adequate to address chronicity. Both components of sleep disturbance, and in particular their co-occurrence, should be addressed.

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1. Introduction

There is a bi-directional link between sleep disturbance and mental health symptoms, with disordered sleep representing both a symptom of and risk factor for the development of common mental disorders [1–6].

Sleep disturbance is a multidimensional concept, comprised of such phenomena as insomnia symptoms, sleep duration, and sleep schedule/timing [7]. Recent research has explored how these sleep disturbance dimensions combine to predict mental health incidence and prevalence [7–11], with a particular focus on the combination of insomnia symptoms and short sleep duration.

One large-scale cross-sectional study (n = 3911) found that those experiencing insomnia with short sleep duration display higher risk of depression than those with insomnia but normal sleep duration, and greater prevalence of depression and anxiety than healthy-sleeping controls [8]. In another large-scale study (n = 1137), Fernandez-Mendoza et al., found that of the sleep subgroups assessed, the odds of incident depression at 7.5 year follow-up were highest among those with insomnia and short sleep duration; and that this association was independent of psychological coping resources [9]. Potential biological underpinnings of insomnia with short sleep duration have also been explored, and this insomnia phenotype has been found to be associated with multiple markers of hyperarousal and cardiometabolic risk [11]. This has led some to describe insomnia with objective short sleep duration as the most “biologically severe” form of insomnia [11].

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It seems clear that insomnia, short sleep duration, and in particular their combination, predict prevalence and/or onset of mental health symptoms and associated biomarkers. However, the factors which precipitate an illness are not necessarily the same as those which maintain it [12,13], and the extent to which these dimensions of sleep disturbance are associated with mental health symptom trajectory after onset is currently unclear. Clarifying this association would have particular clinical utility as sleep disturbance is common among those with mental disorders yet remains undertreated [14].

To date, investigation of the impact of insomnia and/or short sleep duration on mental health symptom trajectory has been limited by (a) considering only a single dimension of sleep disturbance at a time, (b) potential confounders, and (c) issues of measurement [15–19].

A number of studies have found a prospective link between insomnia and chronicity of mental health symptoms [15–17]. However, these have not considered sleep duration, and not controlled for important potential confounders such as past mental illness, physical activity, low social support, stressful life events, or obesity.

Another study by Glozier et al., found that short sleep duration was associated with persistent psychological distress in young adults 12–18 months after baseline [18]. While this study controlled for multiple important confounders, only one dimension of sleep disturbance was considered.

Finally, one study has considered multiple dimensions of sleep disturbance and trajectories of mental health symptoms, while also controlling for important confounders, but this study also has limitations [19]. Van Mill et al., found that both short and long sleep duration, but not insomnia, were associated with a chronic course of depression and anxiety, and found no interaction between sleep duration and insomnia [19]. They conclude that short and long sleep duration – but not insomnia – predict a chronic course of mental illness, independent of disorder symptom severity, and recommend routine assessment of sleep duration to identify subjects at risk of a chronic course. However, the measure and cut-point used to define insomnia were validated in a specific sample (postmenopausal women, mean 67.71 years of age), and the cut-point used yielded limited sensitivity (53%) and specificity (67%) [20]. Therefore, a significant proportion of the sample may have been misclassified with regard to insomnia status, making it difficult to interpret the observed lack of associations with insomnia.

The limitations described mean the extent to which insomnia, sleep duration, and their combination predict a chronic trajectory of mental ill-health is currently unclear. If both dimensions of sleep disturbance predict a chronic trajectory, this would suggest that it may be necessary to identify and specifically target each, where they are occurring, in order to maximise the odds of a positive long-term outcome.

1.1. Aims of the study

The current study aimed to test three primary hypotheses:

1. Insomnia and suboptimal sleep duration (short and/or long duration) will have a prospective association with chronicity of mental health symptoms.
2. The combination of insomnia symptoms and short sleep duration will be more strongly associated with chronicity of mental health symptoms than either dimension of sleep disturbance in isolation.
3. These associations will be robust to adjustment for potential sociodemographic, physical health, and mental health confounders.

2. Methods

2.1. Data

Data were obtained through the ongoing Household, Income and Labour Dynamics in Australia (HILDA) panel survey [21]. The survey was approved by the Human Research Ethics Committee of the University of Melbourne. Commencing in 2001, this survey annually collects information related to labour market dynamics, family life, and personal well-being. It employed a multi-stage sampling approach to obtain a nationally representative sample of households. Selected households were sent information via mail, and later invited to participate directly by interviewers. At wave 1 (2001–02), 19,914 individuals participated (a response rate of 66%). In 2011–12 a further 5451 persons were added to the cohort (a response rate of 69%).

Fig. 1 summarises the selection of participants into the study. Baseline data for this study were collected in 2013–14 (wave 13), the first wave in which sleep was assessed. 17,501 individuals participated at this time point. Follow up data were obtained after one year (2014–15; wave 14) and after two years (2015–16; wave 15). Of those who participated in the survey at baseline, 15,394 (88.0%) also participated in the survey at both follow-up time-points. Of these, 12,525 participants (81.4%) had available mental health data at each timepoint. 2598 (20.7%) of those with full mental health data met criteria for elevated mental health symptoms (described in section 2.2) at baseline and were included in the study.

