

# Meta-Analysis of Sleep Disturbance and Suicidal Thoughts and Behaviors

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## ABSTRACT

**Objective:** The potential association of various sleep disturbances to suicidal thoughts and behaviors is the subject of several reviews. The current meta-analysis was conducted to estimate the size of the association generally as well as between more specific relationships.

**Data Sources:** Electronic databases for years 1966–2011 were searched to identify candidate studies using PubMed search terms *suicide* and *sleep* or *sleep initiation/maintenance disorders* or *dreams* or *nightmares* or *sleep disorders/psychology* or *sleep disorders/epidemiology* as well as Ovid search terms *suicide* and *sleep* or *insomnia* or *nightmares*. The search was supplemented by cross-referencing from identified articles and reviews.

**Study Selection:** Original studies reporting both sleep disturbance and suicide outcomes were identified with 39 of 98 studies (40%) comprising 147,753 subjects selected for inclusion.

**Data Extraction:** Data were extracted by multiple independent observers and verified by a study author. The meta-analysis was performed using random-effects models. The size of associations was calculated for all types of sleep disturbances and suicide outcomes combined and for more specific categories including nightmares, insomnia, and insomnia subtypes and suicidal ideation, suicide attempts, and suicide. Moderator effects were evaluated.

**Results:** Overall, sleep disturbance was significantly associated with an increased relative risk for suicidal ideation, suicide attempt, and suicide ranging from 1.95 (95% CI, 1.41–2.69) to a relative risk of 2.95 (95% CI, 2.48–3.50) in unadjusted studies. Associations were smaller, but remained highly significant among adjusted studies. Depression did not moderate the association between sleep and suicide variables.

**Conclusions:** This meta-analysis supports an association between sleep disturbance and suicidal thoughts and behaviors. Sleep disturbances in general, as well as insomnia and nightmares individually, appear to represent a risk factor for suicidal thoughts and behavior. This proposition is further bolstered by the result that depression did not show risk moderation.

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Suicide accounts for nearly 1,000,000 deaths per year worldwide, with a current global mortality rate of approximately 16 per 100,000.<sup>1</sup> In the United States, for instance, suicide now represents the tenth leading cause of death, accounting for more deaths annually than homicide and human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) combined.<sup>2</sup> In addition to suicide, nonlethal suicide attempts exceed suicides by a factor of 10–20 or more in some age groups, and suicidal ideation that may or may not accompany suicidal behavior is even more common.<sup>3</sup> Despite prevention efforts and targeted interventions,<sup>4–7</sup> rates of suicide have not declined appreciably. This status persists during a time of significant advances in recognizing and treating depression, a major risk factor for suicidal thoughts and behaviors.<sup>8</sup> A number of other psychiatric and medical conditions have been identified as risk factors of suicide (eg, chronic illness, prior suicide attempt, bipolar illness, substance abuse).<sup>9</sup> To the extent that these conditions represent potentially modifiable risk factors for suicide, they may become the focus of new or expanded targeted prevention efforts.

Sleep disturbances are not included in the suicide risk factor lists compiled by the World Health Organization or the US Centers for Disease Control. Nonetheless, the potential association between poor sleep and suicide was recognized and published nearly a century ago,<sup>10</sup> and several recent reviews<sup>11–13</sup> and commentaries<sup>14–16</sup> have highlighted the probable association of sleep disturbance with suicidal thoughts and behaviors, noting that insomnia and nightmares are the sleep disturbances most commonly associated with suicidal thoughts and behaviors. In general, sleep disturbances are prevalent and are associated with a variety of psychiatric and medical conditions<sup>17,18</sup> that are themselves strongly associated with suicide. For instance, there is convincing evidence that insomnia is a risk factor for the development and/or maintenance of major depressive disorder.<sup>19</sup> In summary, there are strong links between sleep problems and risk factors for suicidal thoughts and behaviors as well as preliminary evidence directly implicating sleep disturbances in suicide-related outcomes.

