

Association of sleep duration and sleep quality with the physical, social, and emotional functioning among Australian adults

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Running head: Sleep Health and Functioning

To Sleep Health

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Abstract

Objectives: We aimed to evaluate the interaction of two key determinants of sleep health, quantity and quality, with physical, emotional, and social functioning, in the general population.

Design: Nationally representative Australian cross-sectional study.

Setting: General population.

Participants: 14571 people aged 15 or older in Household, Income and Labour Dynamics in Australia (HILDA) in 2013.

Measurements: The associations of sleep quality (good/poor) in combination with mid-range (6-8 hours), short (<6) or long (>8) sleep duration with functioning, determined from the SF-36, were evaluated using logistic regression adjusting for sociodemographic, relationships, health behaviours, obesity, pain, and mental and physical illness confounders.

Results: After adjusting for gender, and age, poor sleep quality in combination with short, mid-range and long sleep was associated with worse physical, emotional and social functioning. Pain and comorbid illness explained much of these associations, while attenuation from other covariates was minor. The associations of poor sleep quality with worse functioning remained after full adjustment regardless of sleep duration, while among people with good quality sleep, only those with long sleep duration reported poorer functioning.

Conclusions: Poor sleep quality has robust associations with worse functioning regardless of total duration in the general population. There appears to be a substantial number of functional short sleepers with good quality sleep.

Keywords: population-based; insomnia symptoms; sleep quantity; Australia; SF-36

Introduction

Sleep health can be conceptualised as having several different dimensions e.g the five proposed by Buysse (1) and each may have different effects upon human function. The associations between sleep duration and health, work ability, and mortality have been studied in many different cohorts, with the results providing strong and relatively consistent evidence that short and long sleep duration increase the risk of adverse health outcomes (2,3). Other studies have focused on sleep quality, typically characterised as insomnia, with similar consistency of evidence for its impact on health (4,5). Although sleep duration (both objectively measured and subjectively reported) shows high inter-individual variability the vast majority of public health messages focus on everyone achieving a certain number of hours of sleep (6), only recently have these messages attempted to capture the risks related to poor sleep quality (7).

With few exceptions most of the studies have not considered the interaction of sleep duration and quality contributing to health functioning. Where assessed together, sleep quality and quantity have been jointly associated with ill-health, increased work disability and deficits in neuropsychological and psychomotor performance, with the most pronounced risks typically found among people with poor sleep quality and short sleep (8-14). In such studies on sleep quality and sleep duration, mid-range and long sleep durations have often been combined (8,14). This is somewhat surprising, as even the first study published on the association between sleep duration and mortality showed that the risks are highest in both extreme ends of sleep duration distribution, i.e., among short *and* long sleepers (2). Moreover, both short and long sleepers report poorer sleep quality which suggests that each of these groups could be distinguished from people with sleep duration within population mean range (15,16). Findings from The Penn State Cohort suggest for instance that understanding the impact of sleep disturbance on cognition requires knowledge and consideration of both dimensions simultaneously (14), but that study also combined mid-range and long sleep duration. Combining mid-range

and long sleep assumes a linear correlation between sleep duration and health, despite consistent evidence that the association is actually curvilinear or U-shaped (17,18).

To address the above gaps, we aimed to examine how combinations of sleep quality and sleep duration are associated with different dimensions of health functioning. The associations were examined in a population-based nationally representative Australian dataset with the ability to address potential confounders behind any such relationship such as pain, sociodemographic factors, health behaviours, and health. Based on the previous literature, it was expected that both poor sleep quality and short and long sleep duration contribute to poor health functioning, and that the most dysfunctional groups are people with poor sleep quality in combination with short or long sleep.

Participants and methods

Data

Data for this study were derived from the ongoing Household, Income and Labour Dynamics in Australia (HILDA) panel survey (19,20). The primary aims of the survey are to explore the dynamics of family and households, income and welfare and the labour market and as such respondents are less aware of health-related analyses. The data are nationally representative, with the initial reference population for wave 1 being all residents of Australia living in private dwellings (20). A multi-stage sampling approach was applied. Altogether 7,682 households and 19,914 individuals participated at wave 1. The response rate at baseline was 66%. In 2011, 2,153 households, and 5,451 persons were added to the cohort (response rate 69%).

Cross-sectional data from wave 13 collected in 2013 were used for this study (n=17,501), as sleep questions were first introduced in that survey. More than 95% of previous-wave respondents participated at wave 13 (19). We excluded those who died in 2013 and 2014 (n=90) to reduce the effects of severe illnesses on reports of sleep and functioning (near death approach), leaving 14,557 participants, who provided data for the variables of interest, i.e., sleep, functioning and covariates.

