

# Total sleep time as a predictor of suicidal behaviour

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## SUMMARY

Insomnia symptoms are a known predictor of suicide; however, less is known about the relationship between hypersomnia and suicide, and how total sleep time may better account for suicidal ideation compared with subjective reports of insomnia symptoms. In the present secondary data analysis, a squared term confirmed the importance of both short and long total sleep time on suicidal behaviour. Total sleep time had a significant positive direct effect on suicidal behaviour ( $b = 0.20$ ,  $SE = 0.08$ ,  $P < 0.05$ ), significant negative direct effects on insomnia symptoms ( $b = -1.67$ ,  $SE = 0.13$ ,  $P < 0.0001$ ) and on depressive symptoms ( $b = -1.76$ ,  $SE = 0.29$ ,  $P < 0.0001$ ). Depression had a significant positive effect on suicidal behaviour ( $b = 0.17$ ,  $SE = 0.01$ ,  $P < 0.0001$ ), and significantly mediated the relationship between total sleep time and suicidal behaviour, but insomnia symptoms did not. Total sleep time squared had a significant positive relationship with suicidal behaviour ( $b = 0.02$ ,  $SE = 0.01$ ,  $P < 0.05$ ), significant negative direct effects on insomnia symptoms ( $b = -0.12$ ,  $SE = 0.01$ ,  $P < 0.0001$ ) and on depressive symptoms ( $b = -0.12$ ,  $SE = 0.02$ ,  $P < 0.0001$ ). Depression had a significant positive effect on suicidal behaviour ( $b = 0.17$ ,  $SE = 0.01$ ,  $P < 0.0001$ ), and significantly mediated the relationship between total sleep time and suicidal behaviour. These results suggest the importance of assessing for total sleep time in clinical settings with regard to suicide risk.

## INTRODUCTION

The total number of questionnaires collected was 35 327. According to a large multi-national study of over 35 000 respondents, 31.6% of participants reported insomnia as measured by the Athens Insomnia Scale, while 17.5% more reported other sleep problems (Soldatos *et al.*, 2005). In addition to impacting functional outcomes and overall quality of life (Bolge *et al.*, 2009; Daley *et al.*, 2009), sleep problems have also been found to be an independent predictor of suicidal behaviour, with increasing evidence across studies suggesting that sleep problems may be predictive of suicidal ideation, attempts, and death by suicide (Pigeon *et al.*, 2012). A better understanding of the relationship between sleep problems and suicidal behaviour is critical given that suicide is the 10th leading cause of death, with about 42 000 Americans dying by suicide every year (Heron, 2016).

Studies that have examined the relation between sleep problems and suicide have found evidence to suggest that sleep problems are associated with an increased risk for death by suicide. In this study, we use the term 'sleep problems' as an umbrella term for insomnia, hypersomnia, nightmares and other sleep-related issues. With regard to insomnia, Fawcett *et al.* (1990) found that global insomnia was one of six factors predicting suicide within 1 year using a sample of 954 psychiatric inpatients. The authors describe global insomnia as one of the best modifiable risk factors for death by suicide. Similarly, in a psychological autopsy study that compared 140 adolescents that died by suicide with 131 control participants, those who died by suicide were found to have more insomnia symptoms, hypersomnia symptoms and other sleep problems compared with controls (Goldstein *et al.*, 2008). These results remained significant even after controlling for affective disorders, suggesting that sleep problems may explain unique variation in suicidality above

and beyond other well-known correlates such as depressive symptoms.

Other studies have examined the association between sleep problems and suicidality by examining other important precursors to suicide, such as suicidal ideation and suicide attempts (Bernert *et al.*, 2014; Cukrowicz *et al.*, 2006; McCall and Black, 2013; McCall *et al.*, 2013a,b; Nadorff *et al.*, 2011, 2013a,b, 2014; Pigeon *et al.*, 2012; Ribeiro *et al.*, 2012). Data also support the role of biological sleep differences in those who have attempted suicide versus controls. In a polysomnography study comparing individuals who attempted suicide versus control participants, Sabo *et al.* (1991) found that control subjects had a shorter sleep latency, higher sleep efficiency and more delta wave counts than participants who attempted suicide. In sum, although there is substantial evidence linking sleep problems to suicide risk, including that the longer one has sleep problems the greater the suicide risk (Nadorff *et al.*, 2013b), there remains a paucity of research on the role that total sleep time may have on suicidal behaviours.

