This report examines the societal and economic burden of insomnia among adults within high-income, Organisation for Economic Co-operation and Development countries across Northern, Western and Southern Europe, as well as North America and Australia. The results of this report will be of value to clinicians, researchers, policymakers and the public interested in the field of sleep.

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RAND Europe is a not-for-profit research organisation that helps improve policy and decision making through research and analysis. For more information about this document or RAND Europe please contact:

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Executive summary

Context

Sleep is a fundamental biological necessity, just like the need for food or water. Yet for millions of individuals worldwide who suffer from the symptoms of insomnia (such as difficulty falling asleep, staying asleep, or experiencing non-restorative or poor-quality sleep), days and nights can be a constant struggle.

Insomnia is the most common sleep disorder and exacts a significant toll on an individual’s mental and physical health, quality of life (QoL) and productivity. The consequences of insomnia go well beyond the individual, as there may be cascading effects on families, employers and global economies. Understanding the broader societal effects of insomnia is crucial in identifying opportunities for scalable interventions designed to positively impact the health, well-being and productivity of individuals and, collectively, to benefit society as a whole.

Study objectives

The objective of this study was to identify and quantify the societal burden of insomnia and its resultant impacts, both in terms of **indirect economic costs** (i.e. non-healthcare related costs) and **intangible costs** (i.e. costs that are not directly observed through economic transactions but nonetheless have impacts on an individual’s health or well-being). We define societal burden as the effects of insomnia that extend beyond health- and healthcare-related impacts, although the societal burden may also include such impacts.

Based on these findings, the report includes recommendations for future policy, clinical practice and research to mitigate the societal and economic impacts of insomnia. The focus of this research was on general adult populations in high-income, Organisation for Economic Co-operation and Development (OECD) countries of Northern, Southern and Western Europe, as well as North America and Australia.

Approach

This study comprises three main research activities:

- **A literature review** to identify and quantify the societal burden of insomnia, including the prevalence of insomnia and its impacts on QoL and workplace productivity, followed by meta-regression to estimate the predicted prevalence of insomnia.

- **Secondary database analyses** to quantify the impact of insomnia on overall well-being and to calculate intangible costs using a well-being valuation approach that represents a monetary value that people with insomnia would be willing to trade to attain the same level of well-being as a person without insomnia.
• **Macro-economic modelling** to estimate the indirect costs of insomnia related to loss in productivity.

Findings from the study are described based on the following three interrelated insomnia subtypes:

1. **Insomnia symptoms** – defined as any symptoms of insomnia, including difficulty falling asleep, difficulty staying asleep and/or early waking, or poor-quality sleep; or operationalised as an Insomnia Severity Index (ISI; Bastien et al. 2001) score of at least 8 or an Athens Insomnia Scale (AIS; Soldatos et al. 2000) score of at least 4.

2. **Clinical insomnia** – defined as difficulty falling or staying asleep or non-restorative sleep experienced at least three times per week for at least one month, with impairment to daily activities; or operationalised as an ISI score of at least 15 or an AIS score of at least 6. This definition is broadly consistent with the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) criteria for insomnia, regardless of underlying causes.

3. **Chronic insomnia** – defined as difficulty falling or staying asleep or early-morning awakening or non-restorative sleep experienced at least three times per week for at least three months, with impairment to daily activities. This definition is broadly consistent with DSM, fifth edition (DSM-5) criteria for insomnia disorder.

**Key research findings**

**Prevalence of insomnia**

Up to 50% of the general adult population is reported in the literature to suffer from insomnia symptoms, while up to 25% and 15% suffer from clinical and chronic insomnia, respectively. The prevalence of insomnia symptoms from the literature across the 16 identified countries ranged from 17.5% to 51.2%, clinical insomnia ranged from 5.7% to 25.3% and chronic insomnia ranged from 6.0% to 14.8% (Table ES.1). As expected, estimates from the literature for the prevalence of insomnia symptoms were typically larger (and with a wider range) than those for clinical and chronic insomnia, while clinical insomnia estimates were typically larger (and with a wider range) than those for chronic insomnia.

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1 For a comparison of DSM-IV and DSM-5 insomnia definitions, see (as of 20 October 2022): [https://www.ncbi.nlm.nih.gov/books/NBK519704/](https://www.ncbi.nlm.nih.gov/books/NBK519704/)
Table ES.1: Range of reported prevalence estimates by region and country for each insomnia subtype (% of total adult population from each study)

<table>
<thead>
<tr>
<th>Region</th>
<th>Insomnia symptoms</th>
<th>Clinical insomnia</th>
<th>Chronic insomnia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall</strong></td>
<td>17.5–51.2%</td>
<td>5.7–25.3%</td>
<td>6.0–14.8%</td>
</tr>
<tr>
<td>Australia</td>
<td>20.0–34.9%</td>
<td>--</td>
<td>10.7–13.3%</td>
</tr>
<tr>
<td>North America</td>
<td>17.5–51.2%</td>
<td>9.5–23.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Canada</td>
<td>24.0–51.2%</td>
<td>9.5–19.0%</td>
<td>--</td>
</tr>
<tr>
<td>United States</td>
<td>17.5–18.1%</td>
<td>23.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Northern Europe</td>
<td>20.8–37.6%</td>
<td>10.2–20.0%</td>
<td>7.1–9.7%</td>
</tr>
<tr>
<td>Finland</td>
<td>20.8–37.6%</td>
<td>11.7–20.0%</td>
<td>--</td>
</tr>
<tr>
<td>Norway</td>
<td>--</td>
<td>10.2–11.9%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Sweden</td>
<td>24.6–33.1%</td>
<td>10.5–13.4%</td>
<td>8.1–9.7%</td>
</tr>
<tr>
<td>Southern Europe</td>
<td>20.8–42.8%</td>
<td>6.4–25.3%</td>
<td>--</td>
</tr>
<tr>
<td>Greece</td>
<td>--</td>
<td>25.3%</td>
<td>--</td>
</tr>
<tr>
<td>Italy</td>
<td>27.1–27.6%</td>
<td>7.0–8.7%</td>
<td>--</td>
</tr>
<tr>
<td>Portugal</td>
<td>28.1–42.8%</td>
<td>21.1%</td>
<td>--</td>
</tr>
<tr>
<td>Spain</td>
<td>20.8–37.6%</td>
<td>6.4–22.4%</td>
<td>--</td>
</tr>
<tr>
<td>Western Europe</td>
<td>18.6–49.9%</td>
<td>5.7–19.0%</td>
<td>6.8–14.8%</td>
</tr>
<tr>
<td>Austria</td>
<td>32.0%</td>
<td>19.0%</td>
<td>--</td>
</tr>
<tr>
<td>Belgium</td>
<td>49.9%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>France</td>
<td>18.6–37.6%</td>
<td>11.3–19.0%</td>
<td>--</td>
</tr>
<tr>
<td>Germany</td>
<td>21.1–32.9%</td>
<td>5.7–17.4%</td>
<td>--</td>
</tr>
<tr>
<td>Switzerland</td>
<td>36.0%</td>
<td>--</td>
<td>11.0%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>35.0–38.6%</td>
<td>12.6–13.9%</td>
<td>6.8–14.8%</td>
</tr>
</tbody>
</table>

*Note: Dashes indicate where data are missing for a given country.*
Based on statistical modelling, approximately one-third of the general adult population is predicted to suffer from insomnia symptoms, while 14% and 8% are predicted to suffer from clinical and chronic insomnia, respectively. Meta-regression conditional on study characteristics (e.g. mean age, percentage of female participants, year of data collection) was used to estimate prevalence (i.e. predicted values) of each insomnia subtype (Figure ES.1). These prevalence estimates equate to approximately 172m people with insomnia symptoms, 72m with clinical insomnia and 42m with chronic insomnia among working-age populations from the 16 identified countries.²

Figure ES.1: Predicted prevalence of insomnia subtypes for adult populations across identified countries³

Notes: Values represent the predicted prevalence of insomnia for a population with a mean age of 46 years (with 52% females) in 2020. Error bars represent 95% confidence intervals. Estimates for each insomnia subtype are not mutually exclusive.

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² The total working-age population across the 16 identified countries is 507,673,833 based on data from Worldometers (as of 20 October 2022: https://www.worldometers.info/world-population/population-by-country/) and the World Bank (as of 20 October 2022: https://data.worldbank.org/indicator/SP.POP.1564.TO.ZS?end=2021&name_desc=false&start=2021&view=map&year=2021)

³ Predicted prevalence values are based on data from the 16 countries of focus.
By country, about 5–11% of the general adult population is predicted to suffer from chronic insomnia. Specific to chronic insomnia, predicted prevalence estimates derived from meta-regression ranged from 5.3% to 10.9% by country but were statistically different only between the two countries with the largest prevalence estimates (10.9% in Australia and 10.7% in Belgium) compared with the three countries with the smallest prevalence estimates (5.3% in Austria, 5.5% in Germany and 6.1% in Spain) (Figure ES.2).

Figure ES.2: Predicted prevalence of chronic insomnia among adult populations for identified countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Predicted prevalence of chronic insomnia, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>10.9</td>
</tr>
<tr>
<td>Belgium</td>
<td>10.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10.3</td>
</tr>
<tr>
<td>Finland</td>
<td>9.4</td>
</tr>
<tr>
<td>Switzerland</td>
<td>9.2</td>
</tr>
<tr>
<td>Sweden</td>
<td>9.0</td>
</tr>
<tr>
<td>France</td>
<td>8.8</td>
</tr>
<tr>
<td>Canada</td>
<td>8.8</td>
</tr>
<tr>
<td>Norway</td>
<td>7.8</td>
</tr>
<tr>
<td>United States</td>
<td>7.8</td>
</tr>
<tr>
<td>Greece</td>
<td>7.5</td>
</tr>
<tr>
<td>Italy</td>
<td>6.8</td>
</tr>
<tr>
<td>Portugal</td>
<td>6.7</td>
</tr>
<tr>
<td>Spain</td>
<td>6.1</td>
</tr>
<tr>
<td>Germany</td>
<td>5.5</td>
</tr>
<tr>
<td>Austria</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Notes: Estimates shown are ranked from highest (top) to lowest (bottom). Values represent the predicted prevalence of chronic insomnia for a population with a mean age of 46 years (with 52% females) in 2020. Error bars represent 95% confidence intervals (CIs). Non-overlapping CIs reflect statistically significant differences at p<0.05 (the dotted line marks the upper bound of 95% CI for the three bottom countries [Spain, Germany and Austria] for statistically significant differences compared to the top two countries [Australia and Belgium]).

Predicted prevalence estimates are derived from meta-regression, using prevalence estimates reported from the literature for each country across all insomnia subtypes. Thus, predicted estimates were generated for insomnia subtypes even when values for certain countries were missing.
Societal burden of insomnia

**Insomnia is associated with poorer self-rated life satisfaction.** Based on secondary database analyses of a representative sample of adults from the United Kingdom (UK), individuals with insomnia had, on average, lower self-rated life-satisfaction scores compared to those without insomnia, after adjusting for socio-demographic factors, and this effect was only partially mitigated when adjusting for sleep duration and mental well-being. Notably, after accounting for insomnia and mental well-being, short-sleep duration was not associated with life satisfaction, suggesting the independent societal impact of insomnia above and beyond sleep duration.

**Insomnia is associated with poor physical and mental health-related QoL.** Evidence from the literature demonstrates strong associations between insomnia and reduced health-related QoL across various aspects of physical and mental health. For example, one study estimated that insomnia was associated with a loss of 5.6m quality-adjusted life years annually, larger than 18 other common medical conditions including arthritis, depression and hypertension.

**Adults with insomnia are more likely to be absent from work and are less productive whilst at work.** Extrapolating findings from two studies which described the impact of insomnia on the workplace, insomnia symptoms were associated with approximately 14 days of absenteeism, 30 days of presenteeism (i.e. showing up at work but less productive) and 23 days of overall productivity loss annually, whereas chronic insomnia was associated with about 11–18 days of absenteeism, 39–45 days of presenteeism and 44–54 days of overall productivity loss annually.

**Insomnia is associated with an increased risk of workplace-related errors and accidents leading to injuries and disability.** Studies from the literature review found that insomnia was associated with a 75–88% increase in the odds of an accident leading to permanent work disability.
Intangible costs of insomnia

On average, adults suffering from insomnia are willing to trade 14% of their per-capita annual household income\(^5\) to attain the same level of life satisfaction as those without insomnia. Based on estimates of poorer self-rated life satisfaction and applying a well-being valuation approach to calculate a marginal rate of substitution (MRS, i.e. willingness to trade a percentage of income for an increase in well-being), we estimated that adults with insomnia would be willing to trade 14.0% (95% CI: 8.3%, 20.1%) of their per-capita household income. This translates to an absolute monetary value (i.e. compensating income variation [CIV]) ranging, for example, from $3,746.30 (95% CI: $2,216.90, $5,351.60) in Portugal, $5,773.50 (95% CI: $3,416.60, $8,247.60) in Germany and $7,674.80 (95 CI: $4,541.70, $10,963.60) in the US (Figure ES.3). These estimates represent the intangible ‘hidden’ costs of insomnia due to a loss of individual well-being.

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**Figure ES.3: Individual annual compensating income variation (CIV) for insomnia for identified countries (in 2019 USD)**

<table>
<thead>
<tr>
<th>Country</th>
<th>CIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>$7,674.80</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$5,778.50</td>
</tr>
<tr>
<td>Germany</td>
<td>$5,773.50</td>
</tr>
<tr>
<td>Norway</td>
<td>$5,638.50</td>
</tr>
<tr>
<td>Austria</td>
<td>$5,632.30</td>
</tr>
<tr>
<td>Australia</td>
<td>$5,433.70</td>
</tr>
<tr>
<td>Belgium</td>
<td>$5,153.60</td>
</tr>
<tr>
<td>France</td>
<td>$5,071.50</td>
</tr>
<tr>
<td>Finland</td>
<td>$4,906.90</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$4,883.40</td>
</tr>
<tr>
<td>Canada</td>
<td>$4,870.90</td>
</tr>
<tr>
<td>Sweden</td>
<td>$4,801.70</td>
</tr>
<tr>
<td>Italy</td>
<td>$4,455.50</td>
</tr>
<tr>
<td>Spain</td>
<td>$4,011.70</td>
</tr>
<tr>
<td>Portugal</td>
<td>$3,746.30</td>
</tr>
</tbody>
</table>

Notes: CIVs are based on a single marginal rate of substitution value (14.0%; 95% CI: 8.3%, 20.1%) and this value was applied to other countries using country-specific per-capita median household income from OECD data. Greece was not included due to insufficient data on prevalence estimates. USD=United States Dollar.

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\(^5\) This is an average estimate; willingness to forego income is largely dependent on household income, such that people with higher income are likely willing to pay more and those with lower income are likely willing to pay less.
At the population level, intangible costs due to chronic insomnia in the working-age population are in the billions of dollars, annually. Extrapolated to the working-age population and the predicted prevalence of chronic insomnia for each country, the annual well-being loss due to chronic insomnia ranged from $1.5bn in Norway to $127.1bn in the US (Table ES.2).

Table ES.2: Aggregated annual compensating income variation (CIV) by country for the affected working-age population suffering from chronic insomnia (in 2019 USD $bn)

<table>
<thead>
<tr>
<th>Country</th>
<th>Aggregated CIV (billion, 2019 values)</th>
<th>Aggregated CIV (billion, 95% CI: low)</th>
<th>Aggregated CIV (billion, 95% CI: high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>$1.8</td>
<td>$0.8</td>
<td>$3.2</td>
</tr>
<tr>
<td>Australia</td>
<td>$9.7</td>
<td>$4.5</td>
<td>$16.7</td>
</tr>
<tr>
<td>Belgium</td>
<td>$4.0</td>
<td>$1.8</td>
<td>$7.0</td>
</tr>
<tr>
<td>Canada</td>
<td>$10.7</td>
<td>$4.0</td>
<td>$20.8</td>
</tr>
<tr>
<td>Finland</td>
<td>$1.6</td>
<td>$0.6</td>
<td>$2.9</td>
</tr>
<tr>
<td>France</td>
<td>$17.8</td>
<td>$6.7</td>
<td>$34.6</td>
</tr>
<tr>
<td>Germany</td>
<td>$17.0</td>
<td>$7.3</td>
<td>$30.5</td>
</tr>
<tr>
<td>Italy</td>
<td>$11.7</td>
<td>$4.7</td>
<td>$22.2</td>
</tr>
<tr>
<td>Norway</td>
<td>$1.5</td>
<td>$0.6</td>
<td>$3.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>$1.6</td>
<td>$0.6</td>
<td>$3.1</td>
</tr>
<tr>
<td>Spain</td>
<td>$7.4</td>
<td>$3.2</td>
<td>$13.6</td>
</tr>
<tr>
<td>Sweden</td>
<td>$2.7</td>
<td>$1.1</td>
<td>$5.1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$3.0</td>
<td>$1.1</td>
<td>$5.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$21.9</td>
<td>$8.5</td>
<td>$41.8</td>
</tr>
<tr>
<td>United States</td>
<td>$127.1</td>
<td>$49.8</td>
<td>$240.6</td>
</tr>
</tbody>
</table>

Notes: Aggregated CIVs estimated based on individual CIVs and the total working-age population and the predicted prevalence of chronic insomnia for each country. Greece was not included due to insufficient data on prevalence estimates. CI=confidence interval. USD=United States Dollar.