The purpose of the current study was to conduct a meta-analysis to estimate the size of the associations between sleep disturbances and suicidal ideation, suicide attempts, and suicide. In addition, we examined associations with specific sleep disturbance types, including nightmares, insomnia, insomnia subtypes, and other forms of sleep disturbance. Finally, we were interested in how the associations might differ by study characteristic, including age and gender distribution of samples and cross-sectional versus longitudinal study design.

## DATA SOURCES AND STUDY SELECTION

A comprehensive sample of studies was identified by searching electronic databases limited to the years 1966–2011. PubMed was searched using the MeSH terms *suicide* and *sleep* or *sleep initiation/maintenance disorders* or *dreams* or *nightmares* or *sleep*

*disorders/psychology* or *sleep disorders/epidemiology*. Ovid was searched using the terms *suicide* and *sleep* or *insomnia* or *nightmares*.

A priori criteria for inclusion in the meta-analysis were (1) the study was reported in English, (2) the study was an original article (ie, published abstracts were excluded), (3) suicidal thoughts or behaviors were reported as an outcome, (4) sleep disturbance was reported as an outcome, and (5) the association between suicide outcome and sleep disturbance outcome were reported or data were presented in such a way that the association could be calculated.

After review of the abstracts, these searches yielded 89 potentially relevant articles along with an additional 9 articles that were identified by cross-referencing from identified studies and review articles. After review of these articles, 39 met all inclusion criteria (N = 147,753).

## DATA EXTRACTION

### Coding of Variables

We entered the authors and year of publication, sample size, the study design (cross-sectional or longitudinal), the sample procedure (representative sample or convenience/clinical sample), the mean age of the subjects, the percentage of female participants, and percentage of members of ethnic minorities. We also coded the outcomes including suicidal ideation, nonlethal suicide attempt, and suicide.

With respect to sleep outcomes, which varied considerably, we identified 3 major categories of sleep disturbances based on whether insomnia, nightmares, or other sleep disturbances were assessed. The insomnia category included studies in which insomnia was a reported symptom, was defined by a score on a validated insomnia instrument, or was diagnosed through diagnostic interview or chart review. The other sleep disturbances category included studies in which a sleep disorder other than nightmares or insomnia was identified (eg, sleep apnea), a scale identified a global sleep problem (eg, poor sleep quality), or a single-item measure not specific to insomnia or nightmare was used (eg, poor sleep). We also coded whether studies reported any or all of the 3 forms of insomnia presentation often referred to as insomnia subtypes: difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening.

Studies were also coded on whether they controlled for potential confounders (1 = no, 2 = yes) and for individual variables (1 = depression, 2 = anxiety, 3 = age, 4 = ethnicity, 5 = gender, 6 = others). The unadjusted and adjusted risk ratio and its 95% confidence interval (CI) were also calculated and entered as described below. Table 1 lists each of the selected studies and their description.

### Statistical Integration of Research Findings

Calculations for the meta-analysis were performed by using random-effects models and the noniterative method of moments, given the expected variability in effect sizes between studies beyond subject-level sampling error.<sup>59</sup> Calculations were conducted in 6 steps.

- Sleep disturbances in general, and insomnia and nightmares specifically, are significantly associated with suicidal ideation, suicide attempt, and suicide.
- Identification and management of sleep disturbance is a potentially useful strategy to alter the clinical course of individuals vulnerable to suicide.

