Economic Burden of Transport Accidents and Falls at Home and in Public Places Due to Untreated Insomnia in The United States, Estimated by The Population Attributable Fraction Method

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Introduction

- In the United States (US), the total annual cost of insomnia was estimated to be $150.4 to $174.9 billion (2016 USD),[1] the majority of which (~75%) was linked to indirect costs (i.e., loss of productivity, accidents, and errors)
- Insomnia impacts sleep quantity and quality, resulting in detrimental effects on daytime functioning through physical symptoms (e.g., sleepiness, decreased energy), impairment in cognitive performance, and mood disturbance.[2] By this mechanism, impaired daytime functioning is at the origin of loss of productivity, accidents, and errors
- Recently, the annual healthcare costs of sleep disorders, including insomnia, was estimated to be around $94.9 billion.[3] Insomnia is the second most costly sleep disorder after obstructive sleep apnea, representing around one-third of the overall healthcare costs of sleep disorders[4]
- Most of the indirect costs are related to loss of productivity, mainly due to presenteeism[a] at work, around $63.2 billion each year (in USD 2010).[5] Insomnia also increases accidents or errors at work, costing an estimated $31.1 billion annually.[6] Finally, insomnia has also been found to significantly increase the risk of unintentional transport accidents (motor vehicle occupant, motorcyclist, pedal cyclist [bicyclist, etc.], pedestrian, other)[7] and accidents at home or in public places (often referred to as falls)[8]
- To the best of our knowledge, the only cost estimates of transport and home-based and public place accidents due to sleepiness for the US have been provided by Léger in 1988[9] and Léger et al. in 2019.[10] In 1988, motor-vehicle accidents due to sleepiness were estimated to cost between $29.2 and $37.9 billion annually (in USD 1988), while home-based and public place accidents due to sleepiness amounted to between $3.68 and $4.78 billion annually (in USD 1988)
- Recently, based on data from the National Highway Traffic Safety Administration (NHTSA) in 2013, Léger et al estimated that the cost of motor vehicle accidents due to sleepiness to be between $139.4 billion and $152 billion[10]
- Finally, the AAA Foundation for Traffic Safety[11] reported (relying on police and hospital reports) that 328,000 drowsy driving crashes occur annually, including 109,000 injuries and 6,400 fatalities

[a]Presenteeism refers to the lost productivity that occurs when employees are not fully functioning in the workplace because of an illness, injury, or other condition.

Study Objective

- **Based on the Centers for Disease Control and Prevention (CDC) Web-based Injury Statistics Query and Reporting System (WISQARS™)[12] public database and the population attributable fraction (PAF) method[13], the objective was to calculate estimates of the total lifetime medical costs of motor vehicle, home-based, and public place accidents due to untreated insomnia (UI) in the US (in USD 2020), from a healthcare payer perspective**

Methods

- Only transport and home-based and public place accidents are analyzed because the CDC WISQARS™ does not provide data for accidents at work. Falls and home-based and public place accidents are assumed to be the same. We collected the following pre-requisite data:

Incidence rates and medical costs

- The CDC WISQARS™[12] is an interactive, online database that provides data on fatal and nonfatal injury, violent death, and cost of injury. From the CDC WISQARS™, and for each type of accident, we extracted the annual incidence rate (per 100,000 persons) and the average lifetime medical cost per case. Accident injury outcomes encompassed death, hospitalization, and emergency department visit
- Costs were adjusted to the year 2020 for inflation using the consumer price index of the US Bureau of Labor Statistics[14]

Prevalence of insomnia

- We assumed a prevalence of insomnia for the overall US population of 10%.[2] This estimate came from the American Psychiatric Association, who defined insomnia disorder following the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5) criteria[2]

Measures to quantify the association between insomnia & accidents

- A literature search was performed to identify studies assessing the association between UI and unintentional accidents. Two studies were identified (Laugsand 2014[7] and Stone 2014[8])
- The hazard ratio (HR) for fatal motor vehicle injuries for those having three insomnia symptoms was 2.51 (95% confidence interval (CI) [0.66;9.62], p=0.155)) compared with those having no symptoms.[7] The HR was adjusted for main confounding factors including the daily use of sleep medication for more than one month in the past year
- The odds ratio (OR) for falls of participants with an actigraphically measured total sleep time of 5 to 7 hours was 1.42 (95% CI [1.08; 1.89]) compared with the reference group.[8] The OR was adjusted for the main confounding factors, including use of benzodiazepines and antidepressants

Calculations

- Attributable fraction refers to the proportion of an event (e.g., injury, hospitalization, death) that can be directly attributed to a disease. Like another study in the past,[15] we used this method to indirectly estimate the cost of unintentional accidents related to UI. The calculation method required solving the two following equations simultaneously:

$$(1)\quad q_1 \times s_1 + q_2 \times s_2 = p_1 \qquad (2)\quad \frac{\frac{q_1}{1-q_1}}{\frac{q_2}{1-q_2}} = \text{OR}$$

Where:
q_1 = probability of having the accident given the presence of insomnia
q_2 = probability of having the accident given the absence of insomnia
s_1 = share of people with insomnia
s_2 = share of people without insomnia
p_1 = probability of having the accident event (i.e., death, hospitalization or emergency visit)
OR = odds ratio of having the accident given the presence of insomnia

