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Economic burden of insufficient sleep duration in Canadian adults

Jean-Philippe Chaput, PhD^{a,b,*}, Julie Carrier, PhD^{c,d}, Célyne Bastien, PhD^{e,f},
Geneviève Gariépy, PhD^{g,h}, Ian Janssen, PhD^{i,j}

^a Healthy Active Living and Obesity Research Group, CHEO Research Institute, Ottawa, Ontario, Canada^b Department of Pediatrics, Faculty of Medicine, University of Ottawa, Ottawa, Ontario, Canada^c Département de psychologie, Université de Montréal, Montréal, Québec, Canada^d Centre d'étude avancée en médecine du sommeil, Hôpital du Sacré-Cœur de Montréal, Montréal, Québec, Canada^e École de psychologie, Université Laval, Québec City, Québec, Canada^f CERVO, Laboratoire de sommeil, potentiels évoqués cognitifs et rêves, Beauport, Québec, Canada^g École de santé publique, Département de médecine sociale et préventive, Université de Montréal, Montréal, Québec, Canada^h Institut universitaire de santé mentale de Montréal, Montréal, Québec, Canadaⁱ School of Kinesiology and Health Studies, Queen's University, Kingston, Ontario, Canada^j Department of Public Health Sciences, Queen's University, Kingston, Ontario, Canada

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ABSTRACT

Objective: To provide estimates of the health care and productivity costs associated with insufficient sleep duration (<7 hours per night) in Canadian adults.

Methods: A prevalence-based approach was used to estimate the economic costs associated with insufficient sleep duration. Estimates relied on 3 pieces of information: (1) the relative risks of health outcomes consistently associated with insufficient sleep duration obtained from recent meta-analyses; (2) the direct (health care) and indirect (health-related losses of productivity) costs of these health outcomes obtained from the Economic Burden of Illness in Canada data; and (3) the prevalence of insufficient sleep duration in Canadian adults obtained from a representative national survey (17.2%).

Results: The estimated direct, indirect, and total costs of insufficient sleep duration in Canada in 2020 were \$484 million, \$18 million, and \$502 million, respectively. These values represent 0.5% (direct), 2.7% (indirect), and 0.5% (total) of the overall burden of illness costs for Canada (estimated at \$102 billion). The 2 most expensive chronic diseases attributable to insufficient sleep duration were depression (\$219 million) and type 2 diabetes (\$92 million). The main contributors of these health care costs were related to hospital care (for coronary heart disease and obesity), prescription drugs (for type 2 diabetes and depression), physician care (for hypertension and cognitive disorders), and mortality (for accidents/injuries). A 5% decrease in the prevalence of insufficient sleep duration (from 17.2% to 12.2%) in Canadian adults would lead to a yearly savings of \$148 million.

Conclusions: Insufficient sleep duration is an important contributor to health care spending and health-related losses of productivity in Canada. Studies are needed to test cost-effective sleep health interventions at the population level.

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Introduction

Insufficient sleep duration, defined as sleeping less than 7 hours per night in adults aged 18 years or older,^{1–3} is a recognized public health issue. In Canada, surveillance of sleep duration is now integrated into national health surveys. The most recent data from 2020 indicate that 17.2% of Canadian adults self-report sleeping less than 7 hours per night.⁴ While a U-shaped association between sleep

duration and health outcomes is generally found in adults, with 7–8 hours of sleep per day most favorably associated with health benefits,⁵ the public health concern is primarily for insufficient sleep and not long sleep.⁶ Key adverse outcomes associated with insufficient sleep duration include cardiovascular disease, hypertension, obesity, type 2 diabetes, depression, cognitive disorders, and accidents/injuries.⁵ The high prevalence of insufficient sleep duration, coupled with observational evidence of a temporal association between insufficient sleep and a variety of health outcomes as well as laboratory evidence demonstrating biological plausibility for these associations, point to the urgent need to address insufficient sleep in today's world.⁵

*Corresponding author: Jean-Philippe Chaput, PhD, 401 Smyth Road, Ottawa, K1H 8L1. Tel.: +1-613-737-7600 ext. 3683.

E-mail address: jpchaput@cheo.on.ca (J.-P. Chaput).