Indirect economic costs of insomnia

Chronic insomnia is associated with a substantial annual economic impact due to workplace productivity loss. Using a macro-economic modelling approach, which takes into consideration the economic forces between and across national economies and spill-over effects across different sectors of the economy, eliminating the effects of chronic insomnia on productivity loss in the workplace (as estimated from the aforementioned literature) would be expected to increase national gross domestic products (GDPs) by 0.64% in Austria, 0.73% in Germany, 1.23% in France and 1.31% in Switzerland and the UK (Figure ES.4).
Figure ES.4: Estimated annual gross domestic product (GDP, in 2019 USD $bn and % GDP) loss associated with chronic insomnia-related reduced productivity for identified countries.

Note: USD=United States Dollar.
Economic projections suggest that reducing the effects of chronic insomnia across the working population could result in substantial economic gains. Absolute monetary gain due to an increase in annual GDP via reduction in chronic insomnia across the population ranged from a mean of $1.8bn in Portugal to $207.5bn in the US, with annual per-capita gains ranging from a mean of $4,194.60 in Portugal to $19,349.70 in Switzerland (Figure ES.4). Absolute monetary gains, in terms of GDP per capita, ranged from approximately $4,195 to $19,350 by country (Table ES.3).

Table ES.3: Estimated annual productivity costs associated with chronic insomnia by country – gross domestic product (GDP) effects per capita

<table>
<thead>
<tr>
<th>Country</th>
<th>Estimate</th>
<th>95% CI: low</th>
<th>95% CI: high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>$10,351.8</td>
<td>$8,054.6</td>
<td>$12,706.4</td>
</tr>
<tr>
<td>Austria</td>
<td>$9,286.7</td>
<td>$6,752.9</td>
<td>$11,679.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>$6,582.5</td>
<td>$4,955.0</td>
<td>$8,171.6</td>
</tr>
<tr>
<td>Canada</td>
<td>$8,854.2</td>
<td>$5,566.8</td>
<td>$12,219.3</td>
</tr>
<tr>
<td>Finland</td>
<td>$12,971.2</td>
<td>$10,574.5</td>
<td>$14,308.3</td>
</tr>
<tr>
<td>France</td>
<td>$10,432.1</td>
<td>$6,605.0</td>
<td>$14,308.3</td>
</tr>
<tr>
<td>Germany</td>
<td>$9,978.1</td>
<td>$7,183.2</td>
<td>$12,641.4</td>
</tr>
<tr>
<td>Italy</td>
<td>$6,468.4</td>
<td>$4,343.5</td>
<td>$8,623.2</td>
</tr>
<tr>
<td>Norway</td>
<td>$18,331.7</td>
<td>$11,229.0</td>
<td>$25,535.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>$4,194.6</td>
<td>$2,691.1</td>
<td>$5,650.5</td>
</tr>
<tr>
<td>Spain</td>
<td>$6,285.1</td>
<td>$4,490.5</td>
<td>$8,106.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>$11,677.2</td>
<td>$7,931.2</td>
<td>$15,422.1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$19,349.7</td>
<td>$12,137.8</td>
<td>$26,455.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$9,391.5</td>
<td>$6,162.2</td>
<td>$12,662.5</td>
</tr>
<tr>
<td>United States</td>
<td>$12,272.6</td>
<td>$8,018.2</td>
<td>$16,478.1</td>
</tr>
</tbody>
</table>

Notes: The GDP per working adult suffering from chronic insomnia by country varies because of different country-specific prevalence estimates, as well as varying underlying productivity per-capita levels. Greece was not included due to insufficient data on prevalence estimates. CI=confidence intervals. USD=United States Dollar.
What can be done to reduce the societal and economic burden of insomnia?\(^6\)

**Recommendations for policy**

1. **Governments and healthcare systems should provide access to and reimbursement for safe, evidence-based, affordable and cost-effective treatments for chronic insomnia.**

   Cognitive behavioural therapy (CBT) is currently considered the first-line therapy for the treatment of insomnia (i.e. CBT-I); however, this treatment remains under-utilised for a variety of reasons, including issues of access to qualified providers and reimbursement for services. New modalities of delivery of CBT-I, including teletherapy or digital health platforms, may help to enhance access, and policymakers should create avenues to promote access to and reimbursement for these services. However, given that not all patients respond to CBT-I (Trauer et al. 2015; Muench et al. 2022), and to satisfy diverse patient preferences, innovative behavioural and pharmacological treatments for chronic insomnia are needed that are safe and effective for long-term use. Finally, there is a critical need to identify effective strategies to improve scalability and dissemination of existing and new treatments, particularly in socio-economically disadvantaged populations and among racial/ethnic groups most vulnerable to health disparities.

2. **Workplace interventions are needed to better identify insomnia and mitigate its impacts.**

   As our research shows, chronic insomnia can impact the entire economy of a country in terms of its GDP output, but its immediate effects are likely to be felt most acutely within the workplace. Thus, policies to mitigate the impacts of insomnia should start at work. For example, employers (especially human-resource departments) and employees should be educated on the symptoms and signs of insomnia, its impact on cognitive function, health and well-being and its risks related to workplace-related errors, accidents and injuries. Employees, as part of an overall ‘wellness package’, should receive evidence-based resources for managing insomnia, such as access to CBT-I. These interventions are particularly important for employees in high-risk work environments in which errors or accidents could result in severe life-threatening injuries to themselves, co-workers, consumers or other members of the public. Workplaces should also foster a culture that promotes sleep health, such as limiting email traffic after working hours and adopting policies that support work-family balance (e.g. flexible schedules, family-leave policies), given that life events such as a death in the family or the birth of a new child can trigger insomnia (Lancel et al. 2020). Changes to the workplace environment, such as using circadian-effective lighting or providing workplaces with windows (offering exposure to daylight), have also been shown to improve employees’ mood and sleep quality and may therefore be an important preventive strategy (Boubekri et al. 2014).

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\(^6\) Recommendations were proposed by study authors (one of whom, WMT, is a sleep clinician and researcher) and were amended and validated by four clinicians and researchers who served on the study’s steering committee.
3. **Public health campaigns should emphasise the importance of sleep quality in addition to sleep quantity.**

   While insufficient sleep duration has negative impacts on an individual's well-being and on a nation's total economic output (Hafner et al. 2016), increasing evidence points to the unique public health impact of poor sleep quality and insomnia. For example, through our analyses we found that insomnia was associated with lower life satisfaction, independent of sleep duration. Furthermore, a sizeable portion of the population has little control over their sleep duration, and an exclusive emphasis on sleep duration can be a stressor that contributes to further sleep problems. Indeed, current conceptualisations of sleep health emphasise its multi-dimensional nature, including sleep quality, duration, timing, regularity and daytime functioning. Thus, public health campaigns should include ways to improve the quality of sleep, such as maintaining a consistent sleep-wake schedule, removing technology from the bedroom and avoiding alcohol and caffeine. Initiatives to disseminate such knowledge should be encouraged (Altena et al. 2020; Baglioni et al. 2020).

**Recommendations for clinical practice**

1. **Screening for insomnia disorder should be incorporated into routine clinical visits.**

   Chronic insomnia is an under-diagnosed condition, and delays in its diagnosis and treatment may lead to more severe and intractable symptoms. Such delays may result in patients requiring more aggressive management than would be needed if insomnia was addressed earlier in the clinical course. Accordingly, routine screening for sleep problems and disorders, including insomnia, should occur in the primary care/general practice setting to improve diagnosis and treatment. Early detection of sleep disorders and their related causes can ultimately reduce downstream health and productivity consequences, as well as the burden on the healthcare system, and may also enhance patient engagement (Croker et al. 2013).

2. **Medical school and graduate medical training should be revised to include a more in-depth focus on sleep health and the identification and clinical management of sleep disorders, including insomnia.**

   Sleep occupies a major proportion of our lives, and yet sleep education in the medical school curriculum is woefully lacking. In fact, a multi-nation survey of medical schools found that the average amount of time spent on sleep education was just under 2.5 hours, while a striking 27% of respondents indicated that their medical school provided no sleep education to future physicians (Mindell et al. 2011).

3. **Providing ongoing education regarding evidence-based treatments for chronic insomnia is critical to address physician knowledge gaps and improve the identification and management of insomnia.**

   Without knowledge or awareness of the signs and symptoms of insomnia or effective behavioural or pharmacological treatment options, providers must rely on their best judgment or prior experiences, rather than making evidence-based clinical decisions. Thus, efforts are needed to educate and disseminate information on insomnia and
evidence-based treatments that have been proven to be safe and effective in the long-term to improve patient care.

4. **The relationship between insomnia and other health conditions is often bidirectional and requires a holistic approach to management and treatment.**

Chronic insomnia is often co-morbid with numerous other physical and mental-health conditions. While chronic insomnia should be treated as an independent condition, there are benefits to treating co-occurring conditions. For example, some pharmacological and non-pharmacological treatments for anxiety and depression can help reduce symptoms of insomnia and vice versa (Hertenstein et al. 2022). Conversely, failure to treat insomnia has been shown to predict poorer treatment response (Troxel et al. 2012) and a greater likelihood of the recurrence of depression (Inada et al. 2021). Holistic treatment strategies should take a ‘person-centred’ rather than a ‘disease-centred’ approach. Furthermore, some evidence suggests that treating insomnia may be a ‘gateway’ to the treatment of other mental-health conditions among otherwise treatment-reluctant populations (e.g. the military), as sleep disorders tend to be less stigmatised than mental-health conditions (Troxel et al. 2015).

5. **Clinical-care pathways should be established within healthcare systems to ensure that patients have timely access to diagnosis and treatments.**

Clinical-care pathways from screening to diagnosis of insomnia – and ultimately to management and treatment – may vary between national, regional and local healthcare systems. Healthcare systems should consider establishing and/or standardising this pathway so that patients receive timely diagnosis and treatment. Healthcare systems should also consider the continuity between primary and secondary care so that general practitioners (GPs) either know how to diagnose and manage insomnia (see the recommendation above on education and awareness of insomnia among clinicians) or are able to refer patients to specialists for this purpose. Indeed, a lack of awareness of viable referral pathways to specialist care for complex cases has been identified as a critical barrier in GPs’ management of insomnia (Haycock et al. 2021).

**Recommendations for research**

1. **More research is needed on the prevalence of chronic insomnia and its societal and economic impacts.**

This report identified relatively few studies on chronic insomnia (i.e. the current definition of insomnia disorder based on contemporary disease classification and coding systems). More studies are needed to understand the burden of this disorder, especially the prevalence of chronic insomnia among underserved groups and in the context of other physical and mental-health conditions. In addition, more research is needed to examine the societal impacts and economic costs of chronic insomnia and to address other potential mechanisms linking insomnia with economic outcomes, such as the impact of insomnia on workforce retention and employee satisfaction and other detrimental effects on daytime functioning.
2. **Survey instruments need to be designed and validated to measure chronic insomnia.**

The lack of studies on chronic insomnia is, in part, due to the fact that currently available datasets and the validated instruments that measure its symptoms are designed to capture insomnia disorder defined according to outdated diagnostic criteria. Thus, future research is needed that uses validated survey instruments specifically designed to measure chronic insomnia as defined by contemporary disease classification and coding systems.

3. **A better understanding is needed of the interrelationship between the novel coronavirus disease (COVID-19), physical health, mental health and sleep.**

The COVID-19 pandemic has been associated with fundamental changes to society, including where we live and how we work, as well as when and how well we sleep. Research has shown the negative consequences of the pandemic on physical health, mental health and sleep (Gualano et al. 2020; Jahrami et al. 2021; Kokou-Kpolou et al. 2020; Pizzonia et al. 2021). Given that COVID-19 is likely to be an enduring fact of life, more research is needed to examine the interrelationships between physical health, mental health and sleep in the context of the newer ways of living and working resulting from the pandemic. Research is also needed on how ‘long COVID’ symptoms have lasting impacts on sleep and the downstream societal and economic impacts.

4. **Well-designed studies are needed to test the long-term efficacy of current and emerging pharmacological and behavioural interventions for chronic insomnia on societal and economic outcomes.**

There is a critical gap in evidence concerning the long-term benefits and harms of commonly prescribed pharmacological agents used to treat insomnia disorder (De Crescenzo et al. 2022; Schutte-Rodin et al. 2008) and a need to identify safe and effective pharmacological agents that are appropriate for long-term use. Furthermore, given that CBT-I is considered first-line treatment, randomised controlled trials or high-quality observational studies are needed to examine the long-term benefits and risks of pharmacotherapy compared to, and/or in combination with, CBT-I (Edinger et al. 2021). In particular, such trials should incorporate societal and economic outcomes, in addition to clinical outcomes, in order to understand how treatments can benefit not only the individual but also society as a whole.

5. **There is an urgent need to better understand the social and environmental determinants of sleep-health inequalities and identify scalable interventions to treat populations who may be most vulnerable to insomnia yet remain underserved in the healthcare system.**

Because insomnia disproportionately impacts certain groups within society it is critical that future research is dedicated to understanding populations most at-risk and underserved by the healthcare system, as well as opportunities for prevention and intervention in these populations. In particular, more research is needed in diverse racial and ethnic groups, among caregivers and healthcare workers and in those with chronic co-morbidities. This research is particularly important in light of the COVID-19 pandemic, which has exacerbated existing disparities in health, including the risk for insomnia (Jackson & Johnson 2020).
6. **Person-generated digital health data (PGHD) offer innovative opportunities for identifying population-level health problems, including prevalence, risk factors and the consequences of insomnia.**

Deriving from the wide availability of consumer devices such as smartphones and ‘wearables’ (e.g. commercial sleep-tracking devices), the explosion of PGHD may facilitate the early detection and identification of insomnia, and also help identify social and environmental determinants of insomnia. However, most large-scale investigations to date using PGHD data rely on ‘bring-your-own-device’ designs, which may systematically under-represent socio-economically disadvantaged populations and those from marginalised racial/ethnic groups. Nevertheless, such large-scale data offer important opportunities for surveying the prevalence, determinants and consequences of insomnia, but such research should be conducted within a health-equity lens. Research should also investigate the potential iatrogenic effects of such sleep-tracking devices among some populations, including increasing worry about sleep, potentially leading to an increased insomnia risk.

**Conclusions**

Insomnia affects a significant proportion of the general adult population across the 16 high-income countries included in this report, with an estimated 8% predicted to suffer from chronic insomnia and 14% predicted to suffer from clinical insomnia in any given year, representing approximately 41.6m and 72.1m working-age adults, respectively. Insomnia is associated with a host of downstream consequences on both the individual and society as a whole. In particular, insomnia is strongly linked with poorer QoL and lower life satisfaction. Expressed in terms of well-being costs, an individual suffering from insomnia would on average be willing to trade an estimated 14% of their per-capita annual household income in order to recuperate the well-being loss associated with insomnia. At the national level this translates annually to between $1.5bn and $127.1bn in ‘hidden’ costs due to chronic insomnia. Chronic insomnia is also associated with reduced productivity in the workplace due to absenteeism and presenteeism, resulting in the loss of an average of 44–54 working days per year and an estimated loss in annual GDP ranging from 0.64% to 1.31%, or approximately $1.8–207.5bn in indirect economic costs.

Given the substantial societal and economic impact of insomnia, strategies are needed to better mitigate its burden through policy, clinical practice and future research in order to positively impact the health, well-being and productivity of individuals and society as a whole.
## Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
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<td>AIS</td>
<td>Athens Insomnia Scale</td>
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<tr>
<td>BNSQ</td>
<td>Basic Nordic Sleep Questionnaire</td>
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<tr>
<td>CAD</td>
<td>Canadian Dollars</td>
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<tr>
<td>CBT-I</td>
<td>Cognitive Behavioural Therapy for Insomnia</td>
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<tr>
<td>CGE</td>
<td>Computable General Equilibrium</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<td>CIV</td>
<td>Compensating Income Variation</td>
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<tr>
<td>COI</td>
<td>Cost of Illness</td>
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<tr>
<td>COVID</td>
<td>Coronavirus Disease</td>
</tr>
<tr>
<td>DSM</td>
<td>Diagnostic and Statistical Manual</td>
</tr>
<tr>
<td>EPIC</td>
<td>Economic Projections for Illness and Cost of Treatment</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>EVAL</td>
<td>Evaluation</td>
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<tr>
<td>GAMS</td>
<td>General Algebraic Modelling System</td>
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<tr>
<td>GBP</td>
<td>Great British Pound</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GP</td>
<td>General Practitioner</td>
</tr>
<tr>
<td>GTAP</td>
<td>Global Trade Analysis Project</td>
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<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<tr>
<td>HRQoL</td>
<td>Health Related Quality of Life</td>
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<tr>
<td>ICD</td>
<td>International Classification of Diseases</td>
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<tr>
<td>ICSD</td>
<td>International Classification of Sleep Disorders</td>
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<tr>
<td>ISI</td>
<td>Insomnia Severity Index</td>
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<tr>
<td>MPSGE</td>
<td>Mathematical Programming System for General Equilibrium</td>
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<tr>
<td>MRS</td>
<td>Marginal Rate of Substitution</td>
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<tr>
<td>NHWS</td>
<td>National Health and Wellness Survey</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<td>OR</td>
<td>Odds Ratio</td>
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<tr>
<td>PGHD</td>
<td>Person-Generated Digital Health Data</td>
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<td>PSQI</td>
<td>Pittsburgh Sleep Quality Index</td>
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<tr>
<td>QALY</td>
<td>Quality-Adjusted Life Years</td>
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<tr>
<td>QoL</td>
<td>Quality of Life</td>
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<tr>
<td>SAM</td>
<td>Social Accounting Matrix</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<td>SE</td>
<td>Standard Error</td>
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<td>SF</td>
<td>Short Form</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<td>US</td>
<td>United States</td>
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<tr>
<td>USD</td>
<td>United States Dollar</td>
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<tr>
<td>WEMWBS</td>
<td>Warwick-Edinburgh Mental Well-being Scale</td>
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<tr>
<td>WPAI</td>
<td>Work Productivity and Activity Impairment</td>
</tr>
<tr>
<td>WTA</td>
<td>Willingness to Accept</td>
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<tr>
<td>WTP</td>
<td>Willingness to Pay</td>
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Introduction

1.1. Background and context

_Innocent sleep. Sleep that soothes away all our worries. Sleep that puts each day to rest. Sleep that relieves the weary laborer and heals hurt minds. Sleep, the main course in life’s feast, and the most nourishing._

*William Shakespeare, Macbeth*

Sleep is a fundamental biological necessity, just like the need for food or water. Yet for millions of individuals worldwide suffering from insomnia, sleep is a struggle that persists day and night rather than being, in the words of Shakespeare, ‘the main course in life’s feast, and the most nourishing’. Insomnia is the most common sleep disorder and recent evidence suggests that the current global burden may be growing, as the novel coronavirus disease (COVID-19) has led to a steep increase in insomnia in the general population worldwide (Morin et al. 2021), particularly among healthcare workers (Zhang et al. 2020) and individuals with COVID-19 (Liu et al. 2021).