Although adolescents experience distinct changes in sleep timing and duration [22], they were retained in the sample as sleep disturbance has been associated prospectively with mental illness among this age group [23].

Interviews were generally conducted at participant household addresses, with <10% conducted via phone. The HILDA survey consists of two sections. Each member of a participating household over the age of 15 was invited to complete the first section with an interviewer, and the second section alone (without interviewer administration). The second section, referred to as the 'self-completion questionnaire' was comprised of attitudinal and other questions which respondents may be more comfortable answering privately. After this section was completed, it was either left with the interviewer, collected at a later date, or returned by mail. The average time between completion of the self-completion questionnaire at baseline and one-year follow-up was 11.84 months (SD 1.14; 4.8% missing \geq one date). The average time in between completion of the self-completion questionnaire at one-year and two-year follow up was 11.91 months (SD 1.03; 4.7% missing \geq one date).

2.2. Mental illness

2.2.1. Mental illness outcome

The five-item Mental Health Inventory (MHI-5) is a short questionnaire that can be used to detect patients with anxiety and depression in primary care [24]. The measure demonstrates good internal consistency reliability (Cronbach's $\alpha = 0.84$) [25]. Cuijpers et al. [26] reported that a cut-point of 62 yielded acceptable ability to detect DSM–III–R depression and dysthymia (sensitivity 74%, specificity 91%) and anxiety disorders (GAD, panic, OCD; sensitivities 62–75%, specificities 89–90%). Participants were classified as experiencing elevated mental health symptoms (signifying a probable mental illness) at each timepoint for which their MHI-5 score was less-than-or-equal-to 62. Finally, a three-level outcome variable mental health symptom trajectory was created based on participants' mental health symptoms at one-year and two-year follow up. Not meeting the MHI-5 criteria at either follow-up

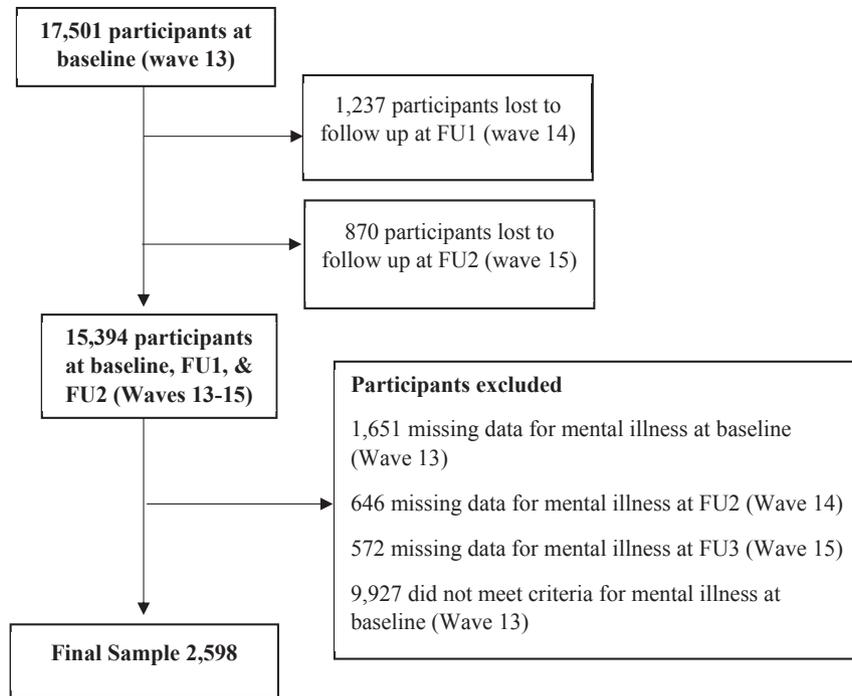


Fig. 1. Flow diagram.

time point was classed as recovery. Meeting the MHI-5 criteria at only one of the follow up time points was classed as intermittent mental health symptoms. Meeting the MHI-5 criteria at both follow-up time points was classed as chronic mental health symptoms.

2.3. Insomnia symptoms and sleep duration

2.3.1. Insomnia symptoms

Key DSM-V and ICD-10 criteria for insomnia include complaints of difficulty initiating or maintaining sleep at least three times per week [27,28]. Participants indicated how frequently over the past month they (a) had trouble sleeping because they cannot get to sleep within 30 min, and (b) had trouble sleeping because they wake up in the middle of the night or early morning. Potential responses included 'not during the past month', 'less than once a week', 'once or twice a week', 'three or four times a week', and 'five or more times a week'. Experiencing either difficulty at least three nights per week was categorized as difficulty initiating or maintaining sleep. The fact that many individuals may experience difficulty initiating or maintaining sleep but have no complaint [27,28] was also taken into account by incorporating subjective sleep quality into the operationalization of insomnia symptoms. Participants rated their overall sleep quality during the past month as "very good", "fairly good", "fairly bad", or "very bad". Responses of "fairly bad" or "very bad" were classified as poor subjective sleep quality. Finally, a dichotomous composite variable, insomnia symptoms, was created, with insomnia defined as reporting both difficulty initiating or maintaining sleep and poor subjective sleep quality.

