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Review Article

Trends of cost-effectiveness studies in sleep medicine

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ABSTRACT

Economic analyses, and cost-effectiveness studies in particular, are increasingly used in medicine and population health to inform policy making and resource allocation. Health economic models have successfully captured sleep medicine outcomes. This study provides an overview of the growth of the use of cost-effectiveness analyses to quantify the outcomes of sleep related interventions. It also identifies highly prevalent sleep disorders, which despite having a high burden of disease, lack basic utility studies.

1. Introduction

In recent years, interest in sleep as a public health determinant and its economic consequences has increased [1,2]. Previous reviews of economic evaluations of sleep disorder interventions have identified sleep apnea as the most studied condition [3–5]. The economic literature assessing interventions for other sleep disorders remains uncharacterized, as the last review of this literature was conducted nearly a decade ago [3]. Our review aims to fill this gap.

2. Methods

Scope: We sought to identify published, peer-reviewed health cost-effectiveness analyses (CEA) of sleep-disorder related interventions. Cost-effectiveness analysis measures the economic favorability of an intervention in terms of its incremental cost-effectiveness ratio (ICER). An ICER is a ratio of an intervention's incremental cost (the difference in the resource cost, expressed in dollars, of the intervention and its comparator) divided by its incremental health benefits. The "comparator" is often the "standard of care" in the absence of the intervention of interest. The ICER can be thought of as a unit "price". Large values are unfavorable since they imply a high cost for each incremental gain in health; correspondingly, low values are favorable.

We restricted attention to CEAs that measure health benefits in terms of quality-adjusted life years (QALYs). A QALY is a year of life scaled by a utility preference weight that ranges from 0 to 1. A utility weight of one corresponds to a hypothetical state of perfect health, whereas 0 corresponds to a state equivalent in preference to being dead. Utility weights between 0 and 1 indicate greater or lesser morbidity, with weights closer to one corresponding to less severe, more preferred states, and weights closer to 0 corresponding to more severe, less preferred states. Preference based measures (such as the QALY compatible EQ-5D) produce standardized utility weights that are both comparable across health states, and can also be combined to estimate quality adjusted survival.

Data: We searched the Cost-Effectiveness Analysis (CEA) Registry maintained by Tufts Medical Center (www.cearegistry.org) for articles which contained the keywords "sleep", "insomnia", "sleepiness", "circadian", "apnea", or "narcolepsy" in their title or abstract. The CEA Registry is a nationally and internationally recognized database with a searchable interface. It contains standardized information on all English-language, PubMed-indexed cost-effectiveness analyses that measure the health outcomes of a broad range of medical and health interventions in terms of quality-adjusted life-years (QALYs) [6,7]. At the time we conducted

Abbreviations: CBT, cognitive-behavioral therapy; CEA, Cost-effectiveness analysis; CPAP, continuous positive airway pressure; ICER, Incremental cost-effectiveness ratio; OSA, obstructive sleep apnea; SD, Standard Deviation; QALY, Quality-adjusted life-year.

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our analysis, the CEA Registry included over 6500 articles published from 1976 through 2016.

3. Results

Our primary search identified 40 articles for "sleep", nine articles for "insomnia", six articles for "sleepiness", 16 articles for "apnea", and one article for "circadian" and no articles for "narcolepsy". Removing duplicates and articles that were not primarily sleep-related left us with 34 articles [8–41]. Among these 34 articles, four addressed screening and diagnosis of sleep related disorders [12,14,25,41], while 30 addressed the treatment of these disorders. Furthermore, of these 34 articles, 25 articles addressed obstructive sleep apnea (OSA) [8,9,12–14,16–21,24–30,33,34,36–38,40,41], while nine addressed insomnia [10,11,15,22,23,31,32,35,39] (Fig. 1, Table 1). Therefore, overall, no article discussed the diagnosis of insomnia, nine articles (26%) addressed treatments of insomnia, four articles (12%) analyzed the diagnosis of OSA, and 21 articles (62%) investigated various treatments of OSA (Table 1).

Based on the countries where the studies were performed, of the total 34 articles, 13 studies (38%) originated from the United States [8,9,11,12,14,26,27,30,32,33,35,39,41]. Seven articles (20%) came from the United Kingdom [10,17,18,21,22,29,40]. Canada [34,36,38] and New Zealand [16,23,31] each presented three articles (9% each). France [25,28] and Spain [13,20] each delivered two articles (6% each); while Finland [19], Greece [37], Japan [24], and the Netherlands [15] were each the origin of one article (3% each).