1. The risk ratio was calculated. If the risk ratio was not reported, it was computed from information about the numbers of persons with and without sleep problems showing high or low suicidality, correlation coefficients, and standardized mean scores, based on Lipsey and Wilson.<sup>59</sup> Outliers that were more than 2 standard deviations from the mean of the effect sizes were recoded to the value at 2 standard deviations. This was the case for 1 uncontrolled effect size.
2. Then, log risk ratio and its standard errors were computed because log risk ratio is approximately normally distributed and allows for combining results across studies.
3. The log risk ratio was weighted by the inverse of the standard deviation and combined to compute an overall weighted mean effect size. The homogeneity of effect sizes was tested by use of the homogeneity statistics Q. The significance of the mean was tested by dividing the weighted mean effect size by the estimated standard error of the mean. Then confidence intervals that include 95% of the effects were computed for each effect size.
4. An analog to the analysis of variance was applied for testing whether the effect sizes would differ between conditions. A significant Q score indicates that the size of the effects differs significantly between studies. Differences between 2 conditions were interpreted as significant when the 95% CIs did not overlap.
5. Summary statistics of the effect size and the 95% CI were converted back to risk ratios by taking the antilogarithms.
6. Because statistically insignificant results may have a lower probability of being published,<sup>60</sup> which could lead to an overestimation of the effect sizes, we used the trim-and-fill procedure that estimates corrected effect sizes after imputing possible lacking effect sizes.<sup>61</sup>

Some studies reported more than 1 suicide outcome (eg, suicidal ideation and suicide attempt) and/or more than 1 sleep disturbance outcome (eg, nightmares and insomnia). In such cases, data for each association were included as separate datapoints. Therefore, a total of 56 such datapoints based on the 39 selected studies was reported. At the broadest