2.3.2. Sleep duration

Employed participants were asked how many hours of sleep they usually obtain on work nights and non-work nights. Participants who were not in paid employment at baseline were asked how many hours of sleep they usually obtain on weekday and weekend nights. All participants were also asked whether they typically nap either

during the daytime or in the evening, and if so, for how long. For the employed, hours of sleep per week was then calculated by adding (a) the product of workday sleep hours and number of days worked in primary job, (b) the product of non-workday sleep hours and number of days not worked in primary job, and (c) weekly nap duration. For the unemployed, hours of sleep per week was calculated based on usual weekday and weekend sleep hours weighted according to number of weekday (five) and weekend (two) nights, and weekly nap duration. Average sleep duration was calculated by dividing hours of sleep per week by seven. As the relationship between sleep duration and mental health is non-linear, with both short and long sleep duration being associated with worse outcomes [29], sleep duration was then converted to a four-category variable (<6 h, ≥ 6 to <7 h, ≥ 7 to <8 h, ≥ 8 h). These cut-offs were selected as typically sleep duration of <6 h is categorized as short [5,10,19], the range for normal sleep duration varies between 6 and 8 h [5,10], and splitting within this range allows for possible differences in strength of associations. For analyses ≥ 7 to <8 h sleep duration was set as the reference group, as this group had the lowest prevalence of chronic mental health symptoms.

2.4. Potential covariates

The current study accounted for a range of factors that are associated with sleep disturbance and/or mental health symptoms. All potential covariates are from baseline unless otherwise stated. Variable definitions/categorizations were based on previous research [30], and greater detail is provided in Appendix, Table A.1.

2.4.1. Demographics and socioeconomic status

Education was classified as high (masters or doctorate, graduate diploma, graduate certificate, bachelor or honours), intermediate (advanced diploma, diploma, Certificate III or IV, completed high school), and low (not completed high school). Dichotomous variables indicated whether respondents were partnered (married or in a de facto relationship), employed, of Aboriginal or Torres Strait Islander background (assumed no if not confirmed), or spoke

English as a second language (assumed no if not confirmed). Equivalised household income was calculated according to the 'modified Organization for Economic Cooperation and Development (OECD) scale' [31], with lower limits set to 0 (ie, negative values were not permitted). Extreme scores at the upper-end of the distribution were top-coded, with upper limits set to the seventy-fifth percentile plus 1.5 times the interquartile range. Low social support was assessed with a 10-item measure described in Milner et al., [32] Items require respondents to report level of agreement with statements such as "I have no one to lean on in times of trouble" on an 8-point Likert scale. The measure demonstrates good internal consistency reliability (Cronbach's $\alpha = 0.84$) [31]. Low social support was defined as average scores below 4.69, as such scores have been found to be associated with poorer mental health [31]. Stressful life events were based on endorsing the occurrence of at least one of a number of stressful life events (eg, death of a family member, loss of relationship, loss of employment) in the two years prior to T3 (reported at T2 & T3) [33].

2.4.2. Physical health and related behaviours

Binary variables reflected physical health characteristics and behaviours as follows: Pain was based on ratings of 'severe' or 'very severe' on a 6-point scale [34]; drinking behaviour was based on drinking alcohol five days per week or more [35]; smoking behaviour was based on smoking daily [36]; obesity was based on a BMI of 30 or higher [37]; and chronic illness was based on self-reported diagnoses of type I or II diabetes, heart disease or circulatory disease, hypertension, asthma, cancer, arthritis or osteoporosis, or other serious illness (with the exception of mental health diagnoses) [38]. Potential undiagnosed sleep apnoea was based on self-reported trouble sleeping due to coughing or snoring at least three nights per week [39]. Physical activity was based on moderate-to-vigorous physical activity more than three times per week [40].

2.4.3. Mental illness and treatment

The presence of a previous episode of mental illness (of which the insomnia symptoms could be a residual symptom) was defined as meeting the above MHI-5 criteria at any of waves 1–12 after initially joining the study (ie, up to 12 years previously). Self-reported sleep and other psychiatric medication use was also obtained, and the MHI-5 was included as a continuous measure of mental health.

2.5. Statistical analyses

All analyses were conducted using SPSS version 25 (IBM). Descriptive statistics were obtained for the final sample, with differences between groups defined by mental health symptom trajectory assessed via t-tests and chi-squared tests. Univariate associations between mental health symptom trajectory and each of the predictors and covariates, and associations between sleep variables (insomnia symptoms and sleep duration) and covariates were assessed via logistic regression.

Associations between sleep variables and mental health symptom trajectory were then adjusted for covariates that were found to be associated with both the outcome measure and at least one of the sleep variables. For adjusted models, multiple imputation was used to impute missing values [41] with the Markov chain Monte Carlo method, under the assumption that data were missing at random (MAR), using all independent variables and two-way interaction terms as predictors. Estimates from 30 imputed samples were pooled for analysis [42].