To better inform policy and decision makers, the economic costs associated with insufficient sleep duration can be used to capture the burden that insufficient sleep places on both the health care system and the economy. Research related to the economic aspects of insufficient sleep and sleep disorders has increased in recent years.^{7,8} However, the economic burden of insufficient sleep duration in Canada is unknown. Knowing the health care and health-related losses of productivity costs associated with insufficient sleep duration can help to increase political engagement and motivate actions by prioritizing funding allocation to develop and implement interventions aimed at reducing insufficient sleep in the population. Moreover, estimating the extent to which costs associated with health care expenditures and health-related aspects of productivity losses would decrease if the prevalence of insufficient sleep were to improve would help justify making more investments into public health interventions that aim to improve sleep duration at the population level.

Therefore, the primary objective of this study was to provide estimates of health care and health-related productivity costs of insufficient sleep duration in Canadian adults. A secondary objective was to estimate potential savings that would occur if the prevalence of insufficient sleep duration was reduced by 5%.

Methods

Prevalence-based approach

A prevalence-based approach was used to estimate the economic costs associated with insufficient sleep duration during a 1-year period, adjusted to represent the year 2020. Three key pieces of information were required to accomplish this task: (1) the relative risks (RRs) of health outcomes in adults with insufficient sleep duration; (2) the direct and indirect costs of these health outcomes; and (3) the prevalence of insufficient sleep duration in the Canadian adult population. This approach has been used to estimate the economic costs of other public health issues in Canada (eg, physical inactivity, obesity) and more details can be found elsewhere.^{9,10}

Step 1

First, the RRs of key adverse health outcomes in short sleepers (<7 hours/day) relative to adults sleeping an adequate amount (7–8 hours/day in most cases) were extracted from a recent overview of systematic reviews that was used to inform the sleep duration recommendations in Canada in 2020.⁵ The present cost analysis used estimates from dose-response meta-analyses that included health outcomes consistently shown to be associated with insufficient sleep duration in prospective data. We used the RRs of the following 7 health outcomes: coronary heart disease, type 2 diabetes, depression, cognitive disorders, work injuries/accidents, obesity, and hypertension. For this type of prevalence-based approach, it is important to choose outcomes that have consistently been shown to be associated with insufficient sleep in longitudinal studies conducted in different populations and samples. For example, osteoporosis and cancer were not included in this cost analysis because of their lack of consistent association with sleep duration in dose-response meta-analyses of prospective cohort studies.⁵

Summary RR estimates used for the present analysis (Table 1) represent a weighted average from the published studies and were adjusted for relevant confounders (ie, fully adjusted models). Detailed information on how the RR estimates were computed for coronary heart disease,¹¹ type 2 diabetes,¹² depression,¹³ cognitive disorders,¹⁴ work injuries/accidents,¹⁵ obesity,¹³ and hypertension¹⁶ can be found in each meta-analysis. Typically, semiparametric and parametric methods were used to calculate the pooled risk estimates,

Table 1

Summary relative risks and population attributable risk (PAR%) estimates for the health outcomes that are related to insufficient sleep duration (<7 hours per night) in Canadian adults in 2020

Health outcome	RR (95% CI)	PAR% (men)	PAR% (women)
Coronary heart disease	1.11 (1.05-1.16)	2.2	1.6
Type 2 diabetes	1.09 (1.04-1.15)	1.8	1.3
Depression	1.50 (0.94-2.40)	9.1	6.8
Cognitive disorders ¹	1.34 (1.15-1.56)	6.4	4.7
Work injuries/accidents	1.35 (1.16-1.58)	6.5	4.8
Obesity	1.38 (1.25-1.53)	7.1	5.2
Hypertension	1.33 (1.04-1.70)	6.2	4.6

¹ Dementia and Alzheimer's disease.
RR, relative risk; CI, confidence interval.

with random-effects models to pool the RRs. Sleep duration was self-reported in almost all original studies.¹¹⁻¹⁶

Step 2

Second, the proportion of the 7 health outcomes explained by insufficient sleep duration among the Canadian adult population was determined by calculating the population attributable risk (PAR%) for each health outcome (Table 2). Both the RR estimate and the population prevalence (P) of insufficient sleep are needed to calculate the PAR%:

$$\text{PAR\%} = [P(\text{RR} - 1)] / [1 + P(\text{RR} - 1)]$$

The prevalence of insufficient sleep duration in Canadian adults aged 18 years and older was based on the most recent nationally representative data from the 2020 Canadian Community Health Survey Rapid Response Module on Healthy Living.⁴ The 2020 Canadian Community Health Survey data were collected between January and March 2020 and predated the emergence of the COVID-19 pandemic in Canada. The prevalence of insufficient sleep duration (<7 hours/night) was 20.0% in men, 14.5% in women, and 17.2% overall. A total of 4 validated questions were used to assess the time participants fell asleep and when they woke up on weekdays and weekends in the past 7 days. A weighted weekday/weekend approach was used to derive average daily sleep duration.