Sleep

Sleep duration was self-reported in hours. It was asked separately from those currently employed and not employed. Both groups were also asked to separately report their sleep for weekdays/work day nights and weekends/non-work nights. From the responses, a sum variable of total sleep duration per week was computed, and this was divided by seven to get mean daily sleep duration for each participant, as we could not assume a 5:2 work:weekend split. The questions specifically asked about "How many hours of actual sleep do you usually get?" (on a work day night/ non-work night, weekdays and weekends), and are assumed to reflect actual sleep duration and not time

in bed. Daily mean sleep duration was classified into short sleep (less than 6 hours per night), mid-range sleep (6 to 8 hours per night) and long sleep (more than 8 hours per night), mid-range broadly reflecting current adult recommendations (21). A more detailed classification was not feasible due to low numbers in the extreme ends of sleep duration combined with sleep quality.

Self-reported sleep quality was based on two core insomnia symptoms reflecting difficulties initiating or maintaining sleep (DIMS): reporting "trouble sleeping because cannot get to sleep within 30 minutes" and "trouble sleeping because wake up in the middle of the night or early in the morning", in addition to overall rating of sleep quality, reflecting daytime consequence of these insomnia symptoms. Five response alternatives ranged from "not during the past month" to "at least five times a week during past month" for insomnia symptoms, and from "very good" to "very bad" for overall sleep quality. Participants were considered to have poor sleep quality if they reported either difficulty initiating OR maintaining sleep at least three times or more per week during the past month AND rated their overall sleep quality as either "fairly bad" or "very bad".

A categorical variable was then made classifying people into good or poor sleep quality and one of the three sleep duration categories, forming six groups (categories in the Appendix 1 and Table 2). Those with good quality and mid-range duration sleep served as a reference group.

Covariates

Covariates were all self-reported and comprised key sociodemographic factors, health behaviours, obesity, pain, physical and mental illnesses. These variables were identified a priori due to their established associations with sleep and functioning in these data and elsewhere (22-26). For the descriptive analyses, age was classified into two groups: 15 to 44 years, and 45 years or more, as poor sleep quality tends to increase particularly in midlife (23,27) alongside declines in health and functioning (26). In the multivariable

analyses, we included age as a continuous variable. Employment status was dichotomized into those working (all current employees, employers or those self-employed, and employees of their own business and <1% who were unpaid family workers) and not working. Descriptive analysis was stratified by employment status, and the dummy variable was adjusted for in all the models, as sleep duration and sleep quality vary by employment status (23). This also better allows comparisons for previous studies that have mainly included employed people and have focused on work disability (8,10,11). Marital status was defined as being married/de facto, with those separated, divorced, widowed or single combined to another category. Education was classified into three hierarchical groups: high (masters or doctorate, graduate diploma, graduate certificate, bachelor or honours), intermediate (advanced diploma, diploma, Certificate III or IV, completed high school) and low (less than high school). We also considered whether the participant was living with children aged 0-4 years (no/yes), as this might affect sleep (19,23). Social connections were defined based on how often participants reported they "got together socially with friends or relatives that were not living with them". Seven response alternatives ranged from "every day" to "less often than once every 3 months".

Smoking was classified into three groups: never smokers, ex-smokers and current smokers. Alcohol use was defined similarly based on current and former drinking patterns: never drinkers, former drinkers, drinking alcohol 1-2 times a week or less, and drinking alcohol 3 times a week or more often. Body mass index (BMI) was based on self-reported weight and height (kg/m^2), with participants divided into normal weight and obese ($\text{BMI} > 30$) categories. Pain was based on responses to the SF-36 question about bodily pain in last 4 weeks with seven response alternatives ranging from "no bodily pain" to "very severe pain". Any chronic disease included any of depression or other mental illness, type I or II diabetes, heart disease or circulatory disease, hypertension, asthma, cancer, arthritis or osteoporosis or other serious illness.

Health functioning

We used transformed scales of the role physical, role emotional and social functioning subscales of the SF-36 for the outcomes (28). The range of each of the transformed scores varied from 0 to 100, with higher scores indicating better functioning. The validity of the SF-36 as well as the item-internal consistency, item-discriminant validity, and scale reliabilities in these data have been found to be good and subscales included in this study were shown to have sound psychometric properties, namely good internal consistency, discriminant validity and high reliability (28). We dichotomized each subscale to focus on the poorest functioning quartile, as has been commonly done in previous literature (29-31).

For sensitivity analyses we ran the same models classifying participants with any positive responses to the original items as having 'poor functioning', separately for all dimensions. This produced very similar distributions and associations, and we present the conventional transformed scales for final analyses only.

Statistical analyses

The descriptive results reflect characteristics of the HILDA wave 13 sample. We first described the distribution of sleep health and potential confounders in the study population by employment status (Table 1), and then cross-tabulated the categorical sleep exposure with each dimension of functioning (Table 2: results of chi-square tests are displayed). Cross-tabulations between the sleep exposure groups and covariates can be found in Appendix 1. Finally, separate logistic regression models were fitted (Table 3). Model 1 was adjusted for gender, age, and employment status, while model 2 additionally included all other sociodemographic and socioeconomic factors. Model 3 was adjusted for gender, age, health behaviours and obesity, model 4 for gender, age and social connections, model 5 for gender, age and pain. In model 6, we estimated the associations adjusting for all covariates simultaneously. As a sensitivity analysis, Appendix 2 shows that a finer categorisation of sleep duration does not substantially

change the associations with health functioning. In further sensitivity analyses (Appendices 3-4), the impact of sleep duration and insomnia on functioning were modelled separately and the pattern of associations was as expected given the main results. All the analyses were conducted using an SAS Statistical Software, version 9.4 (SAS, Cary, NC, USA).