**Table 1. Studies Included in Meta-Analysis of Sleep Disturbances and Suicidal Ideation, Suicide Attempt, and Suicide**

Suicide Outcome	Study	Year	Sample Type	Study Type	Sample Size	Age, Mean, y <sup>a</sup>	Female Sex, %	Sleep Outcome	Covariates <sup>b</sup>
Suicidal ideation	Ağargün et al <sup>20</sup>	1997	MDD	Cross-sectional	113	32.6	65.5	Sleep item	None
Suicidal ideation	Ağargün et al <sup>21</sup>	1997	MDD	Cross-sectional	41	34.6	75.6	Sleep scale	None
Suicidal ideation	Ağargün et al <sup>22</sup>	1998	MDD	Cross-sectional	63	34.9	76.2	Nightmares	None
Suicidal ideation	Ağargün and Kara <sup>23</sup>	1998	Panic disorder	Cross-sectional	67	31.9	72.9	Sleep items	None
Suicidal ideation	Ağargün and Cartwright <sup>24</sup>	2003	Depressed	Cross-sectional	26	35.1	100.0	Polysomnography	None
Suicidal ideation	Bernert et al <sup>25</sup>	2005	Outpatient	Cross-sectional	176	26.9	59.0	Nightmares, insomnia scale	None
Suicidal ideation	Birkholz et al <sup>26</sup>	2004	Community	Cross-sectional	49	65.0	41.0	Sleep item	None
Suicidal ideation	Blasco-Fontecilla et al <sup>27</sup>	2011	Inpatient	Cross-sectional	517	39.2	33.0	Sleep duration	None
Suicidal ideation	Chellappa and Araújo <sup>28</sup>	2007	MDD	Cross-sectional	70	40.5	62.9	Insomnia	1,3,5,6
Suicidal ideation	Choquet et al <sup>29</sup>	1993	Community	Cross-sectional	598	17.0	55.0	Sleep duration	None
Suicidal ideation	Choquet and Menke <sup>30</sup>	1990	Community	Longitudinal	1,351	14.7	44.0	Difficulty maintaining sleep, nightmares	None
Suicidal ideation	Cooper-Patrick et al <sup>31</sup>	1994	Community	Cross-sectional	6,041	18–65+	62.9	Sleep item	None
Suicidal ideation	Cukrowicz et al <sup>32</sup>	2006	College	Cross-sectional	222	19.2	71.2	Nightmares	1
Suicidal ideation	Krakow et al <sup>33</sup>	2000	Sexual abuse	Cross-sectional	153	36.4	100.0	Sleep breathing disorder	None
Suicidal ideation	McCall et al <sup>34</sup>	2010	MDD	Longitudinal	60	41.5	66.7	Insomnia scale	3,5,6
Suicidal ideation	Nadorff et al <sup>35</sup>	2011	College	Cross-sectional	563	19.4	77.4	Nightmares, insomnia scale	1,2,6
Suicidal ideation	Roberts et al <sup>36</sup>	2001	Community	Cross-sectional	3,575	10.1	47.7	Sleep item	3,5,6
Suicidal ideation	Rocha et al <sup>37</sup>	2005	Inpatient	Cross-sectional	200	18–65+	49.5	Insomnia	None
Suicidal ideation	Sjöström et al <sup>38</sup>	2007	Inpatient	Cross-sectional	165	35.3	78.2	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings, nightmares	1,2,5,6
Suicidal ideation	Smith et al <sup>39</sup>	2004	Chronic pain	Cross-sectional	51	44.0	68.6	Sleep scale	None
Suicidal ideation	Yen et al <sup>40</sup>	2010	Population	Cross-sectional	8,319	15.0	52.1	Sleep duration	1,3,5,6
Suicidal ideation	Yoshimasu et al <sup>41</sup>	2006	Outpatient	Cross-sectional	231	36.6	57.1	Sleep item	1,2,3,4,6
Suicidal ideation, suicide attempt	Barbe et al <sup>42</sup>	2005	Depressed	Cross-sectional	135	12.1	45.9	Insomnia symptoms	1,3,5,6
Suicidal ideation, suicide attempt	Goodwin and Marusic <sup>43</sup>	2008	Population	Cross-sectional	8,098	15–54	50.0	Sleep duration	1,2,3,4,5,6
Suicidal ideation, suicide attempt	Liu <sup>44</sup>	2004	Community	Cross-sectional	1,362	14.6	39.7	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings, nightmares	1,3,5,6
Suicidal ideation, suicide attempt	Roane and Taylor <sup>45</sup>	2008	Community	Cross-sectional	4,457	15.8	52.4	Sleep item	1,3,4,5
Suicidal ideation, suicide attempt	Wojnar et al <sup>46</sup>	2009	Population	Cross-sectional	5,692	18–65+	58.2	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings	1,3,4,5,6
Suicidal ideation, suicide attempt	Wong et al <sup>47</sup>	2011	Population	Longitudinal	392	12–17	28.6	Nightmares, sleep item	1,3,5,6
Suicide attempt	Ağargün et al <sup>48</sup>	2007	MDD	Cross-sectional	149	32.1	51.7	Difficulty initiating sleep	None
Suicide attempt	Nrugham et al <sup>49</sup>	2008	Community	Cross-sectional	345	14.9	72.5	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings	None
Suicide attempt	Sjöström et al <sup>50</sup>	2009	Discharged	Longitudinal	95	35.3	78.2	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings, nightmares	None
Suicide	Barraclough and Pallis <sup>51</sup>	1975	Depressed	Longitudinal	192	32.2	53.0	Insomnia symptoms	None
Suicide	Björngaard et al <sup>52</sup>	2011	Population	Longitudinal	52,833	49.6	51.0	Sleep item	1,3,5,6
Suicide	Fawcett et al <sup>53</sup>	1990	Affective disorder	Longitudinal	954	38.1	58.0	Insomnia items	None
Suicide	Fujino et al <sup>54</sup>	2005	Population	Longitudinal	13,259	52.8	55.3	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakenings	None
Suicide	Goldstein et al <sup>55</sup>	2008	Suicide	Cross-sectional	271	17.4	16.6	Sleep items	1,3,4,5,6
Suicide	McGirr et al <sup>56</sup>	2007	Suicide	Longitudinal	237	42.6	22.7	Insomnia symptoms	1,6
Suicide	Tanskanen et al <sup>57</sup>	2001	Population	Longitudinal	36,211	43.5	51.1	Nightmares	1,2,3,5,6
Suicide	Turvey et al <sup>58</sup>	2002	Community	Longitudinal	420	78.6	5.0	Sleep scale	None

<sup>a</sup>The age range of the sample is provided when the mean age was not reported.