The analysis was hierarchical, with mental health symptom trajectory first regressed on baseline insomnia symptoms or sleep duration (in separate analyses), adjusting for age and sex. In

subsequent steps, other covariates were added to the model in blocks ordered from those expected to have a lesser attenuating effect on the coefficient for sleep variables, to those expected to have the greatest attenuating effect or found to be most strongly associated with mental illness outcome. After the first step, other sociodemographic covariates were added to the model, followed by physical health covariates, then mental health covariates. For each model, linearity of the relationships between logits and predictors was assessed using the Box-Tidwell procedure. For continuous covariates which were nonlinear with the logit, two polynomial terms were created by respectively squaring and cubing the continuous variable [43]. These polynomial terms were entered with the associated continuous variable (eg, age-squared and age-cubed entered with age). Quadratic terms were included at each step of the model at which either it or the cubic term was significant, while a cubic term was only included if it was significant.

In another model both sleep variables were added to fully-adjusted models to determine whether each had an independent effect on mental health symptom trajectory.

In a separate model, interactions between insomnia symptoms and sleep duration, adjusted for covariates, were assessed. Interactions between insomnia symptoms and each of the covariates were also included in this model to take into account potential variation in coefficient slopes based on factors other than the potential moderator of interest, and the sample was large enough for inclusion of these additional terms to be feasible. Interactions between sleep variables and age group (<25 years, 25–44 years, 45–64 years, 65 + years) [30], sex, and past mental health were also assessed in this manner.

The treatment of multiple-level categorical variables in regression analyses would not allow all possible categories to be compared. Therefore, as in previous studies [10], we also created a categorical variable with six groups defined by combinations of insomnia symptoms and sleep duration (categories in Table 4). For this analysis, sleep duration of <6 h or ≥ 6 to <7 h were defined as "short sleep duration". The initial analysis was then repeated using this "joint sleep variable", with the combination of no insomnia symptoms and ≥ 7 to <8 h sleep duration as the reference group.

All regressions were re-run with original (non-imputed) data, to assess whether associations of insomnia symptoms or sleep duration with mental illness outcome were sensitive to data imputation. Any differences between analyses using imputed and original (non-imputed) data are reported in the results.

3. Results

For those who had baseline mental health data, missing mental health data at one or two-year follow-up was negatively associated with elevated mental health symptoms at baseline, but not with insomnia symptoms or sleep duration. Missing data comprised 0–4.8% of values per variable, with the exception of psychiatric medication (8.1% missing), past mental illness (9.1%), and chronic illness (15.7%). See Appendix Table A.2 for missing data proportions and characteristics of original and imputed data sets.

3.1. Descriptive statistics

Participants in the final sample ranged from 15 to 94 years of age ($M = 44.35$, $SD = 17.86$). This included 125 individuals <18 years of age. At two-year follow-up, a total of 673 participants (25.9% of the sample) were assessed as meeting criteria for recovery, 711 (27.4%) as experiencing intermittent mental health symptoms, and 1214 (46.7%) as experiencing chronic mental health symptoms. A total of 1056 (40.6%) participants were assessed as experiencing insomnia symptoms at baseline. Characteristics of the sample are found in

Table 1
Characteristics of the sample as a whole and stratified by mental health symptom trajectory.

	Whole sample (n = 2598) ^a	Recovery (n = 673)	Intermittent (n = 711)	Chronic (n = 1214)	F	p
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Age	44.35 (17.86)	42.7 (17.5)	42.5 (18.0)	46.4 (17.8)	14.63	<0.001
Household income (\$10k's)	9.62 (6.68)	10.72 (6.96)	9.71 (6.52)	8.96 (6.55)	15.31	<0.001
Mental health (MHI-5 continuous)	48.03 (11.99)	52.6 (8.8)	49.6 (10.8)	44.6 (13.1)	113.15	<0.001
	n (%)	n (%)	n (%)	n (%)	χ^2	p
Insomnia symptoms	1056 (40.6)	202 (30.3)	270 (38.6)	584 (48.9)	63.39	<0.001
Sleep duration						
<6 h	729 (28.3)	152 (22.7)	192 (27.3)	385 (32.0)	44.80	<0.001
≥6 to <7 h	574 (22.3)	146 (21.8)	137 (19.5)	291 (24.2)		
≥7 to <8 h	708 (27.5)	228 (34.0)	216 (30.7)	264 (21.9)		
≥8 h	567 (22.0)	144 (21.5)	159 (22.6)	264 (21.9)		
Sex (female)	1506 (58.0)	381 (56.6)	438 (61.6)	687 (56.6)	5.31	0.070
Education (low)	881 (33.9)	200 (29.7)	258 (36.3)	423 (34.8)	9.17	0.057
Education (intermediate)	1193 (45.9)	319 (47.4)	314 (44.2)	560 (46.1)		
Education (high)	524 (20.2)	154 (22.9)	139 (19.5)	231 (19.0)		
Partnered	1470 (56.6)	404 (60.0)	400 (56.3)	666 (54.9)	4.75	0.093
Unemployed	1221 (47.0)	244 (36.3)	323 (45.4)	654 (53.9)	54.91	<0.001
ATSI background	84 (3.2)	15 (2.2)	22 (3.1)	47 (3.9)	3.79	0.150
English second language	305 (11.7)	66 (9.8)	81 (11.4)	158 (13.0)	4.41	0.110
Low social support	1350 (53.2)	243 (37.0)	359 (51.8)	748 (63.1)	116.32	<0.001
Stressful life events	2103 (81.5)	542 (81.1)	590 (83.3)	971 (80.6)	2.31	0.315
Pain	418 (16.1)	68 (10.1)	106 (14.9)	244 (20.1)	32.95	<0.001
Drinking >4 times/week	322 (12.5)	86 (12.9)	81 (11.5)	155 (12.9)	0.90	0.638
Smoking daily	522 (20.2)	107 (16.0)	143 (20.3)	272 (22.5)	11.32	0.003
Obesity	718 (29.0)	154 (23.8)	208 (30.8)	356 (31.0)	11.89	0.003
Chronic illness	1190 (54.3)	267 (45.1)	300 (50.1)	623 (62.4)	50.65	<0.001
Potential sleep apnea	266 (10.4)	40 (6.0)	74 (10.6)	152 (12.7)	20.51	<0.001
Physical Activity > 3 times/week	670 (25.9)	198 (29.5)	199 (28.1)	273 (22.6)	13.11	0.001
Past mental illness	2082 (88.1)	441 (75.6)	554 (87.0)	1087 (95.2)	142.19	<0.001
Sleep medication (1 + per week)	474 (18.5)	43 (6.8)	86 (13.1)	280 (25.4)	107.56	<0.001
Psychiatric medication (regular)	409 (17.1)	72 (10.8)	123 (17.5)	279 (23.3)	44.76	<0.001