Insomnia exacts a significant toll on an individual’s mental and physical health, quality of life (QoL) and productivity. For example, evidence suggests that insomnia is associated with a two- to four-fold increased risk of depression (Hertenstein et al. 2019), the leading cause of disability worldwide and a significant contributor to the global burden of disease. Importantly, the consequences of insomnia go well beyond the individual, with cascading effects on employers and global economies. Understanding the broader societal effects of insomnia is crucial in identifying opportunities for scalable interventions to positively impact the health, well-being and productivity of individuals and society as a whole.

1.1.1. Insomnia definitions and prevalence

In order to better understand the individual and societal impacts of insomnia, it is first important to have a clear definition of insomnia, as prevalence estimates vary widely, in part due to conflating insomnia symptoms versus insomnia disorder. Insomnia is broadly characterised by disturbances in sleep, including difficulty falling asleep (sleep latency), difficulty staying asleep or early wakening (sleep maintenance) and/or poor-quality or non-restorative sleep (Roth 2007). Approximately one-third of adults and up to 50% of the elderly are believed to experience symptoms of insomnia in their lifetime (Momin & Ketvertis 2022). For some people, however, insomnia is a recurrent or persistent disorder which impacts daytime functioning, causes distress and results in poorer QoL (Walsh 2004).

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The definition of insomnia disorder has varied by coding and classification system over time, although contemporary definitions are largely consistent across different systems including the International Classification of Diseases (ICD)-11, the International Classification of Sleep Disorders (ICSD)-3, and the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (AP Association 2013). Specifically, DSM-5 defines insomnia disorder (also termed chronic insomnia) as one or more insomnia symptoms occurring at least three times per week with daytime impairment or fatigue lasting at least three months, despite adequate opportunity for sleep (AP Association 2013). DSM-5 also distinguishes chronic insomnia from acute insomnia, which is defined as insomnia symptoms lasting more than one month but less than three. By contrast, the previous edition of the DSM (DSM-IV) defined insomnia as symptoms occurring at least three times per week for at least one month and focused on the distinction between primary insomnia (i.e. insomnia without a known underlying cause) and secondary insomnia (i.e. insomnia due to another underlying condition). Note, however, in the DSM-5 the distinction between primary and secondary insomnia is no longer emphasised.

An estimated 10% of the adult population and up to 20% of older adults suffer from chronic insomnia, as defined by DSM-5 (Patel et al. 2018; Roth & Roehrs 2003). However, there are only limited data on the prevalence of acute insomnia. One study utilising community samples from the United Kingdom (UK) and the United States (US) found a prevalence of acute insomnia ranging from 7.9% to 9.5%, with about one in five of those with acute insomnia eventually transitioning to chronic insomnia (Ellis et al. 2012). Both chronic and acute insomnia can be difficult to estimate and may vary based on the population being evaluated and how it is sampled, as well as the specific diagnostic criteria that are applied and how symptoms are measured. Indeed various instruments have been developed to diagnose insomnia or measure its symptoms, with varying psychometric properties (Ali et al. 2020).

1.1.2. Risk factors for and health-related consequences of insomnia

Regardless of its chronicity, the most well-defined risk factors for insomnia are age and sex, with a large body of evidence demonstrating that insomnia is more prevalent in older adults (Stepnowsky & Ancoli-Israel 2008) and women (Zhang & Wing 2006). Insomnia is also more prevalent among people with chronic illnesses, including primary sleep disorders (e.g. restless-leg syndrome, sleep apnoea), psychiatric disorders (e.g. depression, anxiety, bipolar), pain conditions (e.g. rheumatoid arthritis, osteo-arthritis) and neurological conditions (e.g. neurodegenerative disorders) (Ancoli-Israel 2006; Katz & McHorney 1998). In part, the higher prevalence of chronic co-morbidities in older adults could explain the higher prevalence of insomnia; however, natural changes in sleep-wake cycles during the course of ageing are also at play, as are other psychosocial transitions associated with ageing, such as retirement and caregiving (Stepnowsky & Ancoli-Israel 2008).

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10 For a comparison of DSM-IV and DSM-5 insomnia definitions, see (as of 20 October 2022): https://www.ncbi.nlm.nih.gov/books/NBK519704/
Insomnia can contribute to a wide range of adverse mental- and physical-health effects including disruptions in mood, cognitive impairment and inability or difficulty in performing daily activities. A 2012 meta-analysis of 24 studies (conducted between 1984 and 2008 among 1,197 subjects using objective measures of cognitive performance) found that insomnia is associated with impairments to episodic memory, problem solving, manipulation in working memory and retention in working memory (Fortier-Brochu et al. 2012). These findings were corroborated by a more recently published meta-analysis in 2019 which found impairments in both objective and subjective measures of cognitive performance among individuals with insomnia (Wardle-Pinkston et al. 2019). Such impairments may increase the risk for workplace-related accidents and injuries (Uehli et al. 2014) and result in absences from work (absenteeism) and/or reduced productivity whilst at work (presenteeism).

Insomnia can also contribute to the development of other chronic health conditions. Meta-analyses of prospective cohort studies have shown that insomnia is associated with an increased risk of hypertension (Li et al. 2021), cardiovascular disease (Sofi et al. 2014), dementia (de Almondes et al. 2016) and depression (Li et al. 2016). In fact, evidence suggests a strong bidirectional relationship between insomnia and chronic health conditions, including psychiatric disorders (Hertenstein et al. 2019), pain (Finan et al. 2013) and cognitive decline (Guarnieri & Sorbi 2015), suggesting that insomnia may be both a cause and a consequence of other conditions.

Whereas some studies suggest a link between insomnia and all-cause mortality, current evidence for this relationship is equivocal. One meta-analysis of 17 studies with a total of more than 36m subjects found no association between insomnia symptoms and mortality (Lovato & Lack 2019), whereas another more recent meta-analysis of five studies11 with a total of 17,543 subjects reported an association between mortality and insomnia, with effects most pronounced over a follow-up of ten years or more (Jiang et al. 2020).

1.1.3. Economic impact of insomnia

Insomnia can have a substantial impact on regional and national economies, with losses in productivity due to absenteeism and presenteeism representing a considerable proportion of total costs. A Canadian study published in 2009 estimated that the total annual cost of insomnia in the province of Quebec was $6.6bn Canadian dollars (CAD), with 76% of these costs attributable to insomnia-related work absences and reduced productivity (Daley et al. 2009a). In the US, direct medical costs associated with insomnia have been estimated at $13.9bn annually (in 1995 US dollars), with treatment only accounting for about 14% of total costs ($2bn), of which less than half were due to prescription medication (Walsh & Engelhardt 1999). A subsequent study of the US workforce published in 2011 found that lost productivity due to insomnia cost the US economy $63.2bn annually (Kessler et al. 2011). A more recent US study from 2017 estimated the direct and indirect costs of insomnia at around $150bn (Reynolds & Ebben 2017). In Europe, studies have shown a range of costs due to insomnia, with an estimated €325m in combined benefits.

11 Two of the five included studies report a null effect.
direct and indirect costs in Sweden\textsuperscript{12} and an estimated €40–50bn in indirect costs alone in Germany (Thiart et al. 2016).

The economic impact of insufficient sleep on the workforce and national economies was further illustrated in a 2016 RAND report (Hafner et al. 2016). Using a macro-economic modelling approach this report showed that insufficient sleep (although not specifically due to insomnia) was estimated to result in 1.2m working days lost per year in the US, with a total cost to the US economy of $411bn annually (in 2015 US dollars), or 2.3\% of its gross domestic product (GDP) (Hafner et al. 2016). The RAND report also showed similar impacts on the economies of other Organisation for Economic Co-operation and Development (OECD) nations as a proportion of their annual GDP, including Japan (2.9\%), the UK (1.9\%), Germany (1.6\%) and Canada (1.3\%) (Hafner et al. 2016).

1.2. Gaps in knowledge

Despite insomnia being a common condition, there has been limited systematic investigation of the broader societal consequences of insomnia in adults and the resultant economic costs across different countries. We are also unaware of any research that has specifically examined the burden of chronic insomnia.

In general, the burden of a condition can be estimated through three types of costs:

1. **Direct costs**, which include costs to the healthcare system related to managing and treating the condition;

2. **Indirect costs**, which usually cover costs related to workforce productivity, impairment of patients or their caregivers or out-of-pocket expenses; and

3. **Intangible costs**, related to QoL or general well-being which cannot be measured by economic transactions but nevertheless represent the ‘hidden’ costs of a condition.

Most prior studies, albeit in limited settings and not specific to chronic insomnia, have focused on direct costs, which, as the literature has shown, represent a small fraction of total costs due to insomnia. Other studies have focused on indirect costs, using traditional methods such as cost-of-illness (COI) analyses in which personal out-of-pocket costs (e.g. medical costs) and/or productivity loss are extrapolated to median incomes across the affected population. These methods provide an incomplete picture of the economic impact of a condition, however, as they do not consider the linkage of economic forces within and between countries, and the potential spill-over effects across sectors of the economy.

We sought to build on existing knowledge by quantifying the indirect costs of insomnia using a macro-economic modelling approach (specifically, computable general equilibrium [CGE] modelling). This approach is more comprehensive in capturing economic impacts within and between countries and provides a unique perspective relative to the aforementioned published studies. We also applied a well-being valuation approach to capture the intangible costs.

\textsuperscript{12} Data are from the Swedish Agency for Health Technology Assessment of Social Services. As of 20 October 2022: https://www.sbu.se/en/publications/sbu-assesses/treatment-of-insomnia-in-adults/
associated with insomnia. This approach is novel in terms of estimating costs related to well-being and is one that has gained traction in recent years, as governments shift from solely measuring the financial costs of a project or investment to also capturing the social value and the societal benefits it can generate.

1.3. Project objectives

The objective of this study was to identify and quantify the societal burden of insomnia and its resultant economic impacts both in terms of indirect and intangible costs. We define societal burden as the effects of insomnia that extend beyond health- and healthcare-related impacts, although the societal burden may also include such impacts. Based on these findings, the report includes recommendations for future policy, clinical practice and research to mitigate the societal and economic impacts of insomnia.

The focus of this research was on general adult populations in high-income OECD countries of Northern, Southern and Western Europe, as well as North America and Australia. Although our focus was on chronic insomnia, given that it is the most contemporary definition of this sleep disorder, we did not limit our research exclusively to this definition due to the variation in the way that insomnia has been historically classified and reported in the literature. That said, where possible we estimated the burden and costs for chronic insomnia.

1.4. Overview of research methods

This study comprises three main research activities:

**Literature review.** We conducted a review of the literature to identify prevalence estimates and the societal impacts of insomnia related to: (i) QoL, including quality-adjusted life years (QALYs) and (ii) workplace outcomes, such as absenteeism and presenteeism. We then used meta-regression to generate predicted prevalence estimates of insomnia based on reported prevalence estimates in the literature, conditional on study-level characteristics.

**Secondary database analysis.** We conducted secondary analyses of a publicly available database from the UK to assess the relationship between insomnia and subjective well-being and to monetise the impact of insomnia on well-being (i.e. quantify intangible costs) (Howley 2017). Findings were then extrapolated to other countries using country-specific values of median per-capita household income (based on publicly available data from OECD) and predicted prevalence estimates of chronic insomnia (based on the meta-regression mentioned above).

**Macro-economic modelling.** We used evidence from the literature review, including prevalence estimates of chronic insomnia and quantifiable societal impacts, to develop a CGE macro-economic model to estimate the indirect economic costs associated with insomnia. This model...
estimates the potential GDP gain for a given country using a baseline scenario which takes into account the prevalence of chronic insomnia and its impact on workforce productivity alongside a counterfactual model in which chronic insomnia and its impacts are diminished.

1.5. Report structure

This report describes the results of the study. In Chapter 2 we describe the approach to the literature review and findings on the prevalence of insomnia. In Chapter 3 we describe findings from the literature review on the societal impacts of insomnia. In Chapter 4 we describe the methodological approach to the well-being valuation analysis and findings on intangible costs due to insomnia. In Chapter 5 we describe the methodological approach to the macro-economic modelling and findings on indirect costs due to insomnia. Each of these chapters concludes with a brief review of research findings (and, where relevant, gaps in knowledge). Finally, in Chapter 6 we summarise the findings of the report, describe the limitations of the study and provide recommendations for future policy, clinical practice and research. Supporting materials are referred to throughout the text and can be found in the Annexes.
2 The prevalence of insomnia – a review of the literature

2.1. Review of the published literature

2.1.1. Literature-search strategy

A systematic search of PubMed was performed on 5 February 2022 to identify relevant articles (see Annex B for detailed search terms) on the prevalence of insomnia and societal impacts (i.e. QoL and workplace outcomes) among general adult populations. Two reviewers (FO and GM) initially screened the titles and abstracts of identified citations and flagged them for inclusion. A third reviewer (RJR) then evaluated the flagged citations and conducted a full-text screening of articles. Articles were included in the literature review based on the following criteria:

- Described the prevalence of insomnia and/or impacts on QoL or workforce-related outcomes;
- Described adult populations with insomnia in high-income OECD countries across Northern, Western, and Southern Europe, as well as North America and Australia;
- Described insomnia in general adult populations (studies on insomnia exclusively in children, university students, the elderly or those with specific conditions such as cancer and pregnancy were excluded);
- Measured insomnia using self-reported survey instruments (studies that reported only sleep duration or sleep efficiency in the absence of insomnia or studies that relied on medical record-documented diagnosis of insomnia\textsuperscript{15} were excluded).

The PubMed search was supplemented by a manual search of Google Scholar\textsuperscript{16}. For articles identified through the manual search we applied the prioritisation criteria described above.

2.1.2. Data extraction

A reviewer extracted data from the selected articles using a standardised data extraction template. The following information from articles was extracted: study publication date, study population characteristics (including number of participants, mean/median age, and percentage of females), study design, definitions of insomnia applied, the type of instrument used to measure insomnia and study outcomes. A risk-of-bias assessment for each of the included studies was performed. For detailed information on this assessment, see Annex C.

\textsuperscript{15} Insomnia is often underdiagnosed; thus, this method of identifying or defining insomnia would likely underestimate the number of true cases.

\textsuperscript{16} This involved a search of a combination of key works from the PubMed search and scanning the top 100 results sorted by relevance.
2.1.3. Evidence synthesis

Descriptive summaries for each study were developed. For each type of study outcome (prevalence or impact on QoL or the workplace) we examined findings based on three interrelated categories of insomnia which we identified in the literature.

1. **Insomnia symptoms.** This was defined as any symptom of insomnia including: difficulty falling asleep, difficulty staying asleep and/or early waking, regardless of frequency or duration, or poor-quality sleep; or operationalised as an Insomnia Severity Index (ISI) (Bastien et al. 2001) score of at least 8 or an Athens Insomnia Scale (AIS) (Soldatos et al. 2000) score of at least 4\(^{17}\) (indicating at least subclinical insomnia).

2. **Clinical insomnia.** This was defined as difficulty falling or staying asleep or non-restorative sleep experienced at least three times per week for *at least one month*, with impairment to daily activities; or operationalised as an ISI score of at least 15 or an AIS score of at least 6 (each of which indicate ‘clinical’ insomnia). This definition is broadly consistent with DSM-IV criteria\(^{18}\) for insomnia, regardless of underlying causes.

3. **Chronic insomnia.** This was defined as difficulty falling or staying asleep or early-morning awakening or non-restorative sleep experienced at least three times per week for *at least three months*, with impairment to daily activities. This definition is distinct from the above definition in terms of the duration of symptoms (as italicised). Furthermore, this definition is broadly consistent with DSM-5 criteria for insomnia disorder (and is a subset of clinical insomnia\(^{19}\)) as well as with contemporary definitions in the ICD-11 coding\(^{20}\) and ICSD-3 classification\(^{21}\) systems. Note that DSM-5 criteria further define *acute insomnia* as insomnia with symptoms lasting more than one month but less than three.

The relationship between insomnia subtypes is further illustrated in Figure 2.1 below. As shown, clinical insomnia encompasses both acute and chronic insomnia. However, for the purpose of this report the focus is on clinical insomnia or chronic insomnia as there are very limited epidemiological data on the prevalence of acute insomnia.