<sup>b</sup>For covariates, 1 = depression, 2 = anxiety, 3 = age, 4 = ethnicity, 5 = gender, and 6 = others (eg, other sociodemographic characteristics, other diagnoses). Abbreviation: MDD = major depressive disorder.

**Table 2. Associations of Insomnia, Nightmares, and Other Sleep Disturbances With Suicidal Outcomes: Overall Effect Sizes**

Variable	Unadjusted Effect Sizes					Adjusted Effect Sizes				
	No. of Samples	Risk Ratio <sup>a</sup>	95% CI	Z <sup>b</sup>	Q <sup>c</sup>	No. of Samples	Risk Ratio <sup>a</sup>	95% CI	Z <sup>b</sup>	Q <sup>c</sup>
Sleep disturbances of all types										
Any suicidal outcome	56	2.79	2.44–3.19	15.05***	59.11	31	1.91	1.64–2.23	8.18***	34.50
Comparison by suicidal outcome					5.78					0.18
Suicidal ideation	33	2.95	2.48–3.50	12.28***	22.93	18	1.86	1.52–2.28	6.02***	21.36
Suicide attempt	15	3.13	2.38–4.13	8.09***	14.22	8	2.01	1.47–2.74	4.41***	10.76
Suicide	8	1.95	1.41–2.69	4.02***	16.17*	5	1.96	1.32–2.91	3.36***	2.18
Insomnia										
Any suicidal outcome	32	2.84	2.44–3.31	13.39***	30.69	20	1.98	1.63–2.41	6.90***	18.21
Comparison by suicidal outcome					2.40					
Suicidal ideation	18	2.79	2.29–3.40	10.15***	9.76	12	1.94	1.51–2.49	5.16***	14.48
Suicide attempt	8	3.54	2.50–4.97	7.20***	6.39	4	1.99	1.39–2.99	3.30***	1.89
Suicide	6	2.43	1.74–3.40	5.18***	12.15*	4	2.15	2.35–3.43	3.22**	1.68
Nightmares										
Any suicidal outcome	14	2.61	2.03–3.36	6.70***	14.63	8	1.72	1.18–2.52	2.80**	10.58
Comparison by suicidal outcome					1.86					0.05
Suicidal ideation	9	2.92	2.14–4.00	6.70***	6.16	4	1.75	1.01–3.04	2.00*	4.19
Suicide attempt	4	2.33	1.43–3.81	3.38***	6.61	3	1.76	0.92–3.35	1.72	6.34*
Suicide	1	1.67	0.74–3.78	1.23		1	1.57	0.63–3.93	0.96	
Other sleep disturbances <sup>d</sup>										
Any suicidal outcome	10	2.72	2.00–3.70	6.37***	25.16**	3	1.81	1.30–2.52	2.76**	4.13
Comparison by suicidal outcome					13.20**					1.53
Suicidal ideation	6	3.52	2.33–5.31	6.00***	9.93	2	1.66	1.16–2.38	2.76**	2.60
Suicide attempt	3	3.39	1.90–6.06	4.13***	2.04	1	3.00	1.26–7.14	2.48*	0.00
Suicide	1	0.72	0.33–1.57	–0.82		0				

<sup>a</sup>Risk ratio values > 1 indicate that the risk for suicidality is increased in subjects with sleep problems.

<sup>b</sup>Test for the significance of the mean effect size.

<sup>c</sup>Test for heterogeneity of effect sizes.

<sup>d</sup>Other sleep disturbances include sleep disorders, such as sleep breathing disorders; other sleep disturbances, such as short sleep duration; and other sleep constructs that could not reliably be assigned to the insomnia or nightmares categories.