### Total sleep time

A recent consensus paper suggested the appropriate sleep range is 7–9 h for adults aged 18–64 years, and the range is 7–8 h for older adults over 65 years old (Hirshkowitz *et al.*, 2015). Some studies have defined short-sleep as less than or equal to 6 h per day (Chaput *et al.*, 2012; Knutson *et al.*, 2010), while others have suggested 5 or fewer hours is considered short-sleep (Theorell-Haglöw *et al.*, 2012). Knutson *et al.* (2010) examined data from eight different studies and found the odds of having short-sleep had increased over a 31-year period after controlling for demographic variables, but only for full-time workers. In addition to affecting psychological health, sleep problems and duration of sleep affect physical health and functioning. For example, Irwin *et al.* (2016) conducted a meta-analysis on studies that examined the association between sleep problems and total sleep time and inflammatory disease risk. Evidence across 72 studies demonstrated that long total sleep time, shorter sleep duration and sleep problems were all associated with biomarkers of systemic inflammation (Irwin *et al.*, 2016). Both short and long total sleep time were associated with an increased risk of general mortality in both men and women (Hublin *et al.*, 2007), and sleep deprivation has been associated with hypertension, glucose control impairment, high blood pressure, hormone regulation and symptomatic diabetes (Alvarez and Alyas, 2007; Mullington *et al.*, 2009). Previous studies have compared assessment tools for total sleep time, including polysomnography, actigraphy and subjective reports (Kushida *et al.*, 2001). Findings suggest that polysomnography is the ‘gold standard’, although it did not differ significantly from a combination of actigraphy and a subjective measure. The authors note the importance of subjective report, especially for hypersomnia.

### Statement of the problem

The current state of the sleep and suicide literature is limited in two critical ways. First, a majority of studies fail to determine the influence of total sleep time on suicide risk. Measurement of total sleep time may be preferable to assessing specific sleep problems as sleep problems are commonly co-morbid and therefore looking at sleep difficulties independently may not provide the full clinical picture. Second, many studies do not include an analysis of hypersomnia despite the fact that the extant literature that does exist on hypersomnia suggests a relationship with suicidal behaviour. For example, in a sample of individuals 18–70 years old with major depression, it was found that participants with both insomnia symptoms and hypersomnia symptoms had higher self-reported suicide scores on the Schedule for Affective Disorders and Schizophrenia (SADS) suicide subscale (Ağargün *et al.*, 1997), suggesting both long and short periods of sleep may be important correlates of suicidal behaviour. Total sleep time may predict variance in suicidality that would not be explained by specific sleep problems.

### The present study

The hypotheses for the present study were as follows: (1) there will be a significant relationship between total sleep time and suicidality; (2) there will be a curvilinear effect for total sleep time beyond a linear effect (i.e. also an effect for excess sleep); (3) total sleep time will predict suicidality after controlling for symptoms of depression and subjective experiences of insomnia symptoms.

## MATERIALS AND METHODS

### Participants

Participants ( $n = 789$ ) for this study were recruited using mechanical Turk (mTurk), an Amazon online recruitment system. Participants first selected the study, and then were directed to an agreement form explaining the instructions of the study and inquiring if the participants were over 18 years old. If they responded that they were under 18 years old or did not agree with the instructions, they were directed to the closing screen of the experiment, ending their participation. Respondents that agreed to instructions and were over the age of 18 years were directed to a study on Qualtrics Survey Research Suite, which was used as the host for this online survey. Qualtrics has SAS 70 certification and meets HIPAA privacy standards. Data were collected and stored anonymously in accordance with an approved IRB protocol. The participants filled out the four questionnaires described below in Qualtrics. After completion, participants were directed to a screen listing nationwide mental health resources in case participants desired mental health services after the study, and lastly a page where participants were able to receive