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17 The ISI and the AIS are validated instruments used to measure insomnia symptoms.


19 The ISI and AIS are not designed to capture chronic insomnia, as they measure symptoms only in the past month.


2.1.4. Overview of the literature

The literature search captured 4,895 articles, of which 139 citations underwent full-text screening and 48 were considered eligible for the literature review. An additional 10 articles were identified through a manual search of Google Scholar. Of these 58 articles, 45 described the prevalence of insomnia. See Annex D for a flow diagram showing study eligibility criteria for inclusion/exclusion.

The 45 studies on insomnia prevalence selected were published between 1997 and 2022, with data collected between 1991 and 2020. Studies reported data from 16 countries, with a total of 670,607 participants. Countries studied included Australia, Austria, Belgium, Canada, Finland, France, Germany, Greece, Italy, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the US. Hereafter, these countries are referred to as the ‘countries of focus’ for subsequent research activities. Based on our categorisation of insomnia subtypes (see above), 29 studies reported the prevalence of insomnia symptoms, 25 studies reported the prevalence of clinical insomnia (i.e. encompassing both acute and chronic insomnia), and eight studies reported the prevalence of chronic insomnia.22 Details on each study can be found in Table E.1 in Annex E.

The total risk-of-bias score related to external validity across prevalence studies ranged from 0 to 4 (with higher scores indicating more bias), with a median score of 2, suggesting moderate bias. Overall, 16 studies (35.6%) were classified as having a low risk of bias, while 27 studies (60.0%) and two studies (4.4%) respectively were classified as having moderate and high risk of bias.

Among 21 prevalence studies, the reported mean age ranged from 30 to 58 years, with a median value across studies of 44.7 years. Fifteen studies reported categorical age distributions rather

22 The number of studies reporting each insomnia type are not mutually exclusive.
than mean age. The estimated mean age from these distributions ranged from 40 to 57 years, with a median value of 44.5 years. Nine studies did not report mean age or age distributions. Among 43 studies, the reported percentage of female participants ranged from 31.3% to 100%, with a median value of 52.1% across studies. Two studies did not report the percentage of females.

Prevalence studies used a range of instruments to measure insomnia symptoms. Studies most often used a generic questionnaire\(^2\) (n=19); several studies used validated survey instruments, such as the Sleep-EVAL system (n=6) (Ohayon et al. 1999), ISI (n=5), AIS (n=2) (Soldatos et al. 2000), the Basic Nordic Sleep Questionnaire (BNSQ; n=2) (Partinen & Gislason 1995), or the Pittsburgh Sleep Quality Index (PSQI; n=1) (Backhaus et al. 2022). Most studies used insomnia definitions consistent with DSM-IV or DSM-5 (n=30) respectively for classifying insomnia as clinical or chronic.

A summary of the range of the reported prevalence estimates for each insomnia subtype by country/region can be found in Table 2.1. In the following sections we describe the prevalence of each insomnia subtype as reported in these 45 studies, organised by the following regions: Australia, North America (Canada and the US), Northern Europe (Finland, Norway, Sweden), Western Europe (Austria, Belgium, France, Germany, Switzerland, the UK) and Southern Europe (Greece, Italy, Portugal, Spain). Because there is some indication in the literature that the prevalence of insomnia increases over time, we report the year of data collection (when available) to contextualise prevalence estimates. We also highlight where temporal trends are apparent within and across studies for a given country.\(^24\)

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\(^2\) These surveys included questions related to insomnia symptoms which were consistent with definitions of insomnia symptoms, clinical insomnia or chronic insomnia, but were not necessarily validated instruments.

\(^24\) Within-study temporal trends were based on changes between at least two data points; across-study temporal trends were based on at least three data points (for at least two studies).
Table 2.1: Range of reported prevalence estimates by region and country for each insomnia subtype (% of total adult population from each study)

<table>
<thead>
<tr>
<th>Region</th>
<th>Insomnia symptoms</th>
<th>Clinical insomnia</th>
<th>Chronic insomnia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>17.5–51.2%</td>
<td>5.7–25.3%</td>
<td>6.0–14.8%</td>
</tr>
<tr>
<td>Australia</td>
<td>20.0–34.9%</td>
<td>--</td>
<td>10.7–13.3%</td>
</tr>
<tr>
<td>North America</td>
<td>17.5–51.2%</td>
<td>9.5–23.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Canada</td>
<td>24.0–51.2%</td>
<td>9.5–19.0%</td>
<td>--</td>
</tr>
<tr>
<td>United States</td>
<td>17.5–18.1%</td>
<td>23.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Northern Europe</td>
<td>20.8–37.6%</td>
<td>10.2–20.0%</td>
<td>7.1–9.7%</td>
</tr>
<tr>
<td>Finland</td>
<td>20.8–37.6%</td>
<td>11.7–20.0%</td>
<td>--</td>
</tr>
<tr>
<td>Norway</td>
<td>--</td>
<td>10.2–11.9%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Sweden</td>
<td>24.6–33.1%</td>
<td>10.5–13.4%</td>
<td>8.1–9.7%</td>
</tr>
<tr>
<td>Southern Europe</td>
<td>20.8–42.8%</td>
<td>6.4–25.3%</td>
<td>--</td>
</tr>
<tr>
<td>Greece</td>
<td>--</td>
<td>25.3%</td>
<td>--</td>
</tr>
<tr>
<td>Italy</td>
<td>27.1–27.6%</td>
<td>7.0–8.7%</td>
<td>--</td>
</tr>
<tr>
<td>Portugal</td>
<td>28.1–42.8%</td>
<td>21.1%</td>
<td>--</td>
</tr>
<tr>
<td>Spain</td>
<td>20.8–37.6%</td>
<td>6.4–22.4%</td>
<td>--</td>
</tr>
<tr>
<td>Western Europe</td>
<td>18.6–49.9%</td>
<td>5.7–19.0%</td>
<td>6.8–14.8%</td>
</tr>
<tr>
<td>Austria</td>
<td>32.0%</td>
<td>19.0%</td>
<td>--</td>
</tr>
<tr>
<td>Belgium</td>
<td>49.9%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>France</td>
<td>18.6–37.6%</td>
<td>11.3–19.0%</td>
<td>--</td>
</tr>
<tr>
<td>Germany</td>
<td>21.1–32.9%</td>
<td>5.7–17.4%</td>
<td>--</td>
</tr>
<tr>
<td>Switzerland</td>
<td>36.0%</td>
<td>--</td>
<td>11.0%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>35.0–38.6%</td>
<td>12.6–13.9%</td>
<td>6.8–14.8%</td>
</tr>
</tbody>
</table>

Note: Dashes represent where data are missing for a given country.
2.2. Prevalence of insomnia symptoms

Based on studies from the literature, the reported prevalence of insomnia symptoms among general adult populations ranged from 17.5% to 51.2% across 14 countries (no studies on insomnia symptoms were available from Greece or Norway). Studies were published between 1991 and 2022, with data collected between 1991 and 2020.

Australia

In Australia, prevalence estimates ranged from 20.0% in one study conducted in 2016 using the Australian Sleep Survey to 39.4% in another study conducted in 2019 using a generic questionnaire (Adams et al. 2017; Sweetman et al. 2021).

North America

Eleven studies were from North America. In six studies from Canada conducted between 1991 and 2020 (most of which used the ISI to measure insomnia), prevalence estimates ranged from 24.0% to 51.2% (Daley et al. 2009b; Morin et al. 2006; Morin et al. 2011; Morin et al. 2020; Morin et al. 2022; Sutton et al. 2001). Across these studies there was an apparent increase in the prevalence of insomnia over time (+0.9% point/year from 1991 to 2020). However, only one of these studies (Morin et al. 2022) examined insomnia over time, finding an increase in the prevalence of insomnia from 42.2% in 2018 to 51.2% in 2020 among 594 participants. The authors attribute this increase in part to the onset of the coronavirus (COVID-19) pandemic. Among five studies from the US (most of which used generic questionnaires to measure insomnia), prevalence estimates ranged from 17.5% to 27.6% in studies performed between 1990–1992 and 2012–2013 respectively (Cunningham et al. 2015; Ford et al. 2015; Leger & Poursain 2005; Olsson et al. 2018; Phillips & Mannino 2005). A temporal trend in the prevalence of insomnia was less apparent in these studies. However, in one study (Ford et al. 2015) of 88,823 individuals from the US, the prevalence of insomnia symptoms increased significantly from 17.5% in 2002 to 18.1% in 2007 and 19.2% in 2012.

Northern Europe

Six studies were from Northern Europe. These used several different instruments to measure insomnia including the Sleep-EVAL system, the Gothenburg QoL Instrument and the Karolinska Sleep Questionnaire. In Finland, prevalence estimates were 20.8% and 37.6% in two studies conducted in 1998–2002 and 2000 respectively (Ohayon & Partinen 2002; Tatala et al. 2012). The latter study used the Sleep-EVAL system, whereas the former study used a generic questionnaire. In Sweden, prevalence estimates of insomnia were similar across four independent studies with no clear temporal trend, ranging from 24.6% in a study (Mallon et al. 2014) published in 2014 (data collection year not reported) and 28.6% (Hoglund et al. 2020), 33.1% (Bardel et al. 2009) and 32.1% (Ohayon & Bader 2010) in studies with data collected in 2010, 2007, and 2001 respectively.

Western Europe

Seven studies were from Western Europe and used a range of instruments to measure insomnia including the Clinical Interview Schedule, the PSQI, the Sleep-EVAL system and the AIS. In France, prevalence of insomnia symptoms in two studies ranged from 18.6% in 1993 to 37.6% in 2003
In Germany, the prevalence of insomnia symptoms ranged from 32.9% in a study conducted in 2002 (Soldatos et al. 2005) to 21.1% in a study published in 2003 (Ohayon & Roth 2003) (data collection year not reported) and 30.2% in a study conducted between 2008 and 2011 (Schlack et al. 2013). In a study from the UK using the Clinical Interview Schedule, the authors reported a prevalence of insomnia that increased from 35.0% in 1993 to 38.0% in 2000 and 38.6% in 2007 (Calem et al. 2012). Soldatos et al. (2005), using the AIS to measure insomnia symptoms, reported a prevalence of 32.0% in Austria and 49.9% in Belgium in a study conducted in 2002. One study from Switzerland (Maire et al. 2020) estimated a 36% prevalence of insomnia symptoms in 2018.

Southern Europe
Seven studies were from Southern Europe, most of which used the Sleep-EVAL system or AIS to measure insomnia symptoms. Among two studies from Italy, one (Ohayon & Smirne 2002) reported a prevalence of insomnia of 27.6% with data collected in 1997, and the other (Leger & Poursain 2005) reported a prevalence of 27.1% with data collected in 2002–2003. Similar estimates were found among three studies from Spain, with prevalence estimates of 20.8% in 1998–1999 (Ohayon & Sagales 2010), 37.6% in 2002 (Soldatos et al. 2005) and 28.0% in 2010–2011 (Torrens et al. 2019). In Portugal, the prevalence of insomnia symptoms varied from 17.3% in a study (Ohayon & Roth 2003) published in 2003 (data collection year not reported) to 28.1% in a study conducted in 1998 (Ohayon & Paiva), both of which used the Sleep-EVAL system to measure symptoms. Another study from Portugal, using the AIS to measure insomnia symptoms, reported a prevalence of 42.8% in 2002 (Soldatos et al. 2005).

2.3. Prevalence of clinical insomnia
Based on studies from the literature, the reported prevalence of clinical insomnia, broadly defined as symptoms of difficulty falling asleep, difficulty staying asleep or poor-quality/non-restorative sleep experienced at least three times per week for at least one month (i.e. inclusive of acute and chronic insomnia), ranged from 5.7% to 25.3% across general adult populations in 13 countries (no studies on clinical insomnia were available for Australia, Belgium or Switzerland). Studies were published between 1997 and 2022, with data collected between 1993 and 2020. Prevalence estimates of clinical insomnia varied within and across regions as detailed below.

Australia
No studies reported the prevalence of clinical insomnia in Australia.

North America
Six studies were from North America. One study from Canada (using a generic questionnaire with data collected in 2001) found a prevalence of clinical insomnia of 9.5% (Morin et al. 2006). In another four studies from Canada using the ISI to measure insomnia, the prevalence of clinical insomnia ranged from 13.4% and 19.0% between 2007 and 2020 (Daley et al. 2009b; Morin et al. 2011; Morin et al. 2020; Morin et al. 2022). Across these five studies an increase in the prevalence of clinical insomnia is apparent; however, only one study (Morin et al. 2022) directly reported an increasing prevalence (from 16.8% in 2018 to 19.0% in 2020). The authors attributed this
increase to the onset of the COVID-19 pandemic. In the one available study from the US (using the Brief Insomnia Questionnaire, with data collected in 2008–2009), the authors found a 23.0% prevalence of clinical insomnia (Kessler et al. 2011).

**Northern Europe**

Six studies were from Northern Europe, using a variety of instruments to measure clinical insomnia including the Uppsala Sleep Inventory, Sleep-EVAL system and the Jenkins Sleep Questionnaire. In Finland, the prevalence of clinical insomnia ranged from 11.7% to 20.0% across two studies which collected data between 2000 and 2001 respectively (Haaramo et al. 2014; Ohayon & Partinen 2002). In Sweden, one study reported a prevalence of clinical insomnia of 10.5% (data collection year not mentioned) (Hagg et al. 2015) while another (Mallon et al. 2014) reported an increasing prevalence of clinical insomnia from 11.2% in 2000 to 13.4% in 2010. In Norway, one study reported a prevalence of clinical insomnia of 10.2% in 1995–1997, while another study reported an increasing prevalence of clinical insomnia from 11.9% in 2000 to 15.5% in 2010 (Pallesen et al. 2014; Sivertsen et al. 2006).

**Western Europe**

Eight studies were from Western Europe, using several different instruments to measure clinical insomnia including the Clinical Interview Schedule, the PSQI and the AIS. Prevalence estimates were similar across three studies from France, ranging from 11.3% in a recent study (Aernout et al. 2021) (data collection year not reported), 12.0% in 2008 (Leger et al. 2011) and 12.7% in a study published in 1997 (data collection year not reported) (Ohayon 1997). By contrast, another study from France reported a higher prevalence of 19.0% in 1998 (Leger et al. 2000). Across studies there appeared to be a decrease in the prevalence of clinical insomnia; however, this observation is likely confounded by the use of different survey instruments. The prevalence of clinical insomnia also varied across studies in Germany. Two studies reported a prevalence of 5.7% in 2008–2011 (Schlack et al. 2013) and 6.0% in 1997 (Hajak & Study of Insomnia in Europe [SINE] Study Group 2001), whereas a third study with data collected in 2002 reported a prevalence estimate of 17.4% (Soldatos et al. 2005). In two studies from Belgium, the prevalence of clinical insomnia was reported as 36% in 2002 and 17.9% in 2019 (Aernout et al. 2021; Soldatos et al. 2005), while in one study from Austria the prevalence of clinical insomnia was reported as 19.0% in 2002 (Soldatos et al. 2005). In one study from the UK the authors reported a slightly increasing prevalence of clinical insomnia from 12.6% in 1993 to 13.3% in 2000 and 13.9% in 2007 (Calem et al. 2012).

**Southern Europe**

Six studies were from Southern Europe, using a variety of instruments to measure clinical insomnia including the ISI, AIS and Sleep-EVAL system. In Italy, the prevalence of clinical insomnia ranged from 7.0% in 1996–1997 to 8.7% in a study published in 2021 (data collection year not reported) (Aernout et al. 2021; Ohayon & Smirne 2002). In Spain, prevalence estimates varied from 6.4% in 1999 (Ohayon & Sagales 2010) and 6.9% in 2010–2011 (Torrens et al. 2019) to 10.8% in a study published in 2021 (data collection year not reported) (Aernout et al. 2021) and 22.4% in 2002 (Soldatos et al. 2005). One study from Portugal reported a prevalence of clinical insomnia of 21.1% in 2002 (Soldatos et al. 2005), while one study from Greece reported a prevalence of 25.3% in 2006 (Paparrigopoulos et al. 2010).
2.4. Prevalence of chronic insomnia

Based on studies from the literature, the reported prevalence of chronic insomnia (broadly defined as symptoms of difficulty falling asleep or difficulty staying asleep and/or poor-quality/non-restorative sleep experienced at least three times a week for at least three months) ranged from 6.0% to 14.8% across general adult populations in seven studies comprising six countries (Australia, Norway, Sweden, Switzerland, the UK and the US). Studies were published between 2008 and 2019, with data collected between 2006 and 2016. Four studies used generic questionnaires to measure chronic insomnia; two used the BNSQ.

Australia

Two studies of chronic insomnia in Australia reported a prevalence of 10.7% in 2016 (Hartescu & Morgan 2019) and 13.3% in 2019 respectively (Sweetman et al. 2021).

North America

One study from the US (DiBonaventura et al. 2015) reported a prevalence of chronic insomnia of 6.0%.

Northern Europe

Three studies were from Northern Europe. In two studies from Sweden (published in 2008 and 2019, with both using the BNSQ) the authors reported a chronic insomnia prevalence of 9.7% and 8.1% respectively (Jansson-Frojmark & Linton 2008; Jansson-Frojmark et al. 2019). One study from Norway reported a prevalence of 7.1% between 2006 and 2008 (Uhlig et al. 2014).