^a Reported n's and percentages of those in each mental health symptom trajectory category with listed characteristics are based on data pre-imputation. N missing values (%): age = 0 (0.0), income = 0 (0.0), mental health (MHI-5 continuous) = 0 (0.0), insomnia = 38 (1.5), sleep duration = 20 (0.8), sex = 0 (0.0), education = 0 (0.0), partnered = 0 (0.0), unemployed = 0 (0.0), ATSI background = 0 (0.0), English second language = 0 (0.0), low social support = 62 (2.4), stressful life events = 17 (0.7), pain = 5 (0.2), drinking = 21 (0.8), smoking = 18 (0.7), obesity = 125 (4.8), chronic illness = 408 (15.7), potential sleep apnoea = 36 (1.4), physical activity = 10 (0.4), past mental illness = 236 (9.1), sleep medication = 29 (1.1), other psychiatric medication = 210 (8.1).

Table 2
Association of insomnia symptoms with sleep duration.

Sleep duration	N	No insomnia symptoms (n = 1496/2541) ^a	Insomnia symptoms (n = 1045/2541) ^a	χ^2	p
		n (%) ^b	n (%) ^b		
<6 h	716	207 (13.8)	509 (48.7)	411.48	<0.001
≥6 to <7 h	566	337 (22.5)	229 (21.9)		
≥7 to <8 h	700	526 (35.2)	174 (16.7)		
≥8 h	559	426 (28.5)	133 (12.7)		

^a n = 57 missing either sleep duration or insomnia symptoms.

^b % of those within insomnia symptoms category who report sleep duration within specified range.

Table 1, stratified by mental health symptom trajectory. See **Table 2** for associations between insomnia symptoms and sleep duration.

In univariate logistic regression analyses the majority of independent variables (n = 19/23) were associated with mental health symptom trajectory. All covariates associated with mental health symptom trajectory were also associated with insomnia symptoms and/or sleep duration. See **Appendix Tables A.3–A.5** for associations of mental health symptom trajectory and sleep variables with other predictors/covariates.

3.2. Insomnia symptoms

Associations of sleep variables with mental health symptom trajectory are outlined in **Table 3**. Adjusted for age and sex, insomnia symptoms were associated with intermittent mental health symptoms (odds ratio (OR) 1.43, 95% CI 1.15–1.80) and chronic mental health symptoms (OR 2.16, 95% CI 1.77–2.65). After

adjustment for physical health covariates insomnia symptoms were no longer associated with intermittent mental health symptoms (OR 1.23, 95% CI 0.97–1.56). After mental health covariates were accounted for, insomnia symptoms were still associated with chronic mental health symptoms (OR 1.40, 95% CI 1.11–1.76). When further adjusted for sleep duration, insomnia symptoms remained a significant predictor of chronic mental health symptom (OR 1.34, 95% CI 1.05–1.72).

As those with “no insomnia symptoms” included those with difficulties initiating and maintaining sleep (DIMS) but normal sleep quality, we considered the possibility that this subgroup may differ from the remainder of the “no insomnia symptoms” group (ie, those with no DIMS and normal sleep quality). However, post-hoc analyses indicated that difficulties initiating or maintaining sleep in the absence of poor sleep quality was not associated with greater adjusted odds of intermittent (OR 1.03, 95% CI 0.68–1.57) or chronic (OR 1.28, 95% CI 0.86–1.91) mental

Table 3
Adjusted associations of sleep variables with mental health symptom trajectory.