Step 3

Third, we calculated how much of the direct (ie, health care), indirect (ie, health-related losses of productivity), and total costs (ie, direct + indirect costs) of the health outcomes associated with insufficient sleep duration were attributable to insufficient sleep. To do this, we multiplied the PAR% for each of the 7 health outcomes with the overall health care and productivity costs of that health outcome (for adult men and women). The overall direct and indirect costs of the 7 health outcomes (in Canadian dollars) were taken from the data provided by the Economic Burden of Illness in Canada (EBIC) 2010 (<https://www.canada.ca/en/public-health/services/chronic-diseases/chronic-disease-knowledge-development-exchange/economic-burden-illness-canada.html>). Direct costs include hospital care expenditures, physician care expenditures, prescription drug expenditures, dental services and vision care services, and formal caregiving. Indirect costs include lost production due to morbidity (eg, absenteeism and presenteeism), lost production due to premature mortality, and informal caregiving.

Adjustments

Since there were some differences in the ways that diseases were defined in our study and the EBIC online tool, we made some

Table 2
Direct, indirect, and total costs of insufficient sleep (<7 hours per night) in Canadian adults in 2020

Sex	Cost attributable to insufficient sleep duration ¹			% of overall cost attributable to insufficient sleep duration ²		
	Direct	Indirect	Total	Direct	Indirect	Total
Men	260	14.3	274.3	0.6	3.0	0.6
Women	224	3.6	227.6	0.4	2.1	0.4
Both	484	17.9	501.9	0.5	2.7	0.5

¹ Costs are in millions of Canadian dollars.

² Calculated as cost attributable to insufficient sleep in adults divided by overall cost in the population x 100.

adjustments for the present cost analysis. For “coronary heart disease,” we summed the EBIC costs of “acute myocardial infarction” and “other ischemic heart diseases.” For “type 2 diabetes,” we multiplied the broader “diabetes mellitus” costs presented in EBIC by 90% as 90% of diabetes cases in Canada are type 2.¹⁷ For “depression,” we multiplied the broader “mood (affective) disorders” costs presented in EBIC by 91.4% since depression accounts for 91.4% of mood disorders in Canada.¹⁸ For obesity, EBIC 2010 presented obesity costs within a much broader category called “other endocrine, nutritional and metabolic diseases.” Here we relied on the direct and indirect costs of obesity (ICD-9 code 278) in EBIC 2005 that were obtained by one of the authors (IJ) for use in a report prepared for the Public Health Agency of Canada in 2009.¹⁹ The other health outcomes (cognitive disorders, work injuries/accidents, and hypertension) were easily identified in the EBIC online tool and did not need adjustment.

The 2010 costs in EBIC (and the 2005 cost for obesity) were adjusted to 2020 costs by accounting for inflation, population growth, and increase in average earnings. For direct costs, an inflation value of 15.7% was used, reflecting the increase in health care costs in the Consumer Price Index that occurred from 2010 to 2020.²⁰ For population growth, a value of 12.6% was used, reflecting the adult population growth in Canada from 2010 to 2020.²¹ For indirect costs, an inflation value of 6.8% was used, reflecting the increase in average earnings in Canadian adults from 2010 to 2020.²² The adjustment values for obesity-related costs from 2005 were 22.7% for inflation, 17.9% for population growth, and 11.9% for increase in average earnings.

Additional analysis

Finally, we conducted an additional analysis to estimate the potential change in health care and health-related productivity costs that would occur if there was a theoretical decrease in the prevalence of insufficient sleep by 5 percentage points in Canadian adults. To do so, we reran the same calculations described above, but replaced prevalence estimates of insufficient sleep of 15.0% for men and 9.5% for women instead of the true prevalence estimates.

Results

Table 1 shows the RR estimates for insufficient sleep duration as it relates to the 7 health outcomes included in this analysis. The RRs indicate that the risk of a health outcome was increased by 11% (coronary heart disease) to 50% (depression) with insufficient sleep duration. The PAR% values reported in Table 1 indicate that between 1.8% (type 2 diabetes) and 9.1% (depression) of the health outcomes were attributable to insufficient sleep duration among Canadian men, and that between 1.3% (type 2 diabetes) and 6.8% (depression) of the health outcomes were attributable to insufficient sleep duration among Canadian women.