Results

The sample characteristics are shown in Table 1, stratified by employment status. Roughly two thirds of all participants were employed. Participants not working were less educated, and more likely to have a chronic disease. Short sleep duration was more prevalent ($p < 0.001$) among those not employed (23%) than those employed (16%). The prevalence of long sleep was 27% among people not employed and 19% among those employed (Table 1). Poor sleep quality was also more common among people not employed than employed people (24% vs 17%). Distribution of the 6-category sleep duration/ sleep quality predictor is in Table 2, while the Online Appendix 1 displays the covariates association with sleep health.

Table 2 shows the prevalence of role limitations due to poor physical and emotional health and social functioning in different categories of sleep duration and quality. Participants with poor sleep quality were consistently more likely than those with good sleep quality to report poorer functioning in all three dimensions. Similarly, those with short and long sleep durations had poorer functioning than those reporting 6-8 hours of sleep, regardless of sleep quality. These patterns were similar for those employed and not employed, although the absolute level of poorer functioning was higher among people not employed.

The associations between sleep quantity and quality with health functioning were further examined using logistic regression (Table 3). After adjusting for gender, age, and employment status, all categories of sleep quality/quantity were associated with poorer functioning compared to mid-range sleep duration (6-8 hours) and good sleep quality. For the role physical subscale, the strongest associations were found for people reporting poor sleep quality, and short (OR 3.15; 95% CI 2.76-3.61), mid-range (OR 3.00; 95% CI 2.60-3.46) or long sleep (OR 4.60; 95% CI 3.52-6.02). Adjustments for sociodemographic factors, employment, health behaviours and obesity made but a minor contribution to these associations, whereas somatic and mental illnesses and the level of

pain reduced the associations the most. However, the association between sleep and physical functioning remained statistically significant, except for short sleep with good quality after full adjustment.

The association of sleep categories with the role emotional subscale largely followed those for physical subscale, with people reporting both poor sleep quality and short (OR 3.14; 95% CI 2.75-3.58), mid-range (OR 3.32; 95% CI 2.93-3.76) or long sleep (OR 4.75; 95% CI 3.69-6.11) being the most 'dysfunctional' groups. The effects of adjustment on the associations also followed those for role physical subscale. Thus, the associations similarly remained in the fully adjusted models, with the exception for participants with short duration but good quality sleep.

Finally, strong associations were also found for social functioning. The strongest associations were again found for people with poor sleep quality, in combination with short (OR 4.15; 95% CI 3.65-4.72), mid-range (OR 3.26; 95% CI 2.85-3.74) and long sleep (OR 6.60; 95% CI 5.11-8.54). Adjusting for covariates followed a similar pattern as compared to the other forms of functioning.

Sensitivity analyses stratifying by employment status were conducted but as similar associations were observed, only the results of analyses adjusting for employment status are shown. Additionally, working hours were adjusted for in a sensitivity analysis among employed people to cover the potential effects of overtime on the associations, however, working hours (both continuous and categorized) made a negligible contribution to the examined associations.

Discussion

In this population representative sample self-reported sleep quality and sleep duration interact to impact on physical, emotional, and role functioning such that good quality sleep of short duration is not associated with poor functioning. Poor sleep quality is strongly associated with worse daytime functioning regardless of duration whilst the association of long sleep duration on poorer function appears independent from that of sleep quality. These associations between poor sleep quality and functioning remained significant, if attenuated in size, after considering a priori factors considered likely confounders. People with poor sleep quality had worse functioning even in those with mid-range sleep durations.

Interpretation and implications

Previous studies on the interaction of sleep duration and quality have not considered different dimensions of functioning. Thus, the novelty of this study is that the association between sleep quality and functioning holds across all categories of sleep duration and three domains of function. While our results are in line with previous studies focusing on sleep quantity and quality as separate factors, and their association with quality of life (32-34), comparability to this study remains limited, as these previous studies did not address sleep duration and sleep quality simultaneously. Quality of life has also been measured in various ways from single reports about perceived quality of life using the SF-36 survey. For instance, previous studies have reported that poor sleep quality is associated with poorer emotional reactions, social isolation and physical mobility (35), and lower scores on all dimensions of health functioning (36,37).

Being circumspect that our study is cross-sectional, focus on both sleep quality and duration simultaneously is of importance, as short sleep of good quality appeared to have no or but weak associations with functioning. Furthermore, there is very little or no difference between short and mid-range sleep duration groups in the presence of poor sleep, which is a novel finding and could be further elaborated in prospective studies of

different health outcomes. In previous studies focusing on sleep duration only (34), it is thus possible that the adverse effects have mainly been related to poor sleep quality and not the duration of sleep.