\* $P < .05$ , \*\* $P < .01$ , \*\*\* $P < .001$ .

level, the association of any sleep disturbance to any suicide outcome was assessed. Separate analyses were conducted for insomnia, nightmares, and all other sleep disturbances combined, comparing each of these 3 categories to any suicide outcome as well as to each of the suicide outcomes separately (suicidal ideation, suicide attempt, suicide). Although we planned to compare the independent effects of difficulty initiating sleep, difficulty maintaining sleep, early morning awakening on each of the 3 suicide outcomes, there were not enough selected studies to perform these specific subanalyses. Instead, we analyzed the effect of these presentations of insomnia to all suicide outcomes combined.

## RESULTS

As presented in Table 2, a significant association was observed between sleep disturbances and suicide variables in both unadjusted and adjusted studies. Insomnia, nightmares, and other sleep disturbances were associated with suicidal ideation in both unadjusted and adjusted studies. This was also true with respect to suicide attempts in unadjusted studies, though nightmares were not associated with suicide attempts in the 3 available adjusted studies (risk ratio = 1.76; 95% CI, 0.92–3.35). Other sleep disturbances were also associated with suicidal ideation and suicide attempts in unadjusted studies, with too few adjusted studies to provide a meaningful estimation.

Adjusted studies (ie, those that controlled for at least 1 of 6 confounders mentioned above) had lower effect sizes (risk

ratio = 1.91; 95% CI, 1.64–2.23) than unadjusted studies (risk ratio = 2.79; 95% CI, 2.44–3.19). Although the effect sizes for sleep problems with suicide were similar in adjusted and unadjusted studies, the unadjusted association of sleep problems with suicide was slightly smaller than the associations with suicide attempts and suicidal ideation. The moderator effect (Q) was significant, but the confidence intervals overlapped. Thus, the difference has to be interpreted with caution.

The strength of association of nightmares and other sleep disturbances to any suicidal outcome was comparable to that of insomnia in both adjusted and unadjusted studies. The confidence interval was wider in adjusted studies, owing partly to the smaller sample size.

Cross-sectional unadjusted studies showed stronger effect sizes than longitudinal unadjusted studies (Table 3). No other significant moderator effects of study characteristics were observed.

The trim-and-fill procedure suggests that some unpublished studies may exist that were not included in the present meta-analysis. Correcting for this source of bias for the primary analysis led to somewhat smaller but still significant effect sizes. That is, the corrected unadjusted effect size (+17 imputed effect sizes) was a risk ratio of 2.27 (95% CI, 2.03–2.52), whereas the corrected adjusted effect size (+8 imputed effect sizes) resulted in a risk ratio of 1.69 (95% CI, 1.46–1.96).

Significant associations (not shown) were evident for more specific types of insomnia presentation (difficulty initiating sleep, difficulty maintaining sleep, and early morning