	Intermittent mental health symptoms (n = 711/2598)		Chronic mental health symptoms (n = 1214/2598)	
	AOR (95% CI) ^a	p	AOR (95% CI) ^a	p
Insomnia symptoms (yes/no)				
Age and sex adjusted	1.43 (1.15–1.80)	0.002	2.16 (1.77–2.65)	<0.001
Sociodemographics adjusted ^b	1.34 (1.07–1.69)	0.011	1.96 (1.59–2.41)	<0.001
Physical health adjusted ^c	1.23 (0.97–1.56)	0.081	1.76 (1.42–2.18)	<0.001
Mental health adjusted ^d	1.11 (0.87–1.41)	0.406	1.40 (1.11–1.76)	0.004
Sleep duration (categories)				
Age and sex adjusted				
<6 h	1.33 (1.00–1.77)	0.052	2.06 (1.59–2.68)	<0.001
≥6 to <7 h	0.98 (0.73–1.33)	0.915	1.70 (1.30–2.22)	<0.001
≥7 to <8 h	reference		reference	
≥8 h	1.15 (0.86–1.55)	0.335	1.57 (1.19–2.05)	0.001
Sociodemographics adjusted ^{b,e}				
<6 h	1.19 (0.89–1.59)	0.250	1.72 (1.31–2.26)	<0.001
≥6 to <7 h	0.97 (0.72–1.32)	0.859	1.65 (1.26–2.18)	<0.001
≥7 to <8 h	reference		reference	
≥8 h	1.08 (0.80–1.46)	0.602	1.43 (1.08–1.90)	0.013
Physical health adjusted ^c				
<6 h	1.11 (0.83–1.49)	0.487	1.61 (1.22–2.12)	<0.001
≥6 to <7 h	0.95 (0.70–1.29)	0.755	1.63 (1.23–2.15)	<0.001
≥7 to <8 h	reference		reference	
≥8 h	1.04 (0.77–1.41)	0.777	1.36 (1.02–1.80)	0.034
Mental health adjusted ^d				
<6 h	1.06 (0.79–1.43)	0.689	1.48 (1.11–1.98)	0.008
≥6 to <7 h	0.96 (0.70–1.31)	0.790	1.65 (1.23–2.22)	<0.001
≥7 to <8 h	reference		reference	
≥8 h	1.03 (0.76–1.40)	0.835	1.34 (0.99–1.81)	0.056

^a Based on multinomial logistic regressions, with recovery (n = 673/2598) as reference group.

^b Adjusted for covariates from previous stages plus income, education, partnered, unemployment, English as second language, low social support.

^c Adjusted for covariates from previous stages plus pain, physical activity, smoking, potential sleep apnoea, obesity, chronic illness.

^d Adjusted for covariates from previous stages plus mental health continuous (MHI-5), past mental illness, sleep medication, psychiatric medication.

^e Quadratic and cubic terms included for age.

Table 4
Associations of the joint sleep variable (insomnia symptoms, sleep duration) with mental health symptom trajectory.

	n ^a	Intermittent mental health symptoms (n = 711/2598)		Chronic mental health symptoms (n = 1214/2598)	
		AOR (95% CI) ^b	p	AOR (95% CI) ^b	p
Age and sex adjusted					
No insomnia symptoms, <7 h	544	1.01 (0.74–1.38)	0.946	1.44 (1.08–1.92)	0.012
Insomnia symptoms, <7 h	738	1.61 (1.18–2.20)	0.003	3.15 (2.37–4.18)	<0.001
No insomnia symptoms, ≥7 to <8 h	526	reference		reference	
Insomnia symptoms, ≥7 to <8 h	174	1.53 (0.97–2.40)	0.067	1.81 (1.18–2.78)	0.006
No insomnia symptoms, ≥8 h	426	1.29 (0.92–1.79)	0.136	1.63 (1.19–2.22)	0.002
Insomnia symptoms, ≥8 h	133	1.26 (0.73–2.20)	0.409	2.70 (1.67–4.37)	<0.001
Adjusted for all covariates^c					
No insomnia symptoms, <7 h		0.91 (0.62–1.33)	0.613	1.34 (0.92–1.94)	0.126
Insomnia symptoms, <7 h		1.28 (0.86–1.91)	0.217	2.35 (1.60–3.45)	<0.001
No insomnia symptoms, ≥7 to <8 h		reference		reference	
Insomnia symptoms, ≥7 to <8 h		0.98 (0.56–1.72)	0.956	1.04 (0.60–1.81)	0.882
No insomnia symptoms, ≥8 h		1.15 (0.75–1.75)	0.518	1.46 (0.96–2.22)	0.077
Insomnia symptoms, ≥8 h		0.84 (0.41–1.72)	0.640	1.31 (0.67–2.56)	0.431

^a n's based on original data.

^b Effect sizes based on multinomial logistic regressions using pooled imputed data, with recovery (n = 673/2598) as reference group.

^c Adjusted for covariates from the previous stage plus income, education, partnered, unemployment, English as second language, low social support, pain, physical activity, smoking, potential sleep apnoea, obesity, chronic illness, mental health continuous (MHI-5), past mental illness, sleep medication, psychiatric medication.

health symptom trajectories, compared to those with no DIMS and normal sleep quality.