Accordingly, we found that poor sleep quality combined with any sleep duration was associated with both physical and emotional function, with little or no difference between mid-range and short sleepers. This is in contrast to other studies which suggest that insomnia with mid-range sleep duration is associated with sleep misperception and cognitive-emotional arousal, and that only insomnia with short sleep is linked to worse mental and physical health (13). However, we used self-reported sleep duration in the current study rather than polysomnographic determination of sleep time, so it is possible that objectively measured short sleep has distinct effects on functioning.

Due to a relatively large variation in sleep duration in populations (23,34), for some people 'short' or 'long' sleep by our definition could reflect their preferred sleep pattern. It is assumed that functioning is normal when sleep duration meets the perceived need for sleep. This assumption is supported by our results showing little difference in functioning for people with different sleep durations and good sleep quality, particularly after considering all potential confounders. One might expect that if sleep duration is very extreme (short or long), adverse health effects could emerge (21) but based on our findings, this does not appear to be case for people with short habitual sleep, independent of pre-existing health conditions. As having poor sleep quality is likely worse for functioning than extreme sleep durations, these results suggest that a public health message might need to shift from asking "did you get enough sleep" to "did you sleep well".

With respect to poor sleep quality and long sleep, one explanation for the strong associations with poor functioning could be assumed to be linked to pre-existing ill-health. However, as we omitted all deaths occurring during the year of participation and

the year after, and as we controlled for various serious mental and physical illnesses, this explanation does not seem plausible.

The group of people with long and poor quality sleep is small, and hence of limited public health relevance, but further studies are warranted to better understand who reports long sleep in combination with poor quality and why. In the current study population, the characteristics of people with long and poor quality sleep do not appear dramatically different to other people with poor quality sleep (Appendix 1) with similar sociodemographic background, health behaviours, obesity and health characteristics. As the U-shaped association between sleep duration and reports of sleep problems is well-established (15,16), future studies could corroborate which factors account for varying sleep duration among people with poor quality sleep, particularly with objective indicators of sleep quality such as sleep efficiency and sleep fragmentation. Based on the current results, it appears that perceived sleep quality is more important than sleep duration for functioning.

The approach chosen to examine the contribution of sleep quality and quantity to health functioning could also be of importance. For example, person-orientated methods such as latent class analyses and also cluster analyses have been used in some studies to find what kind of groups naturally occur and exist in the populations (38-40). To examine, if more information could be revealed using a person-orientated approach, we initially also used latent class analysis. Those analyses also supported that sleep duration deviant from the population mean combined with poor sleep quality, is most detrimental to health functioning (data not shown). Producing similar findings with different methods provides more compelling evidence about the significance of sleep quality to health, independent of sleep duration.

Finally, some previous studies have also questioned the implications of short and long sleep. For example, previous studies have not found an association between sleep duration and mortality in midlife (41), or between sleep duration and CRP (42).

Background mechanisms of long sleep – health association have also been discussed and problematized (43).

Methodological considerations

When further interpreting our results, it needs to be acknowledged that self-reported data on sleep duration and poor sleep quality could have led to some bias. Sleep duration is known to be overestimated compared to objective measures, especially among people with short sleep (44,45). In turn, insomniacs with objective normal sleep duration have been shown underestimate their sleep (46). As the actual prevalence of short or long sleep or poor quality sleep was not the focus of the study, we cannot see whether this bias should be associated with our functional outcomes. Negative reporting bias could be assumed to affect the results, if those reporting poorest sleep also were more likely to report worse function. However, with regards to sleep duration, short or long sleep is not by definition negative, as e.g. people with short sleep do not necessarily have worse functioning. To our knowledge, there are no studies focusing on objective sleep duration and sleep quality and functioning, and thus it is difficult to confirm the actual contribution of negative reporting bias to our results. Still, even self-reported symptoms such as insufficient or poor quality sleep should not be ignored, and studies of their associations with different health outcomes such as functioning, and elaboration of mechanisms that explain the associations are needed.

The included sleep quality items are not fully similar to the recent recommendations (7), which we acknowledge as a limitation. However, in large epidemiological studies such as this one, it is not usually feasible to include lengthy multi-item measures. While crude, these included items, nonetheless, reflect core insomnia symptoms and should distinguish between poor and good sleepers. Moreover, the associations between individual insomnia symptoms and work disability have been very similar for both difficulties maintaining and initiating sleep (47). In future studies, more detailed measurements could help distinguish what types of symptoms contribute most strongly

to the perception of sleep quality (e.g. initiation or maintenance). Nonetheless, due to the broad definition of sleep quality, we acknowledge that random misclassification leads to error that will most likely underestimate a true association.

It further needs to be acknowledged that sleep variables were introduced rather late in the HILDA cohort. However, the response rates have remained high among those who initially participated in the study, suggesting that health-related attrition is unlikely to distort the findings (19,20). Nonetheless, if healthier people were more likely to participate at this follow-up survey, their sleep and functioning are assumed better as compared to total population. This makes our findings conservative. As the study was cross-sectional, reverse causality cannot be ruled out. This means that poorer sleep could lead to poorer functioning, or people with poor functioning could have shorter and poorer quality sleep.