And then, a third equation:

$$(3)\quad o_1 = \frac{q_1 \times s_1}{p_1}$$

Where:
o_1 = probability of having insomnia given the accident

- Finally, the attributable fraction to insomnia is obtained by subtracting the insomnia prevalence rate (10%) to o_1. The following final outcomes were estimated:
  - The number of accidents attributable to UI
  - The total lifetime medical costs of accidents attributable to UI

Uncertainty analysis

- Uncertainty around parameters was tested
  - First, we explored the influence of the OR on the outcomes, by fluctuating their values within their 95% CI ranges
  - Second, we ran a deterministic sensitivity analysis (DSA) by applying an arbitrary ±10% on the main parameters and presented the results within tornado diagrams

Results

Base case

- Inputs used to calculate the base case study outcomes are presented in **Table 1**

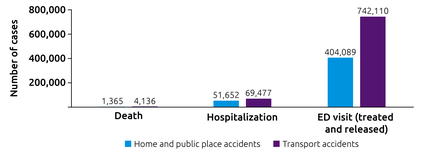
Table 1 Dataset used for the calculations

Parameters to calculate the attributable fraction to insomnia	Equations symbols	Values (95% CI)
OR for transport accidents	OR_1	2.51 (0.66-9.62)
OR for fall accidents	OR_2	1.42 (1.08-1.89)
Share of people with insomnia	s_1	0.1
Share of people without insomnia	s_2	0.9
Transport accidents (age-adjusted event rate per 100,000, number of events) in 2010 • Death (10.70/100,000, 35,003) • Hospitalization (177.63/100,000, 581,142) • ED treated and released visit (1722.15/100,000, 5,634,312)	p_1	
Home-based and public place accidents • Death (11.45/100,000, 37,455) • Hospitalization (328.24/100,000, 1,266,989) • ED treated and released visit (1,944.22/100,000, 6,575,344)	p_1	
Average lifetime medical cost per event		
	Values in USD 2010	**Values in USD 2020**
Transport accidents		
Death	$11,031	$13,045
Hospitalization	$53,143	$62,845
ED treated and released visit	$3,084	$3,647
Home-based and public place accidents (i.e., fall)		
Death	$23,925	$28,293
Hospitalization	$38,928	$46,035
ED treated and released visit	$2,552	$3,018

CI=confidence interval; ED=emergency department; OR=odds ratio

- **Figure 1** shows the annual number of fatal and non-fatal injuries linked to UI
- The estimated total lifetime medical costs due to UI for transport and home-based/public place accident (base case scenario) were $7,126,703,952 and $3,635,911,057 (in USD 2020), respectively

Figure 1 Estimates of the annual number of accident events due to UI in the US

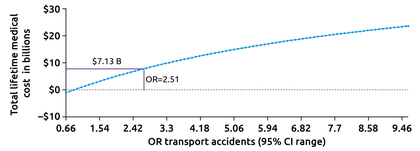


ED=emergency department

Sensitivity analysis

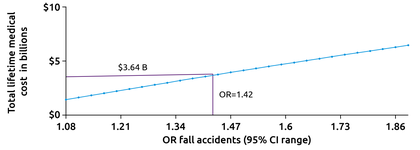
- **Figure 2** displays the variation of the total lifetime medical cost as a function of the UI odds ratio for transport accident
- **Figure 3** displays the variation of the total lifetime medical cost as a function of the UI odds ratio for home-based and public place accident
- **Figures 4** and **5** show the results of the DSA, run with an arbitrary Δ ratio: ±10%

Figure 2 Variation of the total lifetime medical cost as a function of the UI odds ratio for transport accident



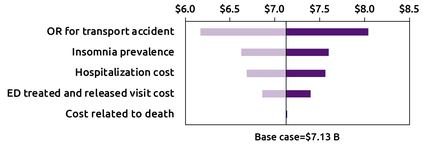
CI=confidence interval; OR=odds ratio

Figure 3 Variation of the total lifetime medical cost as a function of the UI odds ratio for home-based and public place accident



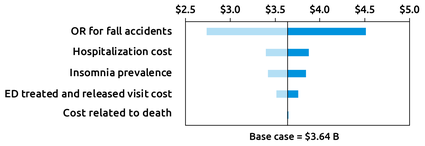
CI=confidence interval; OR=odds ratio

Figure 4 Tornado diagram for the transport accidents lifetime medical costs due to UI (Δ ratio: ±10%)



ED=emergency department; OR=odds ratio

Figure 5 Tornado diagram for the home-based and public place accidents lifetime medical costs due to UI (Δ ratio: ±10%)



ED=emergency department; OR=odds ratio

Conclusions

- **Based on the data and PAF method, UI is estimated to generate total lifetime medical costs of $3.64B for home-based and public place accidents and $7.13B for transport accidents**
- **Annually, UI could be responsible for 5,501 fatal injuries (4,136 due to transport accidents and 1,365 due to falls). Sensitivity analysis shows that the outcomes vary widely on the odds ratio value**
- **This analysis confirms that UI is associated with a significant number of unintentional accidents that lead to high total medical costs**
- **There is an unmet need to treat insomnia and improve daytime functioning in order to avoid unintentional accidents, save lives, and reduce the cost burden for the healthcare system**

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