**Table 1** Basic demographic statistics

Sex	
Female	68.6%
Male	31.4%
Declined to respond	
Race/ethnicity	
White/Caucasian non-Hispanic	80.9%
Black/African American	6.0%
Asian/Pacific Islander	2.7%
Hispanic	6.0%
Other or mixed	4.3%
Declined to respond	
Household income	
Less than \$25 000	31.6%
\$25 000–\$49 999	31.4%
\$50 000–\$74 999	16.5%
\$75 000–\$99 999	10.8%
\$100 000+	7.5%
Declined to respond	
Highest level of education completed	
Grade school	1.4%
GED	1.8%
High school	9.8%
Some college	32.3%
2-year college degree (e.g. Associates)	12.5%
4-year college degree (e.g. Bachelors)	29.5%
Advanced degree (e.g. Master's or Doctoral degree)	12.7%
Declined to respond	
Age	
	Range = 18–75
	M = 35.74
	Mdn = 33.00
	SD = 12.29

compensation for participation. Data collection for the study was approved by Mississippi State University's IRB. The data were collected in an effort to replicate our previous work using an mTurk sample to see whether the samples we collect in the Southern USA are consistent with a sample recruited from across the USA. To date, only one paper has been published using a portion of these data: Golding *et al.* (2015) combined the older adults from this dataset with another large online data collection in order to examine whether our previous work replicates among older adults. The present manuscript represents the first study utilizing the full dataset. Data were analysed at Florida State University following IRB approval for secondary data analyses (see Table 1 for participant demographics).

## Measures

### Depression

Depressive symptoms were measured using the Inventory for Depressive Symptomatology (IDS; Rush *et al.*, 1986). The measure consists of 30 items that are rated on a four-point scale ranging from 0 to 3, with higher scores indicating more severe depressive symptoms. The validity and reliability of this

measure has been demonstrated in previous studies (Rush *et al.*, 1996). In the traditional scoring scheme, a total of 28 of the 30 items are scored, with a maximum total possible score of 84. The larger of items 11 (increased appetite) and 12 (decreased appetite) and the larger of items 13 (increased weight) and 14 (decreased weight) are included in the total score. Item 18 was removed for analysis purposes because the item asks about suicide, which would have been conflated with the measure below asking about suicide. Items 1–4, which assess sleep concerns, were also removed for mediational analyses to reduce the effects of multicollinearity. Cronbach's alpha was 0.92 in the present sample. The distribution of scores for the IDS without the sleep and suicide items was as follows:  $M = 21.35$ ,  $SD = 12.63$ .

### Insomnia symptoms

The Insomnia Severity Index (ISI; Bastien *et al.*, 2001) measures subjective experiences of insomnia symptoms in addition to subjective distress resulting from those symptoms. The measure consists of seven items that occur on a five-point scale ranging from 0 to 4, with higher scores suggesting more severe insomnia symptoms. Cronbach's alpha was 0.88 in the present sample. The distribution of scores on this measure was as follows:  $M = 12.79$ ,  $SD = 6.05$ . Reliability and validity for the ISI were supported in a psychometric study by Rush *et al.* (2003).

### Suicidal ideation and behaviour

The Suicidal Behaviors Questionnaire-Revised (SBQ-R; Osman *et al.*, 2001) is a self-report questionnaire consisting of four items that measure past suicidal ideation, past suicidal behaviour, and potential for future suicidal behaviour. Each item has a different response scale, with scores ranging from 3 to 18 (sample item: 'Have you ever thought about or attempted to kill yourself?'). In the present sample, Cronbach's alpha for responses to SBQ-R items was 0.84, which is classified as good internal consistency based on the number of items and sample size according to published metrics (Ponterotto and Ruckdeschel, 2007). Previous reliability and validity have been demonstrated by a psychometric study by Osman *et al.* (2001). For the present study, the items had a Cronbach's alpha of 0.84. The distribution of scores on this measure was as follows:  $M = 7.63$ ,  $SD = 3.80$ . SBQ-R scores were not normalized due to the bootstrapping procedure. Based on responses to item 1 of the SBQ-R, 129 participants (16.4%) reported a prior suicide attempt.

### Total sleep time

The Stanford Five-City Physical Activity Interview administered was an online self-report questionnaire (Sallis *et al.*, 1985). As part of this interview, participants were asked to report the number of hours they slept on weekdays and weekend days in the past week. There were no significant

weekend versus weekday effects, however. This information was used to calculate a variable consisting of average total sleep time per day over the past week. Total sleep time was the only variable used from this survey. The distribution of hours slept was as follows:  $M = 5.89$ ,  $SD = 1.55$ . With regard to the distribution, 188 (23.8%) had sleep less than 5 h, while 16 (2%) had sleep more than 9 h.