Although self-reported, our measures of functioning have been well-validated, also in this population (28). However, it has already been previously proposed that the included scales are likely unable to capture the multifactorial nature of interference of insomnia to the dimensions of functioning such as social functioning (32). More detailed and in-depth effects could be better addressed in qualitative or intervention studies, targeted to the high risk groups such as the long sleepers with poor sleep quality identified in the present study. In other words, although some aspects of functional limitation are missed in questionnaire surveys, using validated questionnaires is, nonetheless, likely to capture at least in a proxy way the true phenomena about the contribution of sleep quantity and quality to the different dimensions of functioning.

A strength of this study is the inclusion of key correlates of sleep and functioning, and the ability to control for both physical and mental illnesses, pain, health behaviours and sociodemographic factors as well as social connections. This helped produce more robust evidence about the relative contribution of sleep quantity and quality to health

functioning. A further strength is the inclusion and comparison of different dimensions of functioning, namely physical, emotional and social. Most studies have been focusing on mental health, and links between sleep and mental health (48), with social functioning receiving less attention. The apparently strong association and mechanisms between poor sleep and poor social functioning need to be further elaborated and corroborated using prospective data and more objective outcomes. As the associations are clear for different forms of functioning, this highlights the importance of focusing on wide domains of functioning. A further strength of this study is the opportunity to examine nationally representative Australian data comprising a sample of both those currently employed and not employed, and to show that the associations are not unique to working populations most often studied when focusing on the interaction between sleep quantity and quality (8,10,11). Finally, as the initial focus of the study was not related to sleep or health, the participants' responses are less likely to have been affected or biased with respect to the current aims.

Conclusions

This study showed consistent associations between most combinations of poor sleep quantity and quality with functioning in a large population, representative of Australian adults. In line with previous work, poor sleep quality tends to dominate these associations, irrespective of sleep duration. In this general population short sleep in combination with good quality sleep does not appear to be associated with poorer functioning. These findings suggest that public health messages around sleep should focus less on achieving a "normal" sleep duration and more on achieving good quality sleep.

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Table 1. Distributions of study variables in HILDA wave 13 (column %), stratified by employment

	All (n=14571) (col%)	Employed (n=9272) (col%)	Not Employed (n=5299) (col%)
Gender			
Men	46.7	50.7	39.6
Women	53.3	49.3	60.5
Age group			
15-44 years	51.2	59.6	36.5
45 years or more	48.8	40.4	63.5
Current employment status			
Working	63.6	100	0
Not working	36.4	0	100
Marital status			
Married/ cohabiting	64.3	68.4	57.1
Separated, divorced, widowed, single	35.7	31.6	42.9
Education			
High	25.5	31.4	15.1
Intermediate	47.0	50.9	40.1
Low	27.6	17.7	44.9
Children aged 0-4 years in household			
No	87.1	86.0	88.9
Yes	12.9	14.0	11.1
Body mass index			
Normal weight	77.3	78.5	75.3
Obese (BMI => 30)	22.7	21.5	24.7
Smoking			
Never smoker	54.9	56.7	51.7
Ex-smoker	27.4	26.1	29.8
Current smoker	17.7	17.3	18.5
Alcohol drinking			
Never drinker	11.3	7.7	17.6

Former drinker	7.7	5.7	11.2
Current drinker, 1-2 times a week or rarer	25.9	26.9	24.2
Current drinker, 3-7 times a week	55.1	59.7	47.0
Any chronic disease^a			
No	55.2	65.8	36.7
Yes	44.8	34.2	63.3
Poor sleep quality			
No	80.5	83.0	76.2
Yes	19.5	17.0	23.8
Sleep duration			
Less than 6 hours	18.9	16.3	23.3
6-8 hours	59.4	64.7	50.1
More than 8 hours	21.8	19.0	26.6

^a Depression or other mental illness, diabetes type I or II, heart/circulatory disease, hypertension, asthma, cancer, arthritis or osteoporosis or other serious illness

Table 2. Prevalence of outcome by sleep quality and quantity in HILDA wave 13 (n=14571; row %)