Table 2 reports the estimated health care and health-related productivity costs of insufficient sleep duration among Canadian adults (in Canadian dollars). The direct, indirect, and total costs of insufficient sleep duration in Canada in 2020 were \$484 million,

\$17.9 million, and \$501.9 million, respectively. These values represented 0.5% (direct), 2.7% (indirect), and 0.5% (total) of the overall burden of illness costs for 2020 in Canada (estimated at \$102 billion). As shown in Table 3, the 2 most expensive chronic diseases attributable to insufficient sleep duration were depression (\$218.9 million) and type 2 diabetes (\$91.9 million). The main contributors of health care and health-related productivity costs were related to hospital care (coronary heart disease and obesity), prescription drugs (type 2 diabetes and depression), physician care (hypertension and cognitive disorders), and mortality (accidents/injuries).

The potential annual savings in health care and health-related productivity costs with a decrease in the prevalence of insufficient sleep duration by 5 percentage points (from 17.2% to 12.2%) in Canadian adults are estimated at \$148 million (Figure 1).

Discussion

Findings from this study highlight that insufficient sleep duration is an important contributor to health care spending and health-related losses of productivity in Canada. Specifically, we observed that half a billion in health care spending and health-related productivity loss was attributable to insufficient sleep duration in 2020 and that insufficient sleep duration accounted for 0.5% of the overall burden of illness costs in Canada. If public health efforts were able to reduce the prevalence of insufficient sleep duration in Canadian adults by 5%, there would be a corresponding annual health care and health-related productivity savings of approximately \$150 million.

The present study is the first that examined the economic costs associated with insufficient sleep duration in Canada. It is thus not possible to compare our estimates with previous studies and/or examine trends over time. Daley and colleagues²³ examined the direct and indirect costs of insomnia in a random sample of 948 adults from the province of Quebec in 2001. They estimated the annual cost of insomnia in the province of Quebec at \$6.6 billion, with an average annual per-person cost of \$5010 for individuals with insomnia syndrome, \$1431 for individuals presenting with insomnia symptoms, and \$421 for good sleepers. However, they used a different methodology to estimate costs, the estimates no longer represent

Table 3
Direct, indirect, and total costs of insufficient sleep (<7 hours per night) for specific health outcomes in Canadian adults in 2020

Health outcome	Cost attributable to insufficient sleep duration ¹		
	Direct	Indirect	Total
Coronary heart disease	64.0	2.1	66.1
Type 2 diabetes	91.6	0.3	91.9
Depression	218.9	0.01	218.9
Cognitive disorders ²	64.7	0.1	64.8
Work injuries/accidents	0.005	9.6	9.6
Obesity	5.7	5.6	11.3
Hypertension	39.0	0.08	39.1

¹ Costs are in millions of Canadian dollars.

² Dementia and Alzheimer's disease.

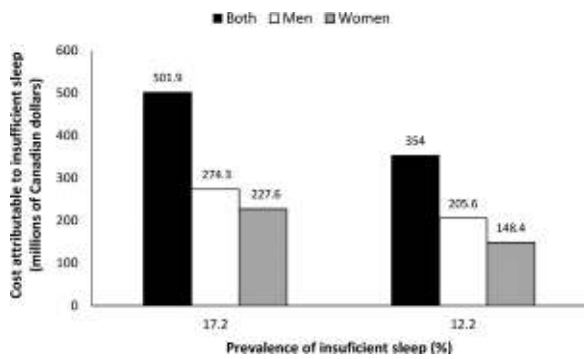


Figure 1. Projected economic costs attributable to insufficient sleep (<7 hours per night) if the prevalence of insufficient sleep duration in Canadian adults is decreased by 5 percentage points (from 17.2% to 12.2%)

contemporary costs, and their study was on insomnia, a specific sleep disorder, precluding comparisons with our study.

Hillman and colleagues²⁴ recently estimated the economic cost of inadequate sleep (sleep disorders and excessive daytime sleepiness) in Australia for the 2016–2017 financial year using national surveys and databases. They estimated the total financial cost at \$17.9 billion (U.S. dollars), representing 1.6% of Australian gross domestic product. Their financial cost component comprised direct health costs (\$160 million for sleep disorders and \$1.1 billion for associated conditions), productivity losses (\$12.2 billion), nonmedical accident costs (\$2.5 billion), informal care costs (\$0.4 billion), and deadweight loss (\$1.6 billion). Their study examined the economic impact of inadequate sleep in all its forms, including those of sleep disorders and excessive daytime sleepiness, thereby explaining the higher values compared to our study.