We identified a consistent increase in the publication of sleep-related CEAs over time. In the 1990s two articles were published in this field [14,36], in the 2000s there were 12 studies [8,11,12,17,19,20,22,30,32,34,40,41], and since 2010, 20 studies have been published [9,10,13,15,16,18,21,23–29,31,33,35,37–39] (Fig. 2). The net result has been an average of 0.82 (SD = 1.46) CEA articles per year since 1976 for the field sleep of medicine, while the overall average number of health related CEA analyses published per year exceeds 154 (SD = 212). More recently, since the year 2000, on average 1.88 (SD = 1.83) CEA articles have been published per year in the field sleep of medicine, while the overall average number of health related CEA analyses published per year exceeds 351 (SD = 211) for this period. In order to test whether there has been a change in the proportion of sleep related CEA articles as compared to non-sleep related CEA articles, we compared two ratios over time. The numerator of the first ratio was the number of sleep related CEA articles published between 2000 and 2005, while the denominator of this first ratio was the number of non-sleep related CEA articles published during the same period. Likewise, the numerator of the second ratio is the number of sleep related CEA articles published between 2006 and 2016, and the denominator of this second ratio was the number of non-sleep related CEA articles published during the same period. This analysis showed that the ratio of sleep CEA articles over total CEA articles had increased from 0.00537 for the period between 2000 and 2005 to 0.00547 for the period between 2006 and 2016. However, this increase was not statistically significant ($p = 0.5$).

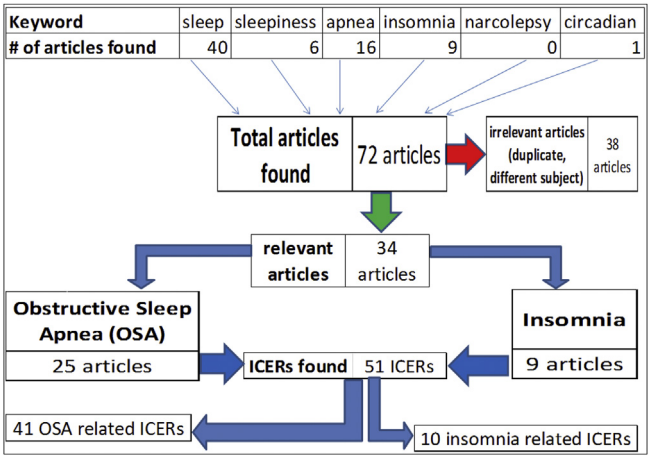

Fig. 1. Schematic framework of the search strategy and results.

The 34 sleep-related articles we identified collectively report 51 ICERs. Of the 51 ICERs, 44 pertain to treatment interventions for sleep disorders while 12 addressed screening and diagnosis. Furthermore, of the 51 ICERs, 41 pertained to OSA, while 10 articles pertained to insomnia. Overall, no ICERs evaluated the diagnosis of insomnia, 10 ICERs (20%) addressed insomnia treatment, 12 ICERs (14%) analyzed the diagnosis of OSA, while 29 ICERs (66%) pertained to OSA treatment (Table 1).

Further in depth analysis of the ICERs revealed that of the 41 ICERs related to OSA, 19 evaluated continuous positive airway pressure (CPAP) therapy [8,17–21,26,27,30,33,34,36,40], 12 were related to OSA screening interventions [9,12,14,25,26,41], six were evaluations of OSA dental treatment interventions [28–30], two assessed surgical interventions [33], and two considered other treatments for OSA [16,38] (Fig. 3, Table 1).

Content analysis of the 10 ICERs unrelated to OSA revealed that they all focused on treatments for insomnia. Of these 10 ICERs, six evaluated CBT interventions [10,15,22,35,39], three assessed the value of pharmaceutical interventions (two studies focused on Eszopiclone) [11,23,32], and one was an evaluation of multiple treatment pathways [31] (Fig. 3).

Most ICERs (37 of the 51) indicated that interventions would increase costs but would also improve health (ie, produce additional QALYs) [12,14,16,18,20,22,25–34,36,38–40]. Of these 37 ratios, 33 had a value below $50,000 per QALY gained [8,10,11,14,16,18,20,22,25–34,36,39,40]. ICERs below (ie, more favorable than) this benchmark are considered to represent good value in the United States [42] and in other settings [43,44] because they indicate the intervention accrues QALYs at a relatively low cost.