Western Europe

Three studies were identified from Western Europe. Two studies from the UK reported a chronic insomnia prevalence of 14.8% in 2019 (Hartescu & Morgan 2019) and 6.8% in a study published in 2020 (data collection year not reported) (Perlis et al. 2020). One study from Switzerland reported a prevalence of 11% in 2018 (Maire et al. 2020).

Southern Europe

No studies were identified.

2.5. Heterogeneity in insomnia-prevalence estimates

2.5.1. Overview of heterogeneity

Our review of the literature indicates that the prevalence of insomnia symptoms, clinical insomnia and chronic insomnia varies widely within and across geographical contexts (see Table 2.1). As would be expected, prevalence estimates of insomnia symptoms within and across studies are typically larger than those for clinical and chronic insomnia, while estimates of clinical insomnia are larger than those for chronic insomnia (with some exceptions). In the following section we further explore heterogeneity in prevalence estimates by study characteristics.
2.5.2. Approach to identifying sources of heterogeneity

To examine potential sources of variation in prevalence estimates we conducted meta-regression to identify study-specific factors associated with insomnia prevalence. Meta-regression is a type of meta-analysis in which a regression model of study-level information (rather than person-level information) is used to examine the association between an outcome and one or more explanatory factors (Deeks & Altman 2022). We used meta-regression to examine the association between the reported prevalence of insomnia (i.e. the outcome) and study-level characteristics (i.e. explanatory factors). Study characteristics included year of data collection, definition of insomnia applied, insomnia survey instrument used, mean age, percentage of females, country/region, and total risk-of-bias score. This allowed us to explore potential sources of heterogeneity in the prevalence of insomnia for each insomnia subtype (i.e. insomnia symptoms, clinical insomnia and chronic insomnia).

Meta-regression was conducted using fractional logit models with weighting of prevalence estimates by inverse standard errors (SEs) for each observation and with clustered robust variance-covariance estimation by study (as each study could have more than one observation) (see Annex F for the fractional logit model equation). This type of model was selected because the outcome of interest was a proportion with a value between 0 and 1, and the assumption of a normal distribution for a typical linear regression model could not be met. SEs were specified as follows, where \( p \) is the proportion of study participants with insomnia and \( n \) is the relevant sample size (i.e. denominator) from each study observation: 
\[
SE = \sqrt{\frac{p(1-p)}{n}}.
\]
All analyses were performed in STATA 17.0 (StataCorp; College Station, Texas, US).

We examined the bivariate associations between insomnia prevalence for each insomnia subtype (i.e. insomnia symptoms, clinical insomnia and chronic insomnia) and the following study-level variables: mean age, percentage of female participants, year of data collection, definition of insomnia applied (simple, DSM, or other), instrument used to classify insomnia (generic questionnaire, AIS, Sleep-EVAL, ISI, or other), total risk of bias (low, moderate or high) and region (US, Canada, Australia, Northern Europe, Western Europe and Southern Europe).

Missing values for explanatory variables were handled as follows:

- If mean age was not directly reported, an approximate value was manually calculated based on the reported distribution of the study sample by age categories (assuming that an approximate median value was equal to the mean value); if age distribution was not reported, then the mean age was imputed at the median value across studies.
- If year of data collection was not reported, this value was imputed by subtracting two years from the study publication date; when data-collection year was reported but spanned multiple years, the midpoint was used; if data collection spanned only two years (e.g. 2000–2001), then the latter year was used.
- If the percentage of females was not reported, the value was imputed at the median value across studies.

25 North America was disaggregated to the United States and Canada, as heterogeneity in prevalence estimates was observed in descriptive analyses.
We also examined associations between prevalence of insomnia and age, sex and data-collection year in the absence of imputation, and also further examined the relationship between prevalence of insomnia and dummy variables indicating imputation of age, sex, and data-collection year.

2.5.3. Study-level factors associated with insomnia prevalence

We describe the findings from the analyses below. To illustrate statistically significant associations, postestimation was performed to generate predicted prevalence with 95% confidence intervals (CIs), stratified by study-level characteristics.

Across most insomnia subtypes, the instrument used to measure insomnia symptoms, the total risk of bias and the region for each study observation were associated with the size of the prevalence estimates (see Annex F, Table F.1). For example, studies that used generic questionnaires had, on average, smaller prevalence estimates for insomnia symptoms (predicted prevalence=22.8% [95% CI: 18.6, 26.9]) compared to studies that measured insomnia with the ISI (predicted prevalence=42.5% [95% CI: 38.1, 46.9]; p<0.001) or the AIS (prevalence from a single study=41.1%; p<0.001). Furthermore, studies of insomnia symptoms with low risk of bias (predicted prevalence=26% [95% CI: 21.8%, 30.3%]) or moderate risk of bias (predicted prevalence=27.0% [95% CI: 20.1, 33.0]) had on average lower prevalence estimates than a study with a high risk of bias (prevalence of insomnia symptoms from this study=36%; p<0.001 vs low or moderate risk of bias).

Within North America, the predicted prevalence of insomnia symptoms was statistically significantly smaller in the US compared with Canada (predicted prevalence=20.0% [95% CI: 17.3%, 24.1%] vs 35.2% [95 CI: 25.7%, 44.6%]; p<0.0001). The US also had a smaller prevalence estimate for insomnia symptoms relative to Western Europe (predicted prevalence: 33.1% [95% CI: 26.9%, 39.4%]; p<0.001). However, for clinical insomnia the US had a significantly larger prevalence compared to Canada and all other regions.

Whereas older age is a well-established risk factor for insomnia, regardless of its chronicity, we did not observe a statistically significant association between the mean age of the study population and insomnia prevalence for any subtype. This could be because the mean ages across study populations were within a relatively narrow range (mean of 36.1 to 58.0 years) and the risk of insomnia is potentially less variable within this range compared to, for example, populations of older adults (ages 65 and older).

Similarly, although female sex is a known risk factor for insomnia, a statistically significant association was observed only for studies of chronic insomnia. For example, the predicted prevalence (95% CI) of chronic insomnia in studies whose populations were 30%, 40%, 50% and 60% female increased, on average, from 4.3% (3.0%, 5.7%), 5.4% (4.2%, 6.7%), 6.8% (5.7%, 7.9%) and 8.5% (7.5%, 9.5%), respectively (p<0.001 for linear trend). Within studies, however, female sex was almost universally associated with a higher prevalence of insomnia (data not shown).

While evidence from the literature review showed an increasing prevalence of insomnia subtypes over time (within and/or across studies) in several country contexts, the year of data collection was not statistically associated with prevalence estimates across studies. This is possibly because temporal trends in insomnia prevalence, and the magnitude of these trends, are country- or region-specific, and pooled analyses may have masked country or regional differences.
Lastly, statistical associations (or lack thereof) were robust to imputation of age, sex and data-collection year; moreover, dummy variables indicating imputation of these three characteristics were not associated with prevalence estimates.

### 2.6. Predicted prevalence of insomnia subtypes

Based on the observed heterogeneity in the prevalence of insomnia subtypes, identified sources of heterogeneity, and the fact that prevalence estimates (particularly for chronic insomnia) were missing for many of the 16 countries of focus, we used postestimation as described above to predict the prevalence of insomnia subtypes for each country, conditional on multiple study-level covariates (see Annex F for details on the multi-variable fractional logit model).

The multivariable model included 86 observations across the 45 prevalence studies from the literature. In addition to the study-level variables mentioned above, an indicator variable for insomnia subtype was included. Postestimation from linear equation 2 (see Annex F) was specified for a population that was 52% female with a mean age of 46 years, based on the median age and sex distribution across studies from the literature review (and broadly consistent with the general populations of the included OECD member countries – see Annex G, Table G.1) in the year 2020 and when DSM-consistent criteria for insomnia were applied.

Overall, the model yielded a predicted prevalence (95% CI) of insomnia symptoms, clinical insomnia and chronic insomnia of 33.8% (28.2%, 39.4%), 14.2% (11.3%, 17.1%) and 8.2% (6.6%, 9.8%) respectively across the countries of focus (Figure 2.2).

**Figure 2.2: Predicted prevalence of insomnia subtypes for adult populations across identified countries**

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Predicted Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insomnia symptoms</td>
<td>33.8</td>
</tr>
<tr>
<td>Clinical insomnia</td>
<td>14.2</td>
</tr>
<tr>
<td>Chronic insomnia</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Notes: Values represent the predicted prevalence of insomnia for a population with a mean age of 46 years, with 52% females, in 2020. Error bars represent 95% confidence intervals. Estimates for each insomnia subtype are not mutually exclusive.

Predicted prevalence values are based on data from the 16 countries of focus.
Country-specific prevalence estimates are shown in Table 2.2, with these estimates extrapolated to the total working-age populations. Proportionally, the prevalence of insomnia subtypes for the countries of focus was highest in Australia and Belgium and lowest in Spain, Germany and Austria. Across the 16 countries, with a total working-age population of 507,672,833, these point estimates equate to approximately 172m people with insomnia symptoms, 72m with clinical insomnia and 42m with chronic insomnia.

A comparison of prevalence estimates for each insomnia subtype by country and predicted prevalence estimates can be found in Annex H, Table H.1. Where study-reported prevalence estimates are available they are generally consistent with (i.e. within or near) the 95% CI range of predicted values. There are, of course, exceptions; however, these are likely due to reported estimates being derived from studies that deviated from the postestimation specifications. Because the predicted prevalence of insomnia across subtypes for Greece was based on a single study, we excluded Greece from analyses described in the subsequent chapters on intangible costs (Chapter 4) and indirect economic costs (Chapter 5).
The societal and economic burden of insomnia in adults

Table 2.2: Predicted prevalence of insomnia and estimated number of affected persons in the working-age population by subtype and country

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall</th>
<th>Australia</th>
<th>Austria</th>
<th>Belgium</th>
<th>Canada</th>
<th>Finland</th>
<th>France</th>
<th>Germany</th>
<th>Greece</th>
<th>Italy</th>
<th>Norway</th>
<th>Portugal</th>
<th>Spain</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>United Kingdom</th>
<th>United States</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Predicted prevalence % (95% CI)</td>
<td>Estimated affected population (millions)</td>
<td>Predicted prevalence % (95% CI)</td>
<td>Estimated affected population (millions)</td>
<td>Predicted prevalence % (95% CI)</td>
<td>Estimated affected population (millions)</td>
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</tr>
<tr>
<td>Overall</td>
<td>33.8 (28.2, 39.4)</td>
<td>171.6</td>
<td>14.2 (11.3, 17.1)</td>
<td>72.1</td>
<td>8.2 (6.6, 9.8)</td>
<td>41.6</td>
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<tr>
<td>Australia</td>
<td>41.2 (32.7, 49.6)</td>
<td>6.7</td>
<td>18.4 (12.9, 24.0)</td>
<td>3.0</td>
<td>10.9 (8.6, 13.2)</td>
<td>1.8</td>
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<tr>
<td>Austria</td>
<td>24.4 (20.6, 28.2)</td>
<td>1.4</td>
<td>9.4 (7.7, 11.2)</td>
<td>0.6</td>
<td>5.3 (3.9, 6.6)</td>
<td>0.3</td>
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<tr>
<td>Belgium</td>
<td>40.7 (35.4, 46.0)</td>
<td>3.0</td>
<td>18.1 (16.0, 20.3)</td>
<td>1.3</td>
<td>10.7 (8.2, 13.1)</td>
<td>0.8</td>
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<tr>
<td>Canada</td>
<td>35.8 (27.2, 44.4)</td>
<td>8.9</td>
<td>15.2 (10.2, 20.3)</td>
<td>3.8</td>
<td>8.8 (5.6, 12.0)</td>
<td>2.2</td>
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<tr>
<td>Finland</td>
<td>37.5 (29.2, 45.6)</td>
<td>1.3</td>
<td>16.2 (11.6, 20.9)</td>
<td>0.5</td>
<td>9.4 (6.5, 12.4)</td>
<td>0.3</td>
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<tr>
<td>France</td>
<td>35.6 (26.3, 44.9)</td>
<td>14.2</td>
<td>15.2 (10.6, 19.7)</td>
<td>6.1</td>
<td>8.8 (5.6, 12.0)</td>
<td>3.5</td>
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<tr>
<td>Germany</td>
<td>25.1 (21.0, 29.1)</td>
<td>13.5</td>
<td>9.7 (8.0, 11.5)</td>
<td>5.2</td>
<td>5.5 (4.0, 6.9)</td>
<td>2.9</td>
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<tr>
<td>Greece</td>
<td>31.8 (17.3, 46.3)</td>
<td>2.1</td>
<td>13.1 (5.3, 20.9)</td>
<td>0.9</td>
<td>7.5 (2.8, 12.2)</td>
<td>0.5</td>
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<tr>
<td>Italy</td>
<td>29.8 (22.7, 36.8)</td>
<td>11.5</td>
<td>12.0 (8.8, 15.2)</td>
<td>4.6</td>
<td>6.8 (4.6, 9.0)</td>
<td>2.6</td>
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<tr>
<td>Norway</td>
<td>32.8 (23.9, 41.7)</td>
<td>1.2</td>
<td>13.6 (9.5, 17.7)</td>
<td>0.5</td>
<td>7.8 (4.8, 10.8)</td>
<td>0.3</td>
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<tr>
<td>Portugal</td>
<td>29.2 (21.9, 36.5)</td>
<td>1.9</td>
<td>11.7 (8.2, 15.3)</td>
<td>0.8</td>
<td>6.7 (4.3, 9.0)</td>
<td>0.4</td>
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<tr>
<td>Spain</td>
<td>27.4 (22.7, 32.0)</td>
<td>8.3</td>
<td>10.8 (8.5, 13.1)</td>
<td>3.3</td>
<td>6.1 (4.4, 7.8)</td>
<td>1.8</td>
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<tr>
<td>Sweden</td>
<td>36.1 (25.8, 46.4)</td>
<td>2.3</td>
<td>15.4 (9.4, 21.4)</td>
<td>1.0</td>
<td>9.0 (6.1, 11.8)</td>
<td>0.6</td>
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<tr>
<td>Switzerland</td>
<td>36.8 (28.0, 45.6)</td>
<td>2.1</td>
<td>15.8 (10.8, 20.9)</td>
<td>0.9</td>
<td>9.2 (5.8, 12.5)</td>
<td>0.5</td>
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<tr>
<td>United Kingdom</td>
<td>39.7 (32.4, 46.9)</td>
<td>17.2</td>
<td>17.5 (13.1, 22.0)</td>
<td>7.6</td>
<td>10.3 (6.8, 13.8)</td>
<td>4.5</td>
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<tr>
<td>United States</td>
<td>32.3 (22.6, 42.2)</td>
<td>69.5</td>
<td>13.9 (7.9, 18.9)</td>
<td>29.9</td>
<td>7.7 (5.1, 10.2)</td>
<td>16.6</td>
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</tbody>
</table>

Notes: Estimated total number of working-age persons affected by insomnia based on total number of working-age persons (see Annex G) and based on the point estimate from the predicted prevalence. CI=confidence intervals.
Chronic insomnia estimates are further illustrated in Figure 2.3. Based on 95% CIs, statistically significant differences in the prevalence of chronic insomnia are limited to comparisons between the top two and bottom three countries.

Figure 2.3: Predicted prevalence of chronic insomnia among adult populations for identified countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Predicted Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>10.9</td>
</tr>
<tr>
<td>Belgium</td>
<td>10.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10.3</td>
</tr>
<tr>
<td>Finland</td>
<td>9.4</td>
</tr>
<tr>
<td>Switzerland</td>
<td>9.2</td>
</tr>
<tr>
<td>Sweden</td>
<td>9.0</td>
</tr>
<tr>
<td>France</td>
<td>8.8</td>
</tr>
<tr>
<td>Canada</td>
<td>8.8</td>
</tr>
<tr>
<td>Norway</td>
<td>7.8</td>
</tr>
<tr>
<td>United States</td>
<td>7.7</td>
</tr>
<tr>
<td>Greece</td>
<td>7.5</td>
</tr>
<tr>
<td>Italy</td>
<td>6.8</td>
</tr>
<tr>
<td>Portugal</td>
<td>6.7</td>
</tr>
<tr>
<td>Spain</td>
<td>6.1</td>
</tr>
<tr>
<td>Germany</td>
<td>5.5</td>
</tr>
<tr>
<td>Austria</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Notes: Estimates shown are ranked from highest (top) to lowest (bottom). Error bars represent 95% confidence intervals (CIs). Non-overlapping CIs reflect statistically significant differences at p<0.05 (the dotted line marks the upper bound of the 95% CI that is statistically significantly different from the top two countries [Australia and Belgium]).
2.7. Summary of the literature on the prevalence of insomnia

2.7.1. Review of key research findings

We identified 45 studies describing prevalence estimates across 16 countries with a total of nearly 700,000 study subjects. These studies had, on average, moderate risk of bias and were published over a span of 25 years. Key research findings are summarised in Box 2.1.

Box 2.1: Key research findings on the prevalence of insomnia from the literature review

Up to 50% of the general adult population is reported in the literature to suffer from insomnia symptoms, and up to 25% and 15% suffer from clinical and chronic insomnia, respectively.

The prevalence of insomnia symptoms from the literature ranged from 17.5% to 51.2%, clinical insomnia ranged from 5.7% to 25.3% and chronic insomnia ranged from 6.0% to 14.8%. As expected, across countries, estimates from the literature for prevalence estimates for symptoms of insomnia were typically larger (and with a wider range) than clinical or chronic insomnia estimates, while clinical insomnia estimates were typically larger (and with a wider range) than chronic insomnia estimates.