Simulation analyses were conducted in 2015 to estimate the economic burden of insufficient sleep across different high-income countries.²⁵ These analyses took into account the association between sleep deprivation and mortality, as well as productivity, to produce estimates. Results suggest that Canada loses about 80,000 working days per year due to insufficient sleep duration (corresponding to about 0.6 million working hours) while the U.S. loses about 1.23 million working days per year (corresponding to about 9.9 million working hours).²⁵ Using a macroeconomic model that simulates the various agents in an economy, the authors found that in absolute terms, the U.S. sustains by far the highest annual economic loss, estimated between \$280 billion and \$411 billion, depending on the scenario, representing between 1.6 to 2.3% of their gross domestic product. In Canada, estimates indicate that the annual economic loss due to insufficient sleep duration is between \$13.5 billion and \$21.4 billion, representing 0.9 to 1.4% of their gross domestic product.²⁵

Information on health care and health-related productivity costs of insufficient sleep duration in Canada, as well as savings that could occur if the prevalence of insufficient sleep were to decrease, could be used to inform policy decisions about the funding of future health care priorities. Given the high prevalence of insufficient sleep in Canada and the burden it places on the health care system and the economy, efforts aimed at preventing and better addressing this public health problem are needed. As there is strong competition for preventive health funds, the present study will be valuable for sleep health advocates and policy makers as it provides a quantitative cost savings that would be associated with decreasing the proportion of the population who gets insufficient sleep. As a matter of comparison (using the same methodology), the total economic costs of physical inactivity in Canada in 2009 were \$6.8 billion (3.7% of the overall burden of illness costs) in comparison to \$502 million and 0.5% for insufficient sleep duration. This difference is mainly explained by the fact that over 80% of adults in Canada are insufficiently active (i.e., they

accumulate less than 150 minutes per week of moderate-to-vigorous physical activity) while 17.2% of Canadian adults sleep less than 7 hours per night. However, one must keep in mind that the burden of insufficient sleep to society is very high, and studies have shown that Canadians are more willing to improve their sleep habits than to move more.²⁶

Limitations

The present study used a prevalence-based methodology to estimate the economic costs associated with insufficient sleep duration. When applying this approach, we used RRs from a recent overview of meta-analyses instead of relying on RRs from single prospective cohort studies, which is a key strength. However, one must be mindful that cost estimates generated with a prevalence-based approach rely on several assumptions and may not necessarily reflect the true costs. It is nevertheless a recognized and very common method to estimate health care and health-related productivity costs across the country. Another limitation pertains to the inclusion of 7 health outcomes in this analysis even though insufficient sleep may contribute to other diseases or health problems (eg, cancer, osteoporosis) or have itself a direct impact on costs, such as loss of production (eg, presenteeism). We did not include other diseases in the present analysis given the lack of consistent prospective evidence linking insufficient sleep and other diseases. This conservative approach likely underestimated the full economic burden of insufficient sleep duration in Canadian adults. We also only quantified the economic costs of insufficient sleep duration and not the costs of sleep disorders or daytime sleepiness. The inability to infer causality in the meta-analyses of prospective studies and reliance on self-reported sleep in primary studies may have also impacted the estimates reported in this paper. Finally, we adjusted the 2010 EBIC data for inflation and population growth to reflect current estimates. This assumes that the relative contribution of the costs of the 7 health outcomes to overall health care expenditures remained constant in the last decade.

Conclusion

Insufficient sleep duration accounts for an important portion of health care spending and health-related losses of productivity in Canada (\$502 million in 2020) and it is hoped that this study will bring more attention to the issue of insufficient sleep as an important public health problem to be addressed in our 24/7 society. Future cost-effectiveness studies are needed to test promising sleep health strategies at the population level.

Authors' contributions

JC and IJ conceived the study and analyzed the data. All authors contributed to data interpretation. JC wrote the first draft of the manuscript. All authors revised it critically for important intellectual content, gave final approval for the version to be published and agreed to be accountable for all aspects of the work.

Declaration of conflict of interest

The authors have declared no conflicts of interest.

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