One of the 51 ICER results indicated that the evaluated intervention would increase costs and make health worse. Another 11 ICERs indicated that the evaluated interventions would both save money and improve health [17,21,23,25,29,35,41]. Finally, two ICERs described interventions that would save money but make health worse.

Collectively these 34 articles also reported 83 utility preference weights. Most of these utility weights pertain to OSA (n = 37) and its treatments (nine for CPAP therapy and three for dental treatments). We also identified six utility weights related to insomnia and four utility weights pertaining to cognitive-behavioral therapy (CBT) training for insomnia. Twenty-four utility weights pertained to other morbidities that were used and reported for comparison purposes (eg, utility of stroke without obstructive sleep apnea) (Table 1, Fig. 4).

4. Discussion

Decision makers in the United States have not traditionally relied on CEA information explicitly. However, it plays an important role in some of the value frameworks that are now beginning to influence coverage decisions [45]. Therefore, seeing an increase in the number of CEA articles in the field of sleep medicine is encouraging.

The share of sleep related CEA articles, however, remains small. As we demonstrate in Fig. 2, and our statistical analysis suggests, the share of sleep medicine CEA literature is 0.005 of all CEA

Table 1
Number (and percentage) of search yielded articles, Incremental Cost-Effectiveness Ratios (ICERs), and health state utility values that related to treatment or diagnosis of Obstructive Sleep Apnea (OSA), Insomnia, and other diagnosis.

Subject	Obstructive Sleep Apnea (OSA)	Insomnia	Others	Total[a]
Articles				
Diagnosis	4 (12%)	0	0	*4 (12%)*
Treatment	21 (62%)	9 (26%)	0	*30 (88%)*
Total Articles[b]	25 (74%)	9 (26%)	0	34 (100%)
Incremental Cost-Effectiveness Ratios (ICERs)				
Diagnosis	12 (23%)	0	0	*12 (23%)*
Treatment	29 (57%)	10 (20%)	0	*39 (76%)*
Total ICERs[b]	41 (80%)	10 (20%)	0	51 (100%)
Health state utility values	49 (59%)	10 (12%)	24 (29%)[c]	83 (100%)

[a] Row totals are cumulative.
[b] 'Total Articles' and 'Total ICERs' are the sum of 'Diagnosis' and 'Treatment' cells above.
[c] Health state utility values classified as 'Others' are utility values that were not related to sleep related conditions but instead were cited and used in the calculations of sleep related articles for comparison purposes (eg: Utility after stroke given the patient has no insomnia which is used for comparison with utility after stroke given the patient has insomnia.).

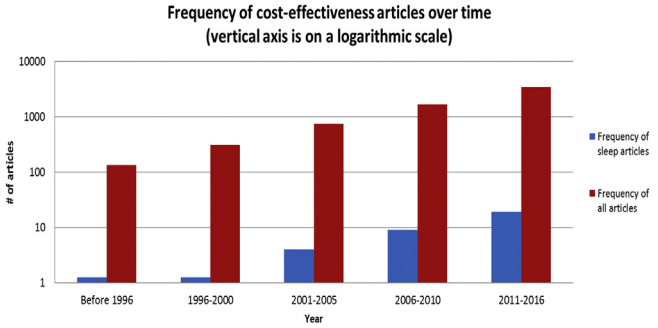

Fig. 2. Frequency of cost-effectiveness articles over time.

literature. Moreover, our statistical analysis reveals that there has been no significant change in the relative rate of the growth of sleep CEA literature as compared to the rest of the field. Future efforts towards increasing the number of cost-effectiveness studies related to sleep medicine and sleep health can help to close this apparent gap.

Our results show that sleep related cost-effectiveness studies have exclusively focused on two sleep disorders: OSA and insomnia. As previously noted, one of the key components of estimating an ICER, specifically in terms of QALYs, is the utility weight associated with various health states. Significant sleep disorders still lack baseline utility measurements, thus highlighting the need for further research in this area. For example, a PubMed search for utility weights for narcolepsy identified two articles [46,47]. Furthermore, we found no studies in a search for the utility weights pertaining to circadian rhythm disorders such as jet lag-induced sleep disturbances, or shift-work circadian disorders, which are all highly prevalent conditions. Future studies aimed at establishing baseline utility measures for more sleep disorders will pave the way for more advanced burden of disease studies, as well as for measuring the economic impact of interventions and treatments.