Based on statistical modelling, approximately one-third of the general adult population is predicted to suffer from insomnia symptoms, while 14% and 8% are predicted to suffer from clinical and chronic insomnia, respectively.

Meta-regression estimated an overall predicted prevalence (95% CI) of insomnia symptoms, clinical insomnia and chronic insomnia of 33.8% (28.2%, 39.4%), 14.2% (11.3%, 17.1%) and 8.2% (6.6%, 9.8%). These estimates equate to approximately 172m people with insomnia symptoms, 72m with clinical insomnia and 42m with chronic insomnia among the working-age populations of the 16 identified countries.

By country, about 5% to 11% of the general adult population is predicted to suffer from chronic insomnia.

Specific to chronic insomnia, predicted prevalence estimates derived from meta-regression ranged from 5.3% to 10.9% by country, but estimates were statistically different only between the two countries with the largest prevalence estimates (10.9% in Australia and 10.7% in Belgium) compared with the three countries with the smallest prevalence estimates (5.3% in Austria, 5.5% in Germany and 6.1% in Spain).
2.7.2. Knowledge gaps

Through this review of prevalence studies, we observed several gaps in knowledge. First, there are limited contemporary, cross-country comparisons of insomnia to provide an understanding of geographical variation in the prevalence of this condition. Where data are available for multiple countries (for example in the case of Europe), prevalence estimates are typically aggregated. Secondly, there are limited studies on the prevalence of chronic insomnia. In part this could be due to issues with operationalising chronic insomnia when using existing databases. For example, many studies used cross-sectional or longitudinal cohorts and applied established instruments (such as the ISI) which capture information on insomnia in the past month only, and which are therefore inconsistent with the contemporary definition of insomnia disorder.

One study identified in the literature review noted an increase in the prevalence of insomnia symptoms and clinical insomnia after the onset of the COVID-19 pandemic (Morin et al. 2022). While much has been written about the impact of the pandemic on insomnia and sleep in general (Gualano et al. 2020; Jahrami et al. 2021; Kokou-Kpolou et al. 2020; Pizzonia et al. 2021), more studies are needed to better understand this relationship, particularly in terms of which groups may be most susceptible (e.g. healthcare workers, shift workers, those infected with COVID-19, marginalised racial/ethnic groups and socio-economically disadvantaged populations). Indeed, a survey of 2,006 adults in the US conducted by the American Academy of Sleep Medicine found that 56% of respondents reported an increase in sleep disturbances after the start of the pandemic, with the largest impact amongst individuals aged 35–44 (with 70% of these individuals reporting an increase in sleep disturbances).29

2.7.3. Caveats

There are several factors that should be taken into consideration when interpreting the literature on the prevalence of insomnia. First, whilst the literature review was systematically conducted and intended to be comprehensive, we searched only one database (PubMed) and important articles may be missing, including articles published after our search period.

Secondly, descriptive comparisons across studies (including temporal trends) are potentially confounded by differences in the composition of study populations (particularly factors such as age, sex and socio-economic status, which are known risk factors for insomnia) as well as the time periods during which data were collected, different criteria applied to define insomnia and different instruments used to measure insomnia.

Thirdly, while we used meta-regression to examine sources of heterogeneity, other factors not measured by the authors of the relevant studies may further explain differences in prevalence estimates. For example, co-morbid physical or mental conditions were seldom reported even though many of these conditions are known risk factors for insomnia.

29 From the American Academy of Sleep Medicine. ‘Americans continue struggling for a good night’s sleep during the pandemic.’ Published 12 April 2021. As of 20 October 2022: https://aasm.org/americans-struggling-good-nights-sleep-during-pandemic/
Lastly, meta-regression was further used to predict the prevalence of insomnia subtypes, conditional on study-level covariates, with the primary goal of feeding this information into the well-being valuation analysis (see Chapter 4) and the macro-economic model (see Chapter 5). The strength of meta-regression is that it draws on information across studies; however, predicted values should be interpreted cautiously as study-reported prevalence estimates were missing for some country-specific insomnia subtypes (particularly chronic insomnia).
3 Societal impacts of insomnia – a review of the literature

3.1. Overview of literature on the societal impacts of insomnia

In the previous chapter we described the methodology of the literature review and findings relating to the prevalence of insomnia subtypes for each country. In this chapter we focus on findings from the literature review relating to the societal impacts of insomnia.

Of the 58 articles identified from the literature search, 19 described societal impacts related to QoL or the workplace (six of these articles also described the prevalence of insomnia and were summarised in the previous section). For study eligibility see the flow diagram in Annex D, Figure D.1.

Studies were published between 2001 and 2018, with data collected between 1995 and 2013. Studies reported data from six countries: Canada, Finland, France, Norway, Sweden and the US. Details on each study relating to QoL and workplace outcomes can be found in Annex I, Table I.1 and Table I.2 respectively. Studies generally included working-age adult populations (18–64 years).

Total risk-of-bias scores for threats to external and internal validity ranged from 1 to 4 and 0 to 4 respectively, with a median score of 3 for each, suggesting overall moderate bias. Regarding external validity, three studies (15.8%) were classified as having low risk of bias, and 13 studies (68.4%) and three studies (15.8%) respectively were classified as having moderate and high risk of bias. Regarding internal validity, seven studies (36.8%) were classified as having low risk of bias, and six each (31.6% and 31.6%) were classified as having relatively moderate and high risk of bias.

Below we summarise the literature for QoL (see Chapter 3.2) and workplace-related impacts (Chapter 3.3). Because fewer studies on societal impacts were identified compared to those on the prevalence of insomnia, we did not organise findings by insomnia subtype or geographical region. Instead, we present studies based on the types of outcomes along with the quality of the evidence and/or threats to internal validity.

3.2. Impact of insomnia on quality of life

Six studies from the literature review examined the impact of insomnia on health-related QoL (HRQoL) and/or QALYs using various versions of the Short Form (SF) Health Survey. These studies were published between 2001 and 2018, with data collected between 1986 and 2012–2013. Overall, studies show that insomnia is associated with a reduction in various aspects of HRQoL.

Health-related quality of life

Three studies were identified as having relatively low risk of bias related to internal validity. In an international 2005–2006 cross-sectional study conducted by Leger et al. (2012), individuals with
chronic insomnia\textsuperscript{30} had on average lower HRQoL utility scores (based on the short form [SF]-6D) than good sleepers\textsuperscript{31} in the US (0.63 vs 0.72; \textit{p}<0.0001) and France (0.57 vs 0.67; \textit{p}<0.0001).\textsuperscript{32} In another study among a cross-sectional cohort of US adults from 2005, Bolge et al. (2009) reported that insomnia symptoms (self-reported physician diagnosis) that occurred at least a few times each month were associated with lower overall physical HRQoL scores based on the SF-8 compared to individuals without insomnia (40.5 vs 50.9; adj. diff. = -5.40; \textit{p}<0.01) and lower overall mental HRQoL (42.9 vs 53.3; adj. diff. = -4.39; \textit{p}<0.01).\textsuperscript{33} A third cross-sectional study, by Katz & McHorney (2002) using data from 1986, found that mild or severe clinical insomnia compared with no insomnia were associated on average with lower scores across eight different HRQoL domains of the SF-36 including physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health.\textsuperscript{34} Similar findings were observed in a French study in which the authors matched\textsuperscript{35} good sleepers to individuals with mild and severe clinical insomnia (Leger et al. 2001); this study was rated as having moderate risk of bias. Lastly, another study (rated as having moderate risk of bias) from Canada found that a higher SF-12 vitality score, but not the other seven domains, was associated with reduced odds of being categorised as having insomnia syndrome or insomnia symptoms as compared to a good sleeper (adj. odds ratio [OR]: 0.99; 95% CI: 0.98, 1.00; \textit{p}=0.02) (LeBlanc et al. 2007).\textsuperscript{36} The authors of this study adjusted simultaneously for multiple SF-12 domains; thus, null findings for other domains could be attributed to correlation between domains.

**Quality-adjusted life years**

In a US-based cross-sectional study of 34,712 adults between 2012 and 2013, Olfson et al. (2018) found that the annual loss of QALYs associated with insomnia, as measured by the SF-6D, was estimated at 5.6m and was larger than that associated with 18 other chronic medical conditions including arthritis (4.9m), depression (4.0m) and hypertension (3.6m) (Olfson et al. 2018). This study was considered to have a high risk of bias as it did not compare directly to a group without insomnia, meaning that it is not known what proportion of these costs can be directly attributable to insomnia compared to other co-morbid conditions.

\textsuperscript{30} Defined as clinical insomnia (ISI score >15) for at least six months regardless of treatment status, or subclinical insomnia (ISI score <15) with treatment for at least six months.

\textsuperscript{31} Defined as ISI score <8 with no treatment for insomnia.

\textsuperscript{32} Statistical adjustment was performed for age, sex, class, BMI, household income, employment status, smoking status, coffee use, alcohol use, family history of insomnia and co-morbidities.

\textsuperscript{33} Statistical adjustment was performed for age, sex, race, marital status, education, number of physical co-morbid conditions and psychiatric co-morbidity.

\textsuperscript{34} Statistical adjustment was performed for sociodemographic characteristics, health habits, index conditions, severity of index conditions, count of medical co-morbidities and study location.

\textsuperscript{35} Matching was performed on age category, sex, occupation, location, marital status and socioeconomic status.

\textsuperscript{36} Statistical adjustment was performed for previous episodes of insomnia and measures of mental health.
3.3. Impact of insomnia on the workplace

Fourteen studies from the literature examined the impact of insomnia on the workplace. These studies were published between 2002 and 2020, with data collected between 1995–1997 and 2009. Overall, studies showed that insomnia resulted in more days away from the workplace and lower productivity while at work as well as an increased risk of workplace-related accidents, errors and injuries leading to disability pensions compared to no insomnia.

Absenteeism and productivity loss

Three studies on absenteeism and productivity loss were rated as having a relatively low risk of bias related to internal validity. Two studies used data from the National Health and Wellness Survey (NHWS) and applied the Work Productivity and Activity Impairment (WPAI) questionnaire to measure the workplace-related impacts of insomnia. The first (Bolge et al. 2009) comprised a cross-sectional study of 19,711 US adults from the 2005 NHWS and found that employed adults with insomnia symptoms experienced on average greater impacts as a percentage of time related to absenteeism (+6.4%), presenteeism (+13.2%) and overall work productivity loss (+10.3%) compared to those without.\(^{37}\) Extrapolated over a year (assuming a total of 225 work days), insomnia was associated with 14.3 days of absenteeism, 29.7 days of presenteeism and an overall productivity loss of 23.2 days annually.

The second (DiBonaventura et al. 2015) comprised a cross-sectional study using 2009 data from the NHWS among 36,959 adults from the US and 31,661 adults from five European countries.\(^{38}\) Compared to the first study, DiBonaventura et al. found similar or more pronounced results for employed individuals with DSM-IV insomnia for at least three months (i.e. chronic insomnia) compared to a propensity score-matched group without chronic insomnia.\(^{39}\) In both the US and European matched cohorts, chronic insomnia was associated on average with greater absenteeism (+4.9% in the US and +7.9% in Europe), presenteeism (+17.2% in the US and +20.0% in Europe) and overall productivity loss (+19.6% in the US and +23.9% in Europe). Extrapolating their findings over a year, chronic insomnia was associated with 11.0 and 17.8 days of absenteeism, 38.7 and 45.0 days of presenteeism and an overall productivity loss of 44.1 and 53.8 days respectively in the US and Europe. Extrapolated to the working-age population with chronic insomnia, this translates to a substantial number of working days lost.

\(^{37}\) Statistical adjustment was performed for age, sex, race, marital status, education, number of physical co-morbid conditions and psychiatric comorbidity.

\(^{38}\) France, Germany, Italy, Spain and the UK.

\(^{39}\) Cohort matched on age, sex, education, marital status, annual household income, employment status, smoking status, exercise behaviour, alcohol use and the Charlson Comorbidity Index score (composite measure of multi-morbidity).
A longitudinal study of 6,892 Norwegian working-age adults aged 40–45 from 1997 to 1999 found that insomnia with daytime impairment compared with no insomnia was associated with a 51% increased adjusted odds of workplace sick days (≥15 days) during a four-year follow-up period (adj. OR: 1.51; 95% CI: 1.19, 1.94) (Sivertsen et al. 2009).40

Four studies were rated has having moderate risk of bias in terms of internal validity and should be interpreted with some caution. One study conducted among 3,760 working-age adults from Finland reported that men with frequent or occasional insomnia symptoms had a 92% and 28% increased risk of work absences41 respectively compared to men with no or rare insomnia symptoms, during a mean follow-up of 7.2 years (Lallukka et al. 2014). The authors also reported that women with frequent and occasional insomnia had a 42% and 35% increased risk of work absences, respectively, compared to women with no or rare symptoms.42 They also found that effects were more pronounced in men and women aged 45–64 compared to those aged 30–44, and that insomnia symptoms were associated with approximately four days of work absences annually in men and approximately one to three days of work absences annually in women. The authors adjusted for a limited number of factors in this analysis including age and working conditions.43

A study of 7,428 employed adults in the US from the 2008–2009 American Insomnia Survey estimated that clinical insomnia, per DSM-IV criteria and after adjusting for co-morbid conditions, was linked to 7.8 days of lost work productivity annually relative to employed adults without insomnia (Kessler et al. 2011). The authors of this study found no differences in rates of absenteeism in individuals with and without insomnia after adjusting for co-morbidities.

In one French study (Leger et al. 2002), 240 people with severe clinical insomnia (defined as at least two types of sleep complaint experienced at least three times per week for at least one month) were matched on a limited number of factors to 391 ‘good sleepers’.44 This study found that insomnia was associated with a higher prevalence of leaves of absence from work in the previous 12 months (31% vs 19%).45 Another French study (Leger et al. 2006) of 369 workers with clinical insomnia matched 1:1 to good sleepers46 found that workers with insomnia had higher odds of at least one work absence (50% vs 35%; p<0.00) and a longer mean duration of absences over the previous two years compared to good sleepers (11.6 vs 4.8 days; p<0.001).

40 Statistical adjustment was performed for age, sex, body-mass index, education, health behaviours and physical and psychological comorbidities.
41 Statistical adjustment for age and working conditions.
42 Statistical adjustment for age and working conditions.
43 Similar findings were observed when the authors adjusted for age, health and health behaviours.
44 Matched on age, sex, occupation, location and marital status.
45 The authors report this finding as statistically significant (p<0.05), although the lower limit for the 95% confidence interval of the odds ratio (0.96) is inconsistent with this interpretation.
46 Matched on age, sex, type of occupation and type of employer.
Three studies were considered to have a high risk of bias in terms of threats to internal validity because they did not take into consideration potential confounding factors; these studies should be interpreted cautiously. A 2006–2007 survey of 4,188 employees in four US corporations found that those with DSM-IV insomnia, when compared to good sleepers, experienced an excess productivity loss of 3.6% \((p<0.05)\) (Rosekind et al. 2010). A study of 953 adults from Quebec reported that, over a three-month period, participants with insomnia syndrome, as measured by the ISI, lost approximately 8.7 hours due to insomnia-related absenteeism compared to 0.7 hours among good sleepers, and 54 hours of insomnia-related reduced productivity compared to 5.4 hours among good sleepers (Daley et al. 2009b). Fatigue was the primary reason attributed to productivity loss. Lastly, a study of 1,570 French working-age adults with chronic insomnia, defined per DSM-V criteria, had on average longer durations of work absenteeism than controls (9.6 vs 5.8 days; \(p<0.01\)) (Philip et al. 2006).

### Workplace-related injuries and disability

Three studies on absenteeism and productivity loss were rated as having relatively low risk of bias related to internal validity. In a Norwegian cohort of 37,308 working-age adults from 1995 to 1997, insomnia with daytime impairment compared to no insomnia was associated with a 75% increased adjusted\(^{47}\) odds of accidents leading to a permanent work disability during a follow-up period of 18–48 months (Sivertsen et al. 2006). Similarly, another longitudinal Norwegian study of 6,599 working adults aged 40–45 from 1997 to 1999 reported that insomnia with daytime tiredness/sleepiness was associated with an 88% increased adjusted odds of accidents resulting in a disability pension during a follow-up period of four years (Sivertsen et al. 2009). A French study of 240 people with severe insomnia (defined as at least two types of sleep complaint experienced at least three times per week for at least one month) matched\(^{48}\) to 391 good sleepers found that over the previous month insomnia was associated with an increased prevalence of having made errors at work which could have resulted in serious consequences (15% vs 6%; \(p<0.001\)) (Leger et al. 2002). This study also reported that, compared to good sleepers, individuals with insomnia were more likely to have reported industrial accidents in the past month (8% vs 1%; \(p=0.015\)).

Three studies were considered to have moderate risk of bias to internal validity and should be interpreted with some caution. In a study from Canada, Kling et al. (2010) investigated workplace injuries related to sleep problems. Using the Canadian Community Health Survey (2000–2001) of 69,584 subjects aged 16–65, men and women who reported trouble sleeping ‘most of the time’ had 25% and 55% higher adjusted odds\(^{49}\) respectively of suffering work

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\(^{47}\) Statistical adjustment for age, sex, education, socio-economic status, night work, lifestyle factors and co-morbidities.

\(^{48}\) Matched on age, sex, occupation, location and marital status.