3.3. Sleep duration

Sleep duration was associated with chronic mental health symptoms after adjustment for sociodemographics, physical health, and mental health. Sleeping <6 h (OR 1.48, 95% CI 1.11–1.98), ≥6 to <7 h (OR 1.65, 95% CI 1.23–2.22) and >8 h (OR

1.34, 95% CI 0.99–1.81) per night were associated with greater likelihood of chronic mental health symptoms at two-year follow-up compared to sleeping ≥7 to <8 h per night, though statistical significance was not reached for >8 h.

After adjustment for insomnia symptoms, the trend remained for sleep duration to be association with chronic mental health symptoms. Sleeping <6 h (OR 1.32 95% CI 0.97–1.80, p = 0.077), ≥6 to <7 h (OR 1.59, 95% CI 1.18–2.14, p = 0.002), and ≥8 h per night (OR 1.36, 95% CI 1.00–1.84, p = 0.047) continued to be associated

with chronic mental health symptoms. The pattern was similar using non-imputed data, though sleeping <6 h (OR 1.50, 95% CI 1.04–2.16) but not ≥ 6 h (OR 1.42, 95% CI 0.98–2.05, $p = 0.064$) reached statistical significance.

In a sensitivity analysis, when <6 h sleep duration was further broken down into ≤ 5 h ($n = 367$ in original data) and >5 to <6 h ($n = 362$ in original data), sleeping ≤ 5 h (OR 1.90, 95% CI 1.29–2.79) but not >5 to <6 h (OR 1.25, 95% CI 0.89–1.75) was associated with chronic mental health symptoms after full covariate adjustment.

3.4. Interactions

There was no significant interaction between insomnia symptoms and sleep duration. However, the analysis using the ‘joint sleep variable’ defined by combinations of insomnia symptoms and sleep duration suggested that insomnia symptoms had a greater independent association with chronic mental health symptoms when combined with <7 h per night sleep duration (Table 4).

There were no significant interactions between sleep variables and sex.

There was no significant interaction between age group and insomnia symptoms. There was a significant interaction between age group and sleep duration. Sleeping <6 h per night was more strongly associated with chronic mental health symptoms for those aged 45–64 years than those aged <25 years (OR 2.51, 95% CI 1.04–6.09, $p = 0.041$). There was also a trend for sleeping <6 h per night to be more associated with chronic mental health symptoms for those aged 25–44 years than those aged <25 years (OR 2.32, 95% CI 0.93–5.80, $p = 0.072$), which was significant using non-imputed data.

There was also a significant interaction between insomnia symptoms and past mental illness (OR 2.49, 95% CI 1.17–5.33, $p = 0.019$). For those with past mental illness, insomnia symptoms, fully-adjusted, were associated with greater risk of chronic mental health symptoms at two-year follow-up (OR 1.56, 95% CI 1.21–2.01), while for those without past mental illness insomnia symptoms were not associated with increased risk of chronic mental health symptoms (OR 0.73 95% CI 0.32–1.68). This interaction was not significant using non-imputed data (OR 2.26, 95% CI 0.98–5.22, $p = 0.055$), but the pattern of a significant association for those with a prior history of mental illness and lack of association for those without such a history remained. There was no interaction between sleep duration and past mental illness.

4. Discussion

To our knowledge, this is the first study to show that both insomnia and sleep duration, alone and in combination, are associated with the trajectory of elevated mental health symptoms after adjustment for a wide range of potential confounders, in a sample aged across the adult lifespan. Insomnia symptoms were more predictive of a chronic trajectory for those with a history of probable mental illness. The combination of insomnia symptoms with short sleep duration (<7 h per night) was more predictive of chronic mental health symptoms than either dimension of sleep disturbance alone.

The findings related to insomnia symptoms were partly consistent with most previous research. They are in line with the results of previous studies which suggest an association between insomnia and mental illness chronicity [15–17]. The current results build on these findings by adjusting for a range of potential confounders not previously considered.

There is also a lack of previous research assessing potential interaction between sleep disturbance and mental health history. We observed that insomnia symptoms were more predictive of

chronic mental health symptoms for those with a history of likely mental illness. It is possible that those with a history of mental illness are more likely to be experiencing chronic (rather than acute) insomnia, and that this stable insomnia is associated with worse mental health prognosis. However, the hypothesis was untestable here as no measure of insomnia symptom chronicity was available, and the possibility warrants future exploration.

Our findings related to sleep duration are also consistent with previous research. Large-scale studies have found that after adjustment for potentially confounding variables, shorter sleep duration was associated with increased risk of persistently elevated psychological distress 12–18 months later [18], and two-year chronic course trajectory of depression/anxiety [19]. We also found that short and long sleep duration were associated with a chronic course trajectory of mental health symptoms, after adjusting for a wider range of covariates than in previous research (though long sleep duration did not reach statistical significance).

Perhaps the primary finding of the current study was that the combination of insomnia symptoms and short sleep duration were more predictive of a chronic course of mental health symptoms than either insomnia or short sleep duration alone. This extends the findings of previous studies [7,9]. Furihata et al., [7] observed an “additive” effect of sleep disturbance dimensions on depression incidence in a population of older women (mean age 80.1 years) [7]. Fernandez-Mendoza et al., [9] found that insomnia with short sleep duration is associated with incident depression independent of coping resources and other covariates. The current study demonstrates a similar “combined” effect of insomnia symptoms and short sleep duration, but in this case shows that (a) this effect is also associated with trajectory (as opposed to incidence) of mental health symptoms, (b) this effect is robust to adjustment for a wider range of confounders than those included previous studies.