	Poor physical functioning (row%)	Poor emotional functioning (row%)	Poor social functioning (row%)	Total row numbers (%)
All				
Sleep quality and quantity				
Good quality, 6-8 hours of sleep	16.7	17.1	14.8	7437 (51.0%)
Good quality, short sleep	23.4	21.3	21.2	1397 (9.6%)
Good quality, long sleep	23.0	22.1	20.2	2901 (19.9%)
Poor quality, 6-8 hours of sleep	34.7	39.9	36.4	1219 (8.4%)
Poor quality, short sleep	42.2	43.7	45.6	1349 (9.3%)
Poor quality, long sleep	44.8	52.6	56.0	268 (1.8%)
<i>p-value (chi-squared test)</i>	<.0001	<.0001	<.0001	
Total %, N	23.0	23.5	21.9	14571 (100%)
Employed				
Sleep quality and quantity				
Good quality, 6-8 hours of sleep	10.8	14.2	11.2	5225 (56.4%)
Good quality, short sleep	13.1	17.4	15.7	839 (9.1%)
Good quality, long sleep	14.2	15.9	14.3	1633 (17.6%)
Poor quality, 6-8 hours of sleep	24.5	33.9	27.1	776 (8.4%)
Poor quality, short sleep	26.9	33.2	31.9	674 (7.3%)
Poor quality, long sleep	29.6	46.4	42.4	125 (1.4%)
<i>p-value (chi-squared test)</i>	<.0001	<.0001	<.0001	
Total %, N	14.2	18.3	15.4	9272 (100%)
Not employed				
Sleep quality and quantity				
Good quality, 6-8 hours of sleep	30.6	23.7	23.5	2212 (41.7%)
Good quality, short sleep	38.9	27.2	29.6	558 (10.5%)

Good quality, long sleep	34.3	30.1	27.9	1268 (23.9%)
Poor quality, 6-8 hours of sleep	52.6	50.3	52.8	443 (8.4%)
Poor quality, short sleep	57.5	54.1	59.3	675 (12.7%)
Poor quality, long sleep	58.0	58.0	67.8	143 (2.7%)
<i>p-value (chi-squared test)</i>	<.0001	<.0001	<.0001	
Total %, N	38.4	32.6	33.4	5299 (100%)

Table 3. Associations of sleep quality and quantity with *poor* physical, emotional and social functioning in HILDA wave 13 (n=14571)

Sleep quality and duration	Model 1: age, gender, and employment status adjusted for		Model 2: Model 1+ marital status, young children, education, employment status		Model 3: Model 1+, smoking, alcohol and body mass index		Model 4: Model 1 + social connections adjusted for		Model 5: Model 1+ pain		Model 6: all covariates in Models 1-5 + any serious mental or physical health condition	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
<i>Poor physical functioning</i>												
Good quality, 6-8 hours	1.00		1.00		1.00		1.00		1.00		1.00	
Good quality, short sleep	1.25	(1.08 -1.45)	1.24	(1.07 -1.44)	1.20	(1.03 -1.39)	1.25	(1.08 -1.45)	0.96	(0.81 -1.14)	0.95	(0.80 -1.12)
Good quality, long sleep	1.40	(1.25 -1.57)	1.38	(1.23 -1.55)	1.40	(1.24 -1.57)	1.41	(1.26 -1.58)	1.36	(1.19 -1.55)	1.34	(1.18 -1.53)
Poor quality, 6-8 hours	3.00	(2.60 -3.46)	2.99	(2.59 -3.45)	2.85	(2.46 -3.29)	2.92	(2.53 -3.36)	1.82	(1.54 -2.15)	1.74	(1.47 -2.06)
Poor quality, short sleep	3.15	(2.76 -3.61)	3.12	(2.72 -3.56)	2.88	(2.52 -3.3)	3.04	(2.66 -3.48)	1.49	(1.27 -1.74)	1.41	(1.20 -1.65)
Poor quality, long sleep	4.60	(3.52 -6.02)	4.49	(3.44 -5.88)	4.33	(3.30 -5.70)	4.43	(3.38 -5.81)	2.50	(1.80 -3.48)	2.32	(1.67 -3.24)
<i>Poor emotional functioning</i>												
Good quality, 6-8 hours	1.00		1.00		1.00		1.00		1.00		1.00	
Good quality, short sleep	1.22	(1.06 -1.41)	1.22	(1.06 -1.41)	1.18	(1.02 -1.36)	1.22	(1.05 -1.4)	1.10	(0.95 -1.27)	1.07	(0.92 -1.24)
Good quality, long sleep	1.26	(1.13 -1.40)	1.22	(1.09 -1.36)	1.26	(1.13 -1.41)	1.27	(1.14 -1.41)	1.22	(1.09 -1.36)	1.19	(1.06 -1.33)