\(^{49}\) Statistical adjustment for age, ethnicity, marital status, self-perceived health, self-perceived work stress, job class, usual hours worked, type of shift, education, province, number of chronic diseases, type of smoker and alcohol consumption.
injuries in the previous 12 months compared to those who reported ‘never’ having trouble sleeping (Kling et al. 2010). In a Swedish cohort of 4,320 working-age women, those who reported persistent insomnia (i.e. insomnia at baseline [2000] and follow-up [2010]) had a higher risk of self-reported workplace-related accidents than those with no insomnia symptoms at either time point (adjusted relative risk$^{50}=1.5; 95\% \text{ CI:} 1.2, 2.0; p=0.002$) (Hagg et al. 2015). There was, however, no association between persistent insomnia symptoms and accidents resulting in sick leave, suggesting that workplace-related accidents may have been relatively minor. By contrast, another study of 369 French workers with clinical insomnia matched 1:1 to good sleepers showed no difference in the occurrence of workplace-related accidents (Leger et al. 2006).$^{51}$

### 3.3.1. Review of key research findings

We identified 19 studies that described QoL and/or workplace-related impacts of insomnia across six of the 16 countries of focus (Canada, Finland, France, Norway, Sweden and the US). These studies, on average, had moderate risk of bias to both external and internal validity. Studies were published between 2001 and 2018, with data collected between 1995 and 2013. Key research findings are summarised in Box 3.1 below.

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50 Statistical adjustment for age, BMI, smoking status, blue- or white-collar, alcohol dependency, night work and physical activity during leisure time.

51 Matched on age, sex, type of occupation and type of employer.
Box 3.1: Key research findings on the societal impacts of insomnia from the literature review

**Insomnia is associated with poor physical and mental HRQoL.**

Several studies from the literature review found a reduced HRQoL across various aspects of physical and mental health. One study estimated that insomnia was associated with a loss of 5.6m QALYs annually, larger than the loss associated with 18 other common medical conditions such as arthritis, depression and hypertension.

**Adults with insomnia are more likely to be absent from work and are less productive whilst at work.**

Extrapolating findings from two well-designed studies based on the WPAI and with relatively low risk of bias, insomnia symptoms were associated with approximately 14 days of absenteeism, 30 days of presenteeism and 23 days of overall productivity loss annually, while chronic insomnia was associated with about 11–18 days of absenteeism, 39–45 days of presenteeism and 44–54 days of overall productivity loss annually.

**Insomnia is associated with an increased risk of workplace-related errors and accidents leading to injuries and disability.**

Studies from the literature review found that insomnia was associated with 75–88% increased odds of accidents leading to permanent work disability.

### 3.3.2. Knowledge gaps

Based on this review of studies on the societal impact of insomnia, we observed several knowledge gaps. First, there are limited studies on the societal impact of insomnia across diverse country settings. Secondly, more longitudinal studies are needed to appropriately capture temporal relationships between insomnia, its chronicity and outcomes, such as HRQoL and workplace-related impacts. Thirdly, many of the available studies examined the impact of insomnia on mental HRQoL but not on other aspects of mental health.

Lastly, the COVID-19 pandemic has fundamentally changed society in terms of our daily behaviours, including where we live and how we work, all of which has likely affected when and how well we sleep. As mentioned previously, much has been written on the impact of the COVID-19 pandemic and its negative impact on sleep (Gualano et al. 2020; Jahrami et al. 2021; Kokou-Kpolou et al. 2020; Pizzonia et al. 2021), with one study from our literature review finding an increase in the prevalence of insomnia after the onset of the pandemic (Morin et al. 2022). Evidence suggests that COVID-19 has also had a substantial impact on physical activity, substance use and physical and mental health (Dai et al. 2021; Shanbehzadeh et al. 2021), which
can further affect sleep patterns and increase the risk of insomnia disorder. More studies are needed to better understand the societal impact of COVID-19, its relationship to insomnia and its consequences, particularly in the workplace (e.g. changes in workplace productivity, accidents and injuries).

### 3.3.3. Caveats

Several caveats should be taken into consideration when interpreting the literature on the societal impacts of insomnia. First, and as previously mentioned in relation to studies on the prevalence of insomnia, we searched only a single database, meaning that important articles may be missing. Secondly, our focus was primarily on workplace-related impacts and so accidents and injuries outside of work were not captured in our literature review. Thirdly, while most studies compared findings to a group without insomnia, and many of these controlled for or matched on important variables, there is likely some degree of residual bias due to unmeasured confounding. Studies were also often cross-sectional in nature and associations between insomnia and outcomes cannot be interpreted as causal relationships.
In Chapter 3 we described the negative consequences that insomnia has on an individual’s productivity at work and wider HRQoL based on existing evidence in the literature. In this chapter we describe the implementation of the well-being valuation approach in order to monetise the intangible costs related to well-being loss due to insomnia’s impact on overall life satisfaction. We first emphasise the need to examine intangible costs and, specifically, the use of the well-being valuation approach in capturing these intangible costs (Chapter 4.1). We then describe the implementation of this method (Chapter 4.2) and report our findings (Chapter 4.3).

4.1. Why consider intangible costs due to loss of well-being?

The well-being valuation approach has been applied in the scientific literature to quantify the well-being effects of things that do not have a direct market value (i.e. intangible costs), such as feelings or states of health (Howley 2017), along with other events such as terrorism and environmental disasters (Frey & Stutzer 2009; Fujiwara et al. 2021). While intangible costs are hard to measure because they are not directly observed (i.e. there is no economic transaction), they can be substantial and should be considered if an evaluation takes a societal perspective.

The appraisal of public and private investment projects has seen a shift away from focusing solely on the financial perspective towards a greater emphasis on the social value that projects can generate. The incorporation of social value in appraisal analysis has gained increasing prominence in OECD countries (Hebb 2017; OECD 2018). Social-value measurement is generally understood as the practice of assessing the extent to which an intervention or project generates value for a society as a whole, and whether it is in that society’s best interest in terms of the outcomes it provides to citizens.

According to the OECD evaluation guidelines, the ultimate outcome of importance is well-being or QoL (OECD 2018). For example, the UK’s latest public appraisal guidelines have upgraded well-being effects to a central role in the valuation of benefits and costs (Social Impacts Task Force 2021), introducing a simple measure of well-being, the so-called ‘WELLBY’ (Well-Being-Adjusted Life Year), defined as a one-point change in life satisfaction for an individual for one year as measured on a Likert scale between 0 and 10 (Frijters & Krekel 2021). Thus, a WELLBY closely relates to a QALY but expands the idea of a QALY to the whole of life, not just health.

The broader consideration of well-being is important in relation to insomnia as its impact appears to be mediated through loss of daytime functioning and productivity, even though in the short-term it often does not result in medical management or treatment. Thus, despite the absence of direct medical costs there are nevertheless hidden societal costs of insomnia which are not captured in traditional costing analyses.

In general, different methodological approaches are used to measure the social value of different non-market goods.
First, the revealed preference approach relies on existing market relationships to implicitly derive the values for non-market goods. For instance, one method of revealed preference contains the hedonic price approach, which may for example use wages as a measure of how much an individual values the risk to their health when choosing one job compared to choosing another job with lower levels of health risks, all else being equal. Another example is using property prices to determine the value of a public benefit (e.g. quality of healthcare or schooling within a neighbourhood). Secondly, stated preference approaches (e.g. contingent valuation technique) directly ask a specific sample of respondents about their willingness to pay for a specific non-market good (e.g. access to a public park or different health services). Thirdly, the more recently introduced well-being valuation approach to economic appraisal is now used increasingly in the economics literature and in governments worldwide, complementing traditional valuation techniques (Social Impacts Task Force 2021). Annex J, Table J.1 outlines the key differences between the three valuation approaches. While QALYs have been assessed using stated preference techniques, recent efforts have also aimed to calculate the ‘willingness to pay’ (WTP) for a QALY using the well-being valuation approach (Himmler et al. 2020). Below we describe in more detail how the well-being valuation approach can be applied to insomnia.

4.2. How the well-being valuation approach is implemented empirically

The underlying empirical approach and the steps taken can be described in simple terms as follows: (1) estimate the association between suffering from insomnia and individual subjective well-being; and (2) estimate the necessary income (or so-called ‘compensating variation’) which would be needed to counteract or compensate the individual (relative to their income) for the reduced subjective well-being resulting from insomnia. This can be expressed as a marginal rate of substitution (MRS) (i.e. the percentage of income) and compensating income variation (CIV; i.e. absolute income). For detailed methods see Annex J and peer-reviewed literature (Fujiwara et al. 2014; Fujiwara et al. 2021; Howley 2017; Lawton et al. 2021).

The MRS and CIV can be interpreted in two ways: (1) the amount of additional income needed to compensate an individual suffering from insomnia for the loss in welfare, i.e. the willingness to accept (WTA); or the amount of income the individual is willing to forgo to be relieved from insomnia, i.e. WTP.52 We used the MRS as calculated based on data from the UK and applied it to other high-income countries, assuming that the MRS is roughly constant across other high-income contexts, to estimate country-specific CIV.

4.2.1. Data sources and main measures

Data were derived from ‘Understanding Society: The UK Household Longitudinal Study’,53 a panel survey which has collected data since 2009. The survey sample is generally representative of the UK’s population. Each annual wave of data collection spans over two years and comprises a main questionnaire and a set of specific questions asked in different waves (i.e. not all questions

52 Within the analytical framework both principles lead to the same monetary value.
53 Understanding Society: The UK Household Longitudinal Study. As of 20 October 2022: https://www.understandingsociety.ac.uk/
are asked every year). For this analysis we used waves 4 (2012–2014), 7 (2015–2017) and 10 (2018–2020), representing the three most recent periods in which information on sleep was collected. Our analysis included adults aged 18–85 who completed the survey in each of the three waves, which can be linked over time through a personal identifier. The data were retrieved and analysed under the UK Data Services’ End User Licence.

We sought to estimate the average effect of insomnia on life satisfaction, controlling for other variables. The outcome variable for life satisfaction is based on the question: ‘How satisfied are you with your life overall?’ with response categories on a 7-point Likert scale from 1 (completely dissatisfied) to 7 (completely satisfied). With regard to income we used a question from the survey on gross monthly household income. In line with the existing scientific literature (e.g. Howley 2017) we transformed the income variable into the equivalent annual household income, calculated by dividing the total household income by the square root of the household size (which was a question asked in the survey). This measure implies that a household with, for example, four members has needs that are twice as large as a household with a single member.

Insomnia was operationalised based on the following three sleep-related questions:

1. During the past month, how often have you had trouble sleeping because you cannot get to sleep within 30 minutes? (Response: less than once a week; once or twice a week; three or more times a week; more than once most nights.)

2. During the past month, how often have you had trouble sleeping because you wake up in the middle of the night or early in the morning? (Response: less than once a week; once or twice a week; three or more times a week; more than once most nights.)

3. During the past month, how would you rate your sleep quality overall? (Response: very good; fairly good; fairly bad; very bad.)

We classified survey respondents as having insomnia if they reported having issues falling or staying asleep (questions 1 and 2) at least three times per week or more than once most nights, in combination with rating their quality of sleep as ‘fairly bad’ or ‘very bad’ (question 3). This definition is broadly consistent with DSM-IV criteria for insomnia, regardless of underlying causes, and our classification of clinical insomnia.

Ordinary least squares (OLS) regression models were run to estimate the average impact of insomnia on life satisfaction (i.e. well-being), controlling the covariates listed below. We use OLS in line with other studies using the same approach. However, because the outcome variable is on an ordinal Likert scale between 0 and 7, non-linear ordered logit could be used instead. Previous empirical research suggests that the findings are robust against the choice of estimation method. Given that we include a large set of fixed effects in the analysis and Maximum Likelihood estimation can face challenges with a large set of fixed effects, we used OLS, as is the case in most empirical studies using the well-being valuation approach (Fujiwara et al. 2014; Fujiwara et al. 2021; Howley 2017; Lawton et al. 2021). For the purpose this model, life satisfaction was assumed to have a normal distribution. Model coefficients, SEs and 95% CIs were generated.

An additional advantage of OLS over ordered logit is the direct estimation of the marginal effects of insomnia on life satisfaction without the need for converting odds ratios.
Covariates:

- Age
- Sex
- Ethnicity
- Equivalised household income
- Marital status
- Current health status
- Current mental-health status (assessed through the Edinburgh Warwick Scale)
- Employment status
- Educational attainment
- Number of children aged under 16 living in the household
- Postcode
- Date of interview (day, month, year)
- Short (less than seven hours a night) and long (more than nine hours a night) duration of sleeping hours

4.3. Findings on the intangible costs of insomnia

4.3.1. Overview of study cohort characteristics

A total of 16,520 survey participants had complete data (i.e. no missing values for outcomes or explanatory variables) across the three data-collection waves, equalling 49,560 observations. Approximately 18.5% of participants (n=3,056) at any given point in time were classified as having insomnia. Table 4.1 provides a descriptive comparison of the insomnia and the non-insomnia survey population. For instance, individuals with insomnia were more frequently female than those without insomnia (64% vs 50%) and more frequently had poorer health status, poorer mental-health well-being and were more likely to report sleeping less than six hours per night. However, there did not appear to be an association between insomnia and longer sleep durations (e.g. more than nine hours a night).

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55 We used ‘current health status’ rather than specific variables to measure multi-morbidity, as it is likely to capture multi-morbidity.

56 This estimate is consistent with the predicted prevalence of clinical insomnia for the UK from meta-regression analyses in Chapter 3.0 (17.5%, 95% CI: 13.1%, 22.0%).
Table 4.1: Descriptive statistics of study cohort, overall and by insomnia status (observation level)

<table>
<thead>
<tr>
<th>Variables</th>
<th>No insomnia (n=40,391)</th>
<th>Insomnia (n=9,169)</th>
<th>All (n=49,560)</th>
</tr>
</thead>
<tbody>
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<td>Age</td>
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<td>52.38 15.26</td>
<td>52.28 16.53</td>
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<td>0.53 0.50</td>
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<td>Health</td>
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<td></td>
<td></td>
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<tr>
<td>Excellent</td>
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<td>0.04 0.21</td>
<td>0.12 0.32</td>
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<td>Very good</td>
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<tr>
<td>Good</td>
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<td>0.30 0.46</td>
<td>0.32 0.47</td>
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<tr>
<td>Fair</td>
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<td>0.16 0.36</td>
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<td>Poor</td>
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<td>0.01 0.09</td>
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<td>Other</td>
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<td>0.00 0.06</td>
<td>0.00 0.06</td>
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<tr>
<td>Mental well-being (WEMWBS)</td>
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<td>22.07 5.04</td>
<td>24.94 4.68</td>
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<td>Log income</td>
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<td>7.53 0.64</td>
<td>7.64 0.65</td>
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<td>0.06 0.24</td>
<td>0.08 0.27</td>
</tr>
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<td>0.05 0.21</td>
<td>0.03 0.17</td>
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<td>0.29 0.45</td>
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<td>0.45 0.92</td>
<td>0.44 0.87</td>
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<tr>
<td>Sleep less than 7 hours</td>
<td>0.33 0.47</td>
<td>0.79 0.40</td>
<td>0.42 0.49</td>
</tr>
<tr>
<td>More than 9 hours</td>
<td>0.01 0.12</td>
<td>0.01 0.09</td>
<td>0.01 0.11</td>
</tr>
</tbody>
</table>

Notes: Table entries report mean (numerical or proportional) values and corresponding standard deviations (SD). Higher WEMWBS (Warwick-Edinburgh Mental Well-being Scale) values indicate better mental health.
4.3.2. Association between insomnia and life satisfaction

Parameter estimates from the OLS regression are shown in Table 4.2. This table shows different model specifications and how they vary based on the inclusion of variables to control for sleep duration and mental health, given that we wanted to observe how the parameter for clinical insomnia changed in the presence of other variables. For instance, the literature suggests that mental health may have a mediating effect on the impact of insomnia on QoL (Ishak et al. 2012); nevertheless, a causal effect is difficult to establish.

Table 4.2: The effect of clinical insomnia, and other covariates, on life satisfaction

<table>
<thead>
<tr>
<th>Model</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable:</td>
<td>Life satisfaction (1–7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insomnia</td>
<td>Estimate</td>
<td>-0.301*</td>
<td>-0.284*</td>
<td>-0.173*</td>
</tr>
<tr>
<td>CI 95%: low</td>
<td>-0.369</td>
<td>-0.352</td>
<td>-0.236</td>
<td>-0.229</td>
</tr>
<tr>
<td>CI 95%: high</td>
<td>-0.234</td>
<td>-0.215</td>
<td>-0.110</td>
<td>-0.100</td>
</tr>
<tr>
<td>Sleep &lt; 7 hours</td>
<td>Estimate</td>
<td>-0.068*</td>
<td></td>
<td>-0.034</td>
</tr>
<tr>
<td>CI 95%: low</td>
<td>-0.117</td>
<td></td>
<td>-0.083</td>
<td></td>
</tr>
<tr>
<td>CI 95%: high</td>
<td>-0.019</td>
<td></td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>Sleep &gt; 9 hours</td>
<td>Estimate</td>
<td>-0.163</td>
<td>-0.153</td>
<td></td>
</tr>
<tr>
<td>CI 95%: low</td>
<td>-0.408</td>
<td>-0.365</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI 95%: high</td>
<td>0.081</td>
<td>0.059</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental well-being</td>
<td>Estimate</td>
<td></td>
<td>0.108*</td>
<td>0.108*</td>
</tr>
<tr>
<td>CI 95%: low</td>
<td></td>
<td>0.101</td>
<td>0.101</td>
<td></td>
</tr>
<tr>
<td>CI 95%: high</td>
<td></td>
<td>0.115</td>
<td>0.115</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>49,559</td>
<td>49,559</td>
<td>49,406</td>
<td>49,406</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.649</td>
<td>0.650</td>
<td>0.683</td>
<td>0.683</td>
</tr>
</tbody>
</table>

Notes: Results shown are from OLS regression models, with life satisfaction as the dependent variable. All models included the following covariates for statistical adjustment: age, sex, equivalised household income, employment status, marital status, health status, education, postcode, number of children aged under 16, as well as individual and time-fixed effects. Stepwise models included additional covariates as follows: (1) insomnia status; (2) insomnia status + sleep duration; (3) insomnia status + mental well-being; and (4) insomnia status + sleep duration + mental well-being. Appropriate survey weights were applied for each regression model to ensure model estimates were representative of the surveyed population, following instructions provided by the data documentation provider.