**Table 3. Moderators of the Association Between Sleep Disturbances of All Types and Suicidal Outcomes of All Types**

Variable	Unadjusted Effect Sizes					Adjusted Effect Sizes				
	No. of Samples	Risk Ratio <sup>a</sup>	95% CI	Z <sup>b</sup>	Q <sup>c</sup>	No. of Samples	Risk Ratio <sup>a</sup>	95% CI	Z <sup>b</sup>	Q <sup>c</sup>
Design					10.60***					0.11
Cross-sectional	43	3.14	2.41–3.64	15.17***	28.73	21	1.95	1.62–2.34	7.14***	21.49
Longitudinal	13	1.94	1.51–2.49	5.16***	25.21*	10	1.83	1.34–2.50	3.79***	12.09
Sample					0.55					3.09
Random	17	2.61	2.06–3.30	7.98***	16.32	14	1.64	1.30–2.06	4.16***	13.21
Nonrandom	39	2.92	2.45–3.48	11.91***	36.36	17	2.16	1.76–2.65	7.33***	18.75
Age, mean, y					0.19					2.31
< 18	20	2.91	2.34–3.62	9.58***	23.27	14	1.66	1.31–2.10	4.23***	15.58
≥ 18	36	2.73	2.27–3.28	10.73***	29.86	17	2.12	1.73–2.59	7.26***	17.31
Percentage of female participants					2.55					1.51
< Median (52.5%)	28	2.52	2.09–3.04	9.60***	32.84	19	1.77	1.45–2.16	5.56***	17.55
> Median	28	3.16	2.58–3.87	11.08***	19.83	12	2.16	1.68–2.77	6.08***	15.20
Statistical control for depression										0.01
No						3	1.87	1.13–3.10	2.45**	1.16
Yes						28	1.92	1.63–2.27	7.71***	32.65
Statistical control for anxiety										0.35
No						20	1.85	1.51–2.26	5.99***	18.45
Yes						11	2.04	1.57–2.64	5.41***	14.69
Statistical control for age										0.11
No						8	1.83	1.35–2.48	3.89***	12.18
Yes						23	1.94	1.62–2.33	7.18***	22.09
Statistical control for race/ethnicity										1.86
No						25	1.80	1.52–2.14	6.82***	34.68
Yes						6	2.29	1.69–3.12	5.30***	0.81
Statistical control for gender										2.78
No						5	1.49	1.08–2.06	2.43*	6.01
Yes						26	2.03	1.72–2.40	8.33***	28.40

<sup>a</sup>Risk ratio values > 1 indicate that the risk for suicidality is increased in subjects with sleep problems.

<sup>b</sup>Test for the significance of the mean effect size.

<sup>c</sup>Test for heterogeneity of effect sizes.

\* $P < .05$ , \*\* $P < .01$ , \*\*\* $P < .001$ .

awakening) with all suicide outcomes combined, though the sample size limited the ability to test associations with specific suicide outcomes (all  $P$  values < .001).

## DISCUSSION

The primary finding of this meta-analysis was that sleep disturbances are significantly associated with suicidal ideation, suicide attempt, and suicide. The finding held for insomnia, nightmares, and other sleep disturbances, with the exception of nightmares and suicide where only 1 study was available for analysis. When suicide outcomes were combined, there were significant associations with insomnia, nightmares, other sleep disturbances, and the insomnia subtypes (difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening). The number of studies available precluded assessments of associations between these specific categorizations of insomnia and specific suicide outcomes. Notably, in those analyses conducted, the significant associations between sleep disturbance and suicide were also found among longitudinal studies. Thus, this meta-analysis supports the proposition that sleep disturbance in general and specific sleep disturbances, including nightmares and insomnia, represent risk factors for suicidal thoughts and behavior. This proposition is further bolstered by the finding that depression, an important correlate of both sleep disturbance and suicide, did not moderate findings in adjusted studies.

Several potential pathways exist to explain an association between sleep disturbance and suicide. For instance, insomnia is a strong predictor of depression,<sup>19</sup> which is itself a potent risk factor for suicide. The neurobiology of insomnia shares a number of features with that of depression that are suggested shared pathways to suicide, including hypothalamic-pituitary-adrenal axis alterations, elevations in proinflammatory cytokines, and decreased serotonergic tone.<sup>62</sup> Recently, for example, increased plasma levels of inflammatory cytokines distinguished suicidal from non-suicidal depressed patients.<sup>63</sup> In addition to such pathways, behavioral and cognitive effects of sleep disturbance contribute to reduced physical activity, increased depressogenic thoughts, and may further tax an individual's ability to cope with other life stressors, psychiatric conditions, and illness.