Poor quality, 6-8 hours	3.14	(2.75 -3.58)	3.15	(2.76 -3.59)	2.99	(2.62 -3.42)	3.01	(2.64 -3.44)	2.46	(2.15 -2.82)	2.27	(1.97 -2.61)
Poor quality, short sleep	3.32	(2.93 -3.76)	3.31	(2.91 -3.75)	3.07	(2.71 -3.49)	3.15	(2.78 -3.58)	2.34	(2.05 -2.67)	2.10	(1.83 -2.41)
Poor quality, long sleep	4.75	(3.69 -6.11)	4.58	(3.56 -5.90)	4.57	(3.54 -5.89)	4.49	(3.48 -5.78)	3.51	(2.70 -4.57)	3.03	(2.31 -3.97)
<i>Poor social functioning</i>												
Good quality, 6-8 hours	1.00		1.00		1.00		1.00		1.00		1.00	
Good quality, short sleep	1.39	(1.20 -1.61)	1.38	(1.19 -1.60)	1.32	(1.14 -1.53)	1.38	(1.19 -1.6)	1.16	(0.99 -1.36)	1.11	(0.95 -1.31)
Good quality, long sleep	1.31	(1.17 -1.47)	1.26	(1.13 -1.42)	1.31	(1.17 -1.47)	1.33	(1.18 -1.49)	1.24	(1.1 -1.41)	1.21	(1.07 -1.37)
Poor quality, 6-8 hours	3.26	(2.85 -3.74)	3.26	(2.84 -3.74)	3.04	(2.65 -3.49)	3.09	(2.69 -3.55)	2.22	(1.91 -2.58)	2.00	(1.71 -2.33)
Poor quality, short sleep	4.15	(3.65 -4.72)	4.09	(3.59 -4.65)	3.73	(3.28 -4.25)	3.89	(3.42 -4.43)	2.46	(2.13 -2.83)	2.15	(1.85 -2.49)
Poor quality, long sleep	6.60	(5.11 -8.54)	6.31	(4.88 -8.17)	6.23	(4.80 -8.09)	6.19	(4.77 -8.03)	4.51	(3.37 -6.03)	3.81	(2.83 -5.12)

Appendix 1. Study variables (column %) by combinations of sleep quality and duration among participants in HILDA wave 2013 (n=14571)

	Good quality, 6-8 hours of sleep (n=7437)	Good quality, short sleep (n=1397)	Good quality, long sleep (n=2901)	Poor quality, 6-8 hours of sleep (n=1219)	Poor quality, short sleep (n=1349)	Poor quality, long sleep (n=268)	<i>p-value (chi- squared)</i>
Gender							
Men	49.3	48.8	45.2	42.4	38.6	39.6	
Women	50.7	51.3	54.8	57.6	61.5	60.5	<.0001
Age group							
15-44 years	51.8	43.0	56.8	52.8	41.9	57.1	
45 years or more	48.2	57.1	43.2	47.3	58.1	42.9	<.0001
Current employment status							
Employed	70.3	60.1	56.3	63.7	50.0	46.6	
Not employed	29.7	39.9	43.7	36.3	50.0	53.4	<.0001
Marital status							
Married/ de facto	67.9	65.6	56.9	63.3	62.3	53.0	
Single	32.1	34.4	43.1	36.7	37.7	47.0	<.0001
Education							
High	29.7	19.9	21.8	26.7	15.9	16.4	
Intermediate	47.4	47.3	45.2	45.8	48.7	48.1	
Low	22.9	32.8	33.0	27.5	35.3	35.5	<.0001
Children aged 0-4 years							
No	86.7	82.4	91.9	85.2	84.4	93.3	
Yes	13.3	17.6	8.1	14.8	15.6	6.7	<.0001
Body mass index							
Normal weight	79.2	74.6	80.8	72.4	68.4	69.8	
Obese (BMI => 30())	20.8	25.4	19.2	27.7	31.6	30.2	<.0001
Smoking							
Never smoker	57.6	49.1	60.6	46.6	42.2	48.5	
Ex-smoker	27.2	31.0	24.0	29.1	30.8	27.2	

Current smoker	15.2	19.9	15.4	24.3	27.1	24.3	<.0001
Alcohol drinking							
Never drinker	9.9	12.4	16.3	8.4	9.3	12.3	
Former drinker	6.3	7.9	7.9	9.8	11.9	14.2	
Current drinker, 1-2 times a week or rarer	27.1	26.4	22.5	27.0	25.0	25.4	
Current drinker, 3-7 times a week	56.6	53.3	53.3	54.8	53.8	48.1	<.0001
Current pain							
No	29.5	23.1	31.1	16.8	10.9	19.4	
Intermediate	55.4	52.3	49.5	49.1	43.9	38.1	
Severe	15.1	24.6	19.4	34.0	45.2	42.5	<.0001
Meeting with friends/relatives							
Every day, several times a week	28.0	28.6	33.9	23.9	21.7	22.8	
About once a week, 2-3 times a month	53.1	48.4	48.5	49.2	49.2	48.9	
About once a month or less	18.9	23.0	17.6	26.9	29.1	28.4	<.0001
Any chronic disease^a							
No	60.4	51.5	56.6	47.7	37.2	39.2	
Yes	39.6	48.5	43.4	52.3	62.8	60.8	<.0001

^a Depression or other mental illness, diabetes type I or II, heart/circulatory disease, hypertension, asthma, cancer, arthritis or osteoporosis or other serious illness

Appendix 2. Prevalence of outcome by sleep quality and detailed quantity in HILDA wave 13 (n=14571)