#### Total sleep time squared

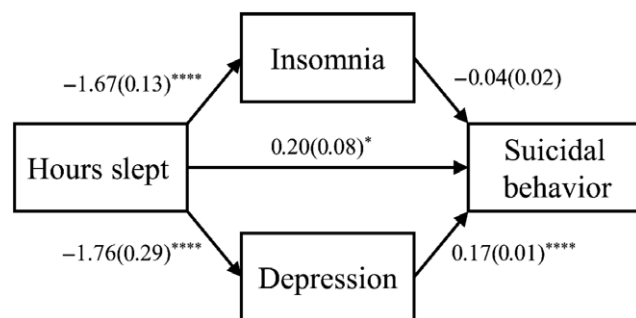
Average sleep time per day over the past week was squared and used to evaluate the potential for a U-shaped relationship between total sleep time and the outcome variable.

### Analyses

We hypothesized that there would be an effect (non-directional statistical hypothesis) of total sleep time on suicidal behaviour beyond depression and insomnia symptoms (Fig. 1). The entire sample was used for analysis, which employed Model 4 of the Process macro (Hayes, 2013) for SPSS Version 23.

### RESULTS

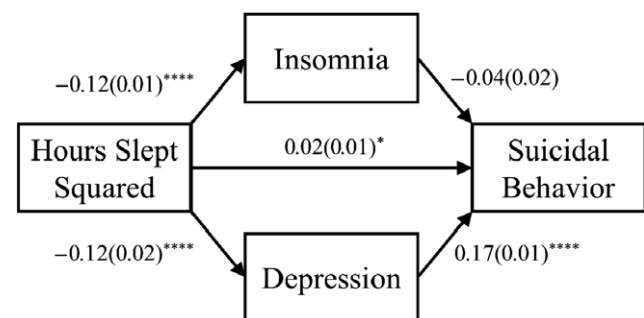
With regard to direct effects (Fig. 1), total sleep time had a significant positive direct effect on suicidal behaviour (i.e.



**Figure 1.** Mediation model depicting the effect of average hours slept on suicidal behaviour after accounting for the effects of insomnia symptoms and depression as mediators operating in parallel. All predictors were centred at their means. \* $P < 0.05$ , \*\*\*\* $P < 0.0001$ .

more sleep time was correlated with more suicidal behaviour,  $b = 0.20$ ,  $SE = 0.08$ ,  $P < 0.05$ ). Total sleep time had a significant negative direct effect on insomnia symptoms ( $b = -1.67$ ,  $SE = 0.13$ ,  $P < 0.0001$ ), and a significant negative direct effect on depressive symptoms ( $b = -1.76$ ,  $SE = 0.29$ ,  $P < 0.0001$ ). Insomnia symptoms did not have a significant direct effect on suicidal behaviour ( $b = -0.04$ ,  $SE = 0.02$ ,  $P = n.s.$ ). Depression had a significant positive effect on suicidal behaviour ( $b = 0.17$ ,  $SE = 0.01$ ,  $P < 0.0001$ ). With regard to mediation effects (Table 2), depression significantly mediated the relationship between total sleep time and suicidal behaviour, but insomnia symptoms did not.

An additional model (Fig. 2) was conducted, with total sleep time squared. The only difference between this model and the first model is that this analysis replicates the first model with total sleep time squared rather than total sleep time (linear). Total sleep time squared had a significant positive relationship with suicidal behaviour ( $b = 0.02$ ,  $SE = 0.01$ ,  $P < 0.05$ ). Total sleep time squared had a significant negative direct effect on insomnia symptoms ( $b = -0.12$ ,  $SE = 0.01$ ,  $P < 0.0001$ ), and a significant negative direct effect on depressive symptoms ( $b = -0.12$ ,  $SE = 0.02$ ,  $P < 0.0001$ ). Insomnia did not have a significant direct effect on suicidal behaviour ( $b = -0.04$ ,  $SE = 0.02$ ,  $P = n.s.$ ). Depression had a significant positive effect on suicidal behaviour ( $b = 0.17$ ,  $SE = 0.01$ ,  $P < 0.0001$ ). With



**Figure 2.** Mediation model depicting the effect of average hours slept squared on suicidal behaviour after accounting for the effects of insomnia symptoms and depression as mediators operating in parallel. All predictors were centred at their means. \* $P < 0.05$ , \*\*\*\* $P < 0.0001$ .

#	Predictor	Mediator	Criterion	Unstandardized indirect estimate		Bootstrap estimate B	95% CI	
				$\beta$	SE		Lower bound	Upper bound
1	Total sleep time	Depression	Suic. Beh.	-0.31	0.06	-0.32	-0.43	-0.20
2	Total sleep time	Insomnia symptoms	Suic. Beh.	0.07	0.04	0.07	-0.02	0.15

Suic. Beh., suicidal behaviour.