The fact that depression did not moderate the association of sleep disturbance and suicide outcomes in adjusted studies and that many such studies statistically adjusted for depression and still showed significant associations makes it unlikely that the association between sleep disturbance and depression alone accounts for its role in suicidal thoughts and behavior. Indeed, sleep disturbance is a common problem that is observed across a number of conditions (eg, alcoholism, chronic pain, depression, and posttraumatic stress disorder [PTSD]) that are known or believed to confer risk for suicidal behavior.<sup>64</sup> The extent to which sleep disturbance leads to or exacerbates these conditions through neurobiological alterations or cognitive-behavioral effects

most likely explains, at least in part, its role in suicidal behavior. For example, in the presence of depression, the nearly ubiquitous experience of insomnia may not only provide the opportunity for negative rumination but also contribute to behavioral disinhibition and impulsivity. Similarly, in the presence of PTSD, nightmares can be a frequent reminder of traumatic events, and being awakened by them in the middle of the night also provides opportunity for negative rumination. While admittedly speculative, such scenarios may increase the likelihood of suicidal thoughts and behaviors.

Regardless of the specific pathways involved, because sleep disturbances are ubiquitous and confer risk for suicidal thoughts and behaviors, they are an inviting target of preventive interventions. Moreover, an intervention designed to target sleep disturbance may be more acceptable to some vulnerable populations (eg, older men, returning military service members) than those addressing mental disorders, given the lower stigma and accusation associated with sleep problems.

### Limitations

As noted, one of the limitations of this meta-analysis was the relatively small number of studies that assessed specific sleep disturbances with each specific suicide outcome. Similarly, there was variability in methods to operationalize sleep disturbance across the studies; this same variability applies to how depression and anxiety, major confounders of interest, were operationalized across studies. Other potential confounders, such as bipolar disorder and schizophrenia, that are associated with suicide were not well represented in the studies analyzed, precluding an assessment of their moderating effects. The above limitations may have influenced the analyses. In addition, 10 studies presenting objective sleep data in the form of overnight polysomnography were reviewed, but only 1 met inclusion criteria, mainly due to both the number and nature of the sleep variables reported in these studies. That is, polysomnography produces quite a number of variables (up to a dozen in some studies), and some variables do not readily correspond to a sleep disturbance, making selection of variables for the current analysis difficult if not untenable. For the entire study sample, studies were heterogeneous, deriving their data from epidemiologic or from clinical samples as well as from adolescent or adult samples. Sampling procedure and age did not, however, moderate the size of association between sleep disturbances and suicide outcomes in all but 1 analysis. Finally, the majority of studies included were cross-sectional.

### Implications

On the basis of findings from the current meta-analysis, we propose that sleep disturbance be included among the list of risk factors for suicide. The findings do also indicate a need for further work with respect to sleep disturbance and suicide. Additional work is needed to refine our understanding of how specific presentations of sleep disturbances contribute to risk. For instance, the association of sleep apnea to suicide is largely unknown. In related literatures, the

associations of insomnia subtypes (difficulty initiating sleep, difficulty maintaining sleep, and early morning awakening) to depression risk have been evaluated,<sup>65</sup> and an insomnia phenotype that includes male subjects with short sleep duration has been associated with increased mortality risk.<sup>66</sup> Our analysis does include several studies that included sleep duration as an outcome.<sup>27,29,40,43</sup> In addition, although age did not moderate effects, it is entirely possible that the relationship of sleep disturbances to suicide outcomes is based on different processes in adolescents compared to adults. Finally, a thorough review of polysomnography studies that have been achieved would be useful.

Given that efficacious interventions do exist for major sleep disorders<sup>67</sup> and have been shown to reduce psychiatric symptoms associated with suicide, such as depression and anxiety,<sup>68-71</sup> identification and management of sleep disturbance may alter the trajectory of individuals vulnerable to suicide. Controlled intervention trials would also be the best test for causal associations between sleep disturbances and suicide outcomes. As yet, no systematic research has been undertaken to test the potential of sleep interventions as viable stand-alone or adjuvant suicide prevention interventions. As basic research proceeds to elaborate neurobiologic pathways to suicidal thoughts and behaviors, it is essential to investigate how sleep may be involved in these pathways.

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