*p<0.05; CI=confidence interval.
In Model 1 (Table 4.2), the coefficient of -0.301 indicates that an individual suffering from insomnia on average reported a -0.30-point lower life satisfaction on a 1–7 scale than a person without insomnia. Compared to a population average life-satisfaction value of 5.16, this corresponds to a subjective well-being decrease of about 6%.\(^{57}\) The inclusion of short- and long-duration sleep variables in Model 2 reduced the coefficient for insomnia to -0.28, albeit not a considerable reduction. Not surprisingly, the inclusion of mental well-being in Model 3 substantially reduced the insomnia coefficient to -0.17, suggesting that mental well-being may be an important mediator between insomnia and life satisfaction. That said, a causal relationship between insomnia-related mental well-being and life satisfaction cannot be established since we cannot know if mental well-being (or lack thereof) is a consequence of or an antecedent to insomnia. That is to say, mental-health issues may be the cause of insomnia rather than insomnia being the cause of mental-health issues, though there is evidence to support bidirectional associations (Manber & Chambers 2009; Riemann 2007).

Notably, after accounting for insomnia, the effect of short sleep duration was statistically significant (-0.068 [95 CI: -0.117, -0.019]) (Table 4.2, Model 2), albeit smaller in magnitude than the effect of insomnia itself (-0.284; [95% CI: -0.352, -0.215]). Moreover, short-sleep duration was not independently associated with life satisfaction after controlling for both insomnia and mental well-being in Model 4.

The inclusion in Model 4 (Table 4.2) of both mental well-being and sleep duration nominally reduced the coefficient for the association between insomnia and life satisfaction to -0.165 (95% CI: -0.229, -0.100) and represents the average direct effect of insomnia on life satisfaction that cannot be explained by factors adjusted for in the model, including short-sleep duration or mental-health status. We used this parameter to calculate the CIV, as shown in Annex J.

Applying this parameter, we calculated an MRS of 14.0% (95% CI: 8.3%, 20.1%).\(^{58}\) indicating, on average, that an individual with insomnia would be willing to trade 14.0% of their household income (lower and upper estimate of 8.3% and 20.1%, respectively) to reach the same level of life satisfaction as an individual not suffering from insomnia. We then used household income per-capita data by country from the OECD\(^ {59}\) as our measure M to calculate the CIV (i.e. the monetary well-being loss associated with insomnia) across countries (see Figure 4.1 below and Annex J, Table J.1). Note that we applied the MRS value derived from the UK data to other countries; therefore, the main source of variation in CIV by country stems from country-specific household-income levels. As an example, among people suffering from insomnia, the extra equivalent household income (in 2019 USD) required for an individual to either accept suffering from insomnia (WTA) or willingness to trade income in exchange for not suffering from insomnia (WTP) in Austria is $5,632 (95% CI: $3,333–8,046) per person per year. Note that this value depends on the time value of the income taken (in this case a full year), assuming an individual suffering from

\(^{57}\) \(\frac{-0.301}{5.16}\times 100\)

\(^{58}\) This is an average estimate; willingness to forego income is largely dependent on household income, such that people with higher income are likely willing to pay more and those with lower income are likely willing to pay less.

\(^{59}\) As of 20 October 2022: https://data.oecd.org/hha/household-disposable-income.htm
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Insomnia for a full year. This value can also be expressed by person per week, dividing the annual estimate by the number of weeks per year, resulting in a value for Austria of $108.3 per week.60

Figure 4.1: Individual annual compensating income variation (CIV) for insomnia for identified countries (in 2019 USD)

<table>
<thead>
<tr>
<th>Country</th>
<th>CIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>$7,674.80</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$5,778.50</td>
</tr>
<tr>
<td>Germany</td>
<td>$5,773.50</td>
</tr>
<tr>
<td>Norway</td>
<td>$5,638.50</td>
</tr>
<tr>
<td>Austria</td>
<td>$5,632.30</td>
</tr>
<tr>
<td>Australia</td>
<td>$5,433.70</td>
</tr>
<tr>
<td>Belgium</td>
<td>$5,153.60</td>
</tr>
<tr>
<td>France</td>
<td>$5,071.50</td>
</tr>
<tr>
<td>Finland</td>
<td>$4,906.90</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$4,883.40</td>
</tr>
<tr>
<td>Canada</td>
<td>$4,870.90</td>
</tr>
<tr>
<td>Sweden</td>
<td>$4,801.70</td>
</tr>
<tr>
<td>Italy</td>
<td>$4,455.50</td>
</tr>
<tr>
<td>Spain</td>
<td>$4,011.70</td>
</tr>
<tr>
<td>Portugal</td>
<td>$3,746.30</td>
</tr>
</tbody>
</table>

Notes: CIVs are based on a single marginal rate of substitution value (14.0%; 95% CI: 8.3%, 20.1%) and this value was applied to other countries using country-specific per capita median household income from OECD data. Greece was not included due to insufficient data on prevalence estimates. USD=United States Dollar.

To put these estimates into context, monetised well-being loss (i.e. CIV) for other health conditions in the UK has been previously estimated by Howley (2017). In order to compare the estimates across different health conditions, we used the parameter estimates from Howley (2017) for the association between each health condition and life satisfaction. Applying these estimates in the same analysis as the parameter estimates reported in Table 4.2, we found that the well-being loss associated with insomnia ($4,883 in 2019 USD) in the UK appears to be lower than some conditions but larger than for others. For example, the well-being loss was higher for heart failure ($21,152), chronic bronchitis ($12,971), cancer ($9,802) and diabetes ($9,095), whereas insomnia is associated with a higher well-being than stroke ($2,116), asthma ($2,323) or arthritis ($3,957).61

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60 $5,632/52
61 A comparison of all conditions reported in Howley (2017) with insomnia is included in Annex J, Table J.2
The analyses described in this chapter necessarily focused on a definition of insomnia that is consistent with 'clinical insomnia' (which is inclusive of both acute and chronic insomnia), based on the way the sleep-related survey questions were asked (i.e. self-rated sleep symptoms in the past month). While we cannot be certain of how these estimates would differ for a sample of individuals with chronic insomnia (i.e. symptoms lasting at least three months) we hypothesise that the effects would be similar, if not more pronounced (i.e. individuals would have a similar or more pronounced reduction in life satisfaction, which would translate into a willingness to trade a similar or higher percentage of their per-capita household income to achieve the same life satisfaction as a person without insomnia, all else being equal). Therefore, the estimates calculated in this analysis might be conservative if extrapolated to chronic insomnia. These findings are also conservative in that they (1) estimate the effect of insomnia independent of effects attributable to insufficient sleep and poor mental-health conditions, which are known to vary alongside insomnia and share a common aetiology, and (2) they do not take into account the life satisfaction of others impacted by a person's insomnia (e.g. partner/spouse or caregiver).

Table 4.3 shows the CIV extrapolated to the working-age population of each country of focus by multiplying the individual CIVs reported in Figure 4.1 by the estimated prevalence of chronic insomnia in Table 2.1 (see Chapter 2) and the corresponding size of the working-age population for each country. For instance, the aggregated value of well-being loss associated with insomnia (in 2019 USD) is $1.8bn per year in Austria compared to $10.7bn in Canada and $21.9bn in the UK.

---

62 As noted in Chapter 3.0, Greece was excluded because the prevalence estimates of insomnia subtypes were based on a single study.
Table 4.3: Aggregated annual compensating income variation (CIV) by country for the affected working-age population suffering from chronic insomnia (in 2019 USD $bn)

<table>
<thead>
<tr>
<th>Country</th>
<th>Aggregated CIV ($bn, 2019 values)</th>
<th>Aggregated CIV ($; 95% CI: low)</th>
<th>Aggregated CIV ($; 95% CI: high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>$1.8</td>
<td>$0.8</td>
<td>$3.2</td>
</tr>
<tr>
<td>Australia</td>
<td>$9.7</td>
<td>$4.5</td>
<td>$16.7</td>
</tr>
<tr>
<td>Belgium</td>
<td>$4.0</td>
<td>$1.8</td>
<td>$7.0</td>
</tr>
<tr>
<td>Canada</td>
<td>$10.7</td>
<td>$4.0</td>
<td>$20.8</td>
</tr>
<tr>
<td>Finland</td>
<td>$1.6</td>
<td>$0.6</td>
<td>$2.9</td>
</tr>
<tr>
<td>France</td>
<td>$17.8</td>
<td>$6.7</td>
<td>$34.6</td>
</tr>
<tr>
<td>Germany</td>
<td>$17.0</td>
<td>$7.3</td>
<td>$30.5</td>
</tr>
<tr>
<td>Italy</td>
<td>$11.7</td>
<td>$4.7</td>
<td>$22.2</td>
</tr>
<tr>
<td>Norway</td>
<td>$1.5</td>
<td>$0.6</td>
<td>$3.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>$1.6</td>
<td>$0.6</td>
<td>$3.1</td>
</tr>
<tr>
<td>Spain</td>
<td>$7.4</td>
<td>$3.2</td>
<td>$13.6</td>
</tr>
<tr>
<td>Sweden</td>
<td>$2.7</td>
<td>$1.1</td>
<td>$5.1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$3.0</td>
<td>$1.1</td>
<td>$5.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$21.9</td>
<td>$8.5</td>
<td>$41.8</td>
</tr>
<tr>
<td>United States</td>
<td>$127.1</td>
<td>$49.8</td>
<td>$240.6</td>
</tr>
</tbody>
</table>

Notes: Aggregated CIVs are estimated based on individual CIVs and the total working-age population and predicted prevalence of chronic insomnia for each country. Greece was not included due to insufficient data on prevalence estimates. CI=confidence interval. USD=United States Dollar.

4.4. Summary

4.4.1. Review of key research findings

We used data from ‘Understanding Society: The UK Household Longitudinal Study’ surveying 16,520 individuals in the UK who responded to three waves of data collection (2012–2014, 2015–2017 and 2018–2020); approximately 18.5% of individuals had insomnia at some point during follow-up. This definition of insomnia is broadly consistent with DSM-IV’s definition of clinical insomnia and is within the 95% CI range for the predicted prevalence in the UK, as calculated in Chapter 2 (i.e. 13.1% to 22.0%). Key research findings are summarised in Box 4.1 below.
Insomnia is associated with poorer self-rated life satisfaction.

Multivariable analysis showed that individuals with insomnia had, on average, lower self-rated life satisfaction scores (-0.301; 95% CI: -0.369, -0.234) compared to those without insomnia, after adjusting for socio-demographic factors, and that this effect was only partially mitigated when adjusting for sleep duration and mental well-being (-0.165; 95% CI: -0.229, -0.100). Notably, after accounting for insomnia and mental well-being, short-sleep duration was not independently associated with life satisfaction (-0.034; 95% CI: -0.083, 0.011).

On average, adults suffering from insomnia would be willing to trade 14% of their per-capita annual household income to attain the same level of life satisfaction as those without insomnia.

Given an MRS of 14.0% (95% CI: 8.3%, 20.1%) this translates to a monetary value ranging from $3,746.30 (95% CI: $2,216.90, $5,351.60) in Portugal, $5,773.50 (95% CI: $3,416.60, $8,247.60) in Germany and $7,674.80 (95 CI: $4,541.70, $10,963.60) in the US.

At the population level, intangible costs due to insomnia in the working-age population are in the billions of dollars annually.

Extrapolated to the working-age population of each country, the annual well-being loss due to chronic insomnia ranged from $1.5bn in Norway to $127.1bn in the US.

4.4.2. Knowledge gaps

More studies are needed to estimate the impact of insomnia on well-being in different country contexts in order to better quantify intangible costs. In addition, more studies are needed to estimate how the intangible costs of insomnia compare to other conditions.

4.4.3. Caveats

There are some caveats to bear in mind. First, the estimate for the MRS was derived from a single database surveying a representative sample of UK residents. This value was then extrapolated to other high-income OECD nations to calculate country-specific CIVs, even though the MRS may differ by country. However, we do report CIs for this estimate, and while these represent a value of statistical uncertainty around the point estimate relevant to the UK perspective, given that the statistical analysis has been adjusted for a wide variety of confounding factors the estimated effects are not likely to vary dramatically if estimated directly with country-specific data, even if the prevalence of these confounding factors varies across other high-income countries. Secondly, the estimate for the MRS was based on clinical insomnia (and not the current definition of insomnia disorder); however, we would expect that the impact of chronic insomnia on life satisfaction would be similar or worse. Thus, the MRS and corresponding CIVs reported here are potentially a conservative estimate for CIV. Thirdly, given that insomnia was defined via self-reporting, rather than through clinical diagnosis, it is possible that some insomnia cases were misclassified due to the inability to rule-out other differential diagnoses (e.g. obstructive sleep apnoea).
The societal and economic burden of insomnia in adults
5 Macro-economic effects of productivity losses associated with insomnia

In Chapter 4 we described the intangible costs associated with insomnia using the well-being valuation approach. In this chapter, we describe the indirect economic costs of productivity loss in the workplace due to insomnia. To estimate these costs, we used a macro-economic model similar to the World Health Organization’s EPIC (Economic Projections for Illness and Cost of Treatment) model, although our model is more detailed and comprehensive in that it takes into account full general equilibrium effects across the economy. For example, our model is calibrated on the underlying economic factors and economic input data for each of the countries analysed, with the effects of insomnia based on parameter estimates for the prevalence of chronic insomnia (as described in Chapter 2) and parameters from the literature on the associations between chronic insomnia and productivity loss due to absenteeism and presenteeism (as described in Chapter 3). This analytical framework allows us to quantify the economic cost of insomnia, measured in terms of lost economic output by country. In the following sections we explain in more detail the analytical approach and research findings.

5.1. The macro-economic model

5.1.1. A CGE model to assess impacts of health on the economy

The current economic projection for each country is calculated within a computable general equilibrium (CGE) modelling framework which compares current underlying economic factors (the so-called ‘status quo’ or ‘baseline scenario’) against a ‘what-if’ scenario in which the effects of chronic insomnia on productivity parameters are changed. For the purpose of this analysis we examined how various outcomes (e.g. the economic output of a country) would change compared to the status quo if chronic insomnia were to be diminished in the country’s population.

In the field of health economics, the application of CGE models has recently become more common due to its advantages compared with more traditional approaches, such as cost of illness (COI) methods (see e.g. Bloom et al. 2020). COI is an easy-to-understand method which summarises direct and indirect costs associated with ill-health, taking into account for instance the sum of all direct personal medical costs, as well as indirect costs (e.g. income loss due to absenteeism or premature death). While the approach is relatively straightforward, it only captures partial equilibrium effects. For instance, when calculating productivity losses, traditionally the number of days lost due to the health condition are multiplied either by the average wage or per-capita GDP for the country. This partial equilibrium approach does not consider the potential spill-over effects on other agents or markets in an economy. In reality
many adjustment mechanisms play out, such as the substitution between labour and capital if labour supply is negatively affected due to ill-health, and a general equilibrium model such as CGE takes into account these ripple effects on other parts of the economy by reporting how overall economic output is affected.

The CGE model is multi-regional, whereby each region has bilateral trade with all other regions simultaneously. World prices are, therefore, determined globally by the model, and each country/region influences all the other regions. Larger regions will have larger effects compared to smaller regions. This is different from small open economy health models (e.g. Smith et al. 2005) in which countries cannot affect world prices, but rather take them as given. Each country/region produces three types of output (agriculture, industry and services), while a government collects taxes and provides public services. Finally, households, the government and foreign countries save/invest within each country following a Ramsey-type modelling approach.

5.1.2. How chronic insomnia affects the economy in the model

Figure 5.1 depicts the linkages in the CGE model between different economic agents. In the model, as in reality, different agricultural, industrial and services production sectors require capital and labour inputs which they access through capital and labour markets. Firms hire labour and borrow capital from households, which allows households to obtain income. Goods are then sold in the marketplace, which households pay for out of their available income.

The framework depicted does not include the government, which in our model collects taxes and provides and buys goods and services. Finally, households and the governments save and borrow in the capital markets. The economy also trades with the rest of the world through a complex set of international linkages. Specifically, through absenteeism and presenteeism chronic insomnia can directly reduce the supply of effective labour, which is viewed as a key resource in the economy.64

The core model used is a standard static multi-country CGE model based on Hafner et al. (2019) and following the structure of Lanz and Rutherford (2016). The model was programmed in the software General Algebraic Modelling System (GAMS) using the Mathematical Programming System for General Equilibrium (MPSGE) solver by Rutherford (1999).

One key element of the model is the focus on the supply of effective labour, which basically augments the labour supply in an economy with factors that can be related to health.65

64 In more technical terms, in a country r, output in sector i consists of goods and services Y_{ir}, which are produced by capital K_{ir}, other inputs N_{ir} (e.g. intermediate inputs from sector j) and labour L_{ir}. Thus, production is modelled