**Table 3** Hypothesized indirect effects

#	Predictor	Mediator	Criterion	Unstandardized indirect estimate		Bootstrap estimate B	95% CI	
				$\beta$	SE		Lower bound	Upper bound
1	Total sleep time squared	Depression	Suic. Beh.	-0.02	0.005	-0.02	-0.03	-0.01
2	Total sleep time squared	Insomnia symptoms	Suic. Beh.	0.005	0.003	0.006	-0.001	0.01

Suic. Beh., suicidal behaviour.

regard to mediation effects (Table 3), depression significantly mediated the relationship between total sleep time and suicidal behaviour, but insomnia symptoms did not.

## DISCUSSION

We conducted mediational analysis in this study to determine if effects between total sleep time and suicidal ideation were better accounted for by subjective feelings about insomnia symptoms or by depressive symptoms. Results demonstrated the importance of long-sleep on suicidal behaviour, and a model with a squared term confirmed the importance of both short- and long-sleep on suicidal behaviour. Taken together, the results emphasize the ambiguity of the linear relationship between sleep duration and suicide risk, and the promise of examining sleep as a quadratic predictor.

Our total sleep time results are analogous to those found with regard to other health outcomes, such as hypertension. In the Sleep Heart Health Study, it was found that those sleeping a length of time other than the median 7–8 h a night had increased risk of hypertension. Those who slept less than 6 h per night or more than 9 h per night had the highest levels of risk (Gottlieb *et al.*, 2006). A review by Nagai *et al.* (2010) reported findings of a U-shaped relationship between total sleep time and coronary heart disease from the Nurses' Health Study. Two additional studies reviewed by Nagai *et al.* (2010) found a U-shaped relationship between total sleep time and diabetes mellitus.

Thus, these results suggest the importance of assessing for total sleep time in clinical settings, as both too much and too little sleep may be associated with future suicide risk. More specifically, findings suggest that asking about total sleep time in a clinical setting may be more informative than only assessing for insomnia symptoms. This is not to say that total sleep time is a more informative predictor than insomnia, but rather that it is better to assess for both rather than one or the other. Taken together, the findings suggest the importance of total sleep time in addition to symptoms of insomnia to more fully characterize the relationship of sleep to suicide. We did not assess for hypersomnia symptoms in this study, but future studies should determine whether total sleep time predicts suicide risk beyond hypersomnia symptoms. It should also be briefly noted that there is a subtype/

phenotype of individuals with short-sleep who deny functional impairment. A functional magnetic resonance imaging study found that diminished wakefulness is likely present in all short-sleepers, and that those who deny functional impairment likely have inaccurate perceptions about their deficits. However, those denying impairment had 'increased connectivity between sensory cortices and bilateral amygdala and hippocampus, suggesting that efficient sleep-related memory consolidation may partly explain individual differences in perceived daytime dysfunction' (Curtis *et al.*, 2016).

With regard to limitations, the mediational analyses conducted in this study were based on associations derived from a cross-sectional design, limiting the ability to disentangle the temporal order of our variables. Future sleep studies using objective sleep measures such as with actigraphy or polysomnography are warranted based upon this work and would be a valuable addition to the present study, given that there is a paucity of objective sleep data in the sleep-suicide literature. While we are hopeful that our results are generalizable to other countries, our sample was made up of American participants. While there is no specific reason to believe that results would not generalize to samples from other countries, caution should be taken when making this additional assumption. Another limitation arises from the fact that our sample was non-clinical, hence the results may not be generalizable to clinical scenarios and samples. Additionally, the online sample of individuals using the mTurk platform may not be representative of the population as a whole. Indeed, our sample had higher rates of insomnia and suicidality than other published studies (Beaulieu-Bonneau *et al.*, 2007; Blüml *et al.*, 2013). Having a long total sleep time was considerably rarer than having a short total sleep time in our sample. Thus, it may be beneficial for a future research study to include targeted recruitment of those with long total sleep time.

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## CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose, and the study did not make use of off-label or investigational use products.

## AUTHOR CONTRIBUTIONS

Matthew Michaels conducted the analysis and the majority of the writing, Tia Balthrop assisted with the writing, Michael Nadorff was involved in conceptualization of the study, and Thomas Joiner was involved in the conceptualization of the study.

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