It should be noted that one previous study adjusting for a range of confounders suggested that insomnia does not contribute to the impact of sleep disturbance on chronicity of common mental disorders [19]. However, this may be explained by differences in measurement. Rather than using diagnostic criteria, insomnia in this earlier study was determined using a measure which has previously been found to have limited sensitivity (53%) and specificity (67%) when used to detect insomnia, and was validated in an age-and-sex-restricted sample of postmenopausal women [20]. Resultant misclassification may have prevented the identification of a relationship between insomnia and illness chronicity. Furthermore, the finding in the current study that the combination of insomnia and short sleep duration is more strongly associated with mental health chronicity than either sleep dimension in isolation is supported by growing evidence that insomnia with objective short sleep duration is the most “biologically severe” form of the disease, as evidenced by associations with multiple physiological markers of hyperarousal [11].

It is important to consider that in theory, the sleep disturbance which is associated with chronicity of mental ill-health may simply be a residual symptom of prior mental illness, or indicative of more severe mental health symptoms at baseline, rather than a causal/maintaining factor. However, these factors (past mental health and baseline mental health symptoms) were controlled for in the current analyses. Furthermore, it is also possible that the attenuation of effects following covariate adjustment to some degree represents over adjustment [44]. For example, controlling for an intermediate variable on a causal path from sleep disturbance to mental health symptom chronicity (eg, continuous mental health at baseline, possibly a function of sleep disturbance) may bias the effect of sleep disturbance towards the null.

Therefore, the significant association of insomnia symptoms and sleep duration with mental health symptom trajectory, even after

adjustment for multiple confounders, suggests that maximising the probability of mental illness recovery may require targeting sleep disturbance when present, regardless of other illness-maintaining factors, notably including the baseline severity of mental health symptoms and past mental illness. It is also noteworthy that associations of sleep disturbance with mental health symptom chronicity appeared strongest for those with insomnia symptoms and short sleep duration combined as opposed to either in isolation. Combined with evidence that insomnia with objective short sleep duration is more biologically severe than insomnia with normal sleep duration [11], this suggests intervention is particularly indicated for those presenting with this phenotype.

4.1. Limitations & future work

The strength of the above recommendations is tempered by several limitations in the present study. It is possible that had complete diagnostic criteria been used to classify probable mental illness (rather than a cut-point on a mental health scale), sleep disturbance may have been more or less strongly associated with chronicity. The measure we used shows good ability to discriminate between cases and non-cases of depression and anxiety [26], and excellent specificity in particular means nearly the whole sample might be expected to meet criteria for depression and/or anxiety. However, using diagnostic criteria would also make it possible to determine whether sleep disturbance is predictive of illness chronicity for particular diagnoses. The temporal “coverage” of the measures was also a limitation, as illness during the one-year period between each timepoint was not assessed. This means the true trajectory of illness was not assessable. However, those who were ill at both follow-up timepoints might be expected to be doing worse on average than those who were not, and so the measure is likely at least a good proxy for chronicity. There were also limitations in the measurement of covariates. For example, the measure of alcohol consumption accounted for frequency but not quantity of consumption, and the measure of unemployment did not distinguish between unemployment due to retirement versus inability to find work.

Another limitation is the reliance on self-report and potential associated inaccuracies. This is especially relevant for our population, as those with mental illness are often not individually accurate in estimating their habitual sleep duration [45]. Further assessment of the relationship between sleep disturbance and mental health symptom trajectories using objective measures of sleep (and adjusting for potential confounders) is therefore warranted.

Finally, the results of the current study suggest that it may be especially important to address insomnia when combined with short sleep duration, but do not indicate how. It is beyond the scope of this paper to thoroughly explore this question. However, one notable hypothesis is that patients with insomnia and short sleep duration, who display higher physiological arousal and poorer response to cognitive-behavioural interventions for insomnia (CBT-I), may benefit from pharmacotherapy or combined therapy (CBT-I + medication) [46]. In any case, the current results indicate that research confirming effective interventions for sleep disturbance and its phenotypes in psychiatric populations may aid in optimising mental health symptom trajectories.

5. Conclusion

Notwithstanding acknowledged limitations, the results of the current study suggest that insomnia and short sleep duration are not simply symptoms of physical or mental illness, but predict a chronic trajectory of elevated mental health symptoms. This speaks to a need for those with mental health symptoms and their clinicians to identify

and address sleep disturbance (ie, insomnia and/or short sleep duration) when present, regardless of other illness-maintaining factors. This may be particularly important for those presenting with the combination of insomnia and short sleep duration.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

This paper uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Project was initiated and is funded by the Australian Government Department of Social Services and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this paper, however, are those of the authors and should not be attributed to either DSS or the Melbourne Institute. NG serves on the advisory board for Lundbeck, receives honoraria from Lundbeck and MSD, and is supported by grants from NHMRC of Australia. TL is supported by the Academy of Finland (Grants #287488 and #319200).

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2018.10.008>.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sleep.2018.10.008>.

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