Finally, the vast majority of articles and ICERs in the sleep medicine field pertain to the evaluation of therapeutic and treatment techniques (88% and 76%, respectively). Therefore, additional assessment of screening and diagnostic techniques could shed light on the value of interventions in these areas.

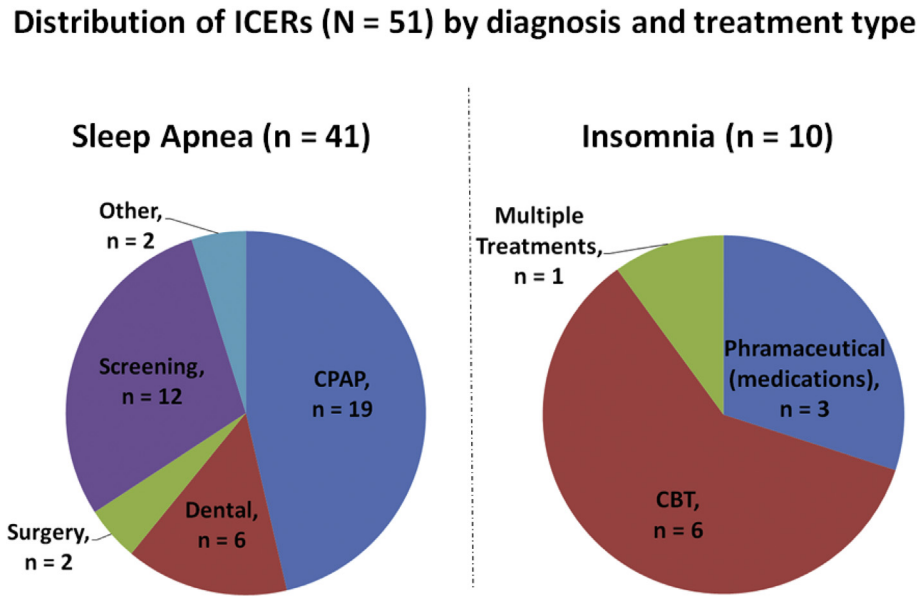

Fig. 3. Distribution of Incremental Cost Effectiveness Ratios (ICERs) by diagnosis and treatment type.

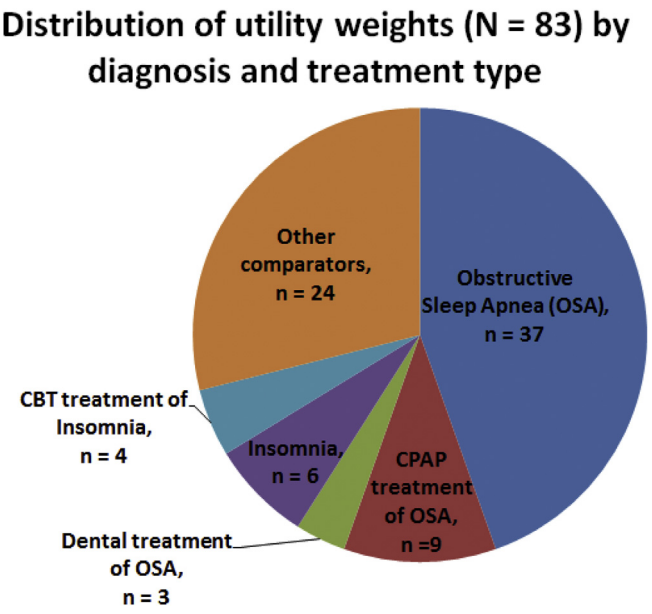

Fig. 4. Distribution of utility weights by diagnosis and treatment type.

Statement of significance

What is known:

- Economic analyses and cost-effectiveness studies in particular, are increasingly used in medicine and population health for policy making and resource allocation purposes.
- Health economic models have successfully captured sleep medicine outcomes.

What this study adds:

- Provides an overview of the growth of the use of cost-effectiveness analyses to quantify the outcomes of sleep related interventions.
- Identifies highly prevalent sleep disorders, which despite having a high burden of disease, lack basic utility studies.

Disclosures

Financial Disclosure

None.

Non-financial or conflicts of interest

none.

Conflicts of interest

None declared.

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