Sleep quality and duration	Poor physical functioning (row %)	Poor emotional functioning (row %)	Poor social functioning (row %)	Total row numbers (%)
Good quality, 6-8 hours of sleep	16.7	17.1	14.8	7437 (51.0%)
Good quality, very short sleep (less than 5 hours)	26.0	22.2	26.0	316 (2.2%)
Good quality, short sleep (5 hours to less than 6 hours)	22.7	21.1	19.9	1081 (7.4%)
Good quality, longish sleep (more than 8 hours to less than 9 hours)	19.9	19.9	17.0	1982 (13.6%)
Good quality, long sleep (9 hours to less than 10 hours)	24.4	22.5	22.2	614 (4.2%)
Good quality, very long sleep (10 hours or more)	39.7	35.7	37.4	305 (2.1%)
Poor quality, 6-8 hours of sleep	34.7	39.9	36.4	1219 (8.4%)
Poor quality, very short sleep (less than 5 hours)	47.0	48.2	50.2	662 (4.5%)
Poor quality, short sleep (5 hours to less than 6 hours)	37.6	39.3	41.2	687 (4.7%)
Poor quality, longish sleep (more than 8 hours to less than 9 hours)	37.7	47.9	49.1	167 (1.2%)
Poor quality, long sleep (9 hours to less than 10 hours)	56.7	58.3	66.7	60 (0.4%)
Poor quality, very long sleep (10 hours or more)	56.1	63.4	68.3	41 (0.3%)
	<i>p-value</i>	<.0001	<.0001	<.0001
Total %, N	23.0	23.5	21.9	14571 (100%)

Appendix 3. Associations of sleep quantity with physical, emotional and social functioning in HILDA wave 13 (n=14571)

	Model 1: age, gender, and employment status adjusted for		Model 2: Model 1+ marital status, young children, education		Model 3: Model 1+, smoking, alcohol and body mass index		Model 4: Model 1 + social connections adjusted for		Model 5: Model 1+ pain		Model 6: all covariates in Models 1-5+ any serious mental or physical health condition	
Sleep duration	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
<i>Poor physical functioning</i>												
6-8 hours	1.00		1.00		1.00		1.00		1.00		1.00	
Less than 6 hours sleep	1.69	(1.52 -1.87)	1.67	(1.50 -1.85)	1.57	(1.42 -1.75)	1.65	(1.49 -1.83)	1.08	(0.96 -1.22)	1.05	(0.92 -1.18)
More than 8 hours	1.29	(1.17 -1.44)	1.27	(1.15 -1.41)	1.30	(1.17 -1.44)	1.30	(1.17 -1.45)	1.29	(1.14 -1.46)	1.28	(1.13 -1.45)
<i>Poor emotional functioning</i>												
6-8 hours	1.00		1.00		1.00		1.00		1.00		1.00	
Less than 6 hours sleep	1.70	(1.54 -1.88)	1.70	(1.54 -1.87)	1.60	(1.45 -1.77)	1.66	(1.5 -1.83)	1.38	(1.24 -1.53)	1.30	(1.17 -1.44)
More than 8 hours	1.16	(1.05 -1.28)	1.12	(1.02 -1.24)	1.18	(1.06 -1.30)	1.18	(1.07 -1.30)	1.14	(1.03 -1.26)	1.12	(1.01 -1.24)
<i>Poor social functioning</i>												
6-8 hours	1.00		1.00		1.00		1.00		1.00		1.00	
Less than 6 hours sleep	2.02	(1.83 -2.23)	1.99	(1.8 -2.2)	1.86	(1.69 -2.06)	1.96	(1.77 -2.16)	1.49	(1.33 -1.66)	1.38	(1.23 -1.55)
More than 8 hours	1.24	(1.12 -1.38)	1.20	(1.08 -1.33)	1.25	(1.13 -1.39)	1.26	(1.14 -1.40)	1.22	(1.09 -1.36)	1.20	(1.07 -1.34)

Appendix 4. Associations of sleep quality with physical, emotional and social functioning in HILDA wave 13 (n=14571)

	Model 1: age, gender, and employment status adjusted for		Model 2: Model 1+ marital status, young children		Model 3: Model 1+, smoking, alcohol and body mass index		Model 4: Model 1 + social connections adjusted for		Model 5: Model 1+ pain		Model 6: all covariates in Models 1-5+ any serious mental or physical health condition	
Sleep quality and duration	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
<i>Poor physical functioning</i>												
No insomnia	1.00		1.00		1.00		1.00		1.00		1.00	
Insomnia	2.84	(2.58 -3.13)	2.82	(2.57 -3.11)	2.66	(2.41 -2.93)	2.74	(2.49 -3.02)	1.57	(1.4 -1.76)	1.50	(1.34 -1.68)
<i>Poor emotional functioning</i>												
No insomnia	1.00		1.00		1.00		1.00		1.00		1.00	
Insomnia	3.07	(2.81 -3.36)	3.09	(2.82 -3.38)	2.90	(2.65 -3.18)	2.93	(2.68 -3.20)	2.33	(2.12 -2.56)	2.13	(1.93 -2.34)
<i>Poor social functioning</i>												
No insomnia	1.00		1.00		1.00		1.00		1.00		1.00	
Insomnia	3.49	(3.19 -3.82)	3.48	(3.18 -3.82)	3.22	(2.93 -3.53)	3.28	(2.99 -3.6)	2.30	(2.08 -2.55)	2.06	(1.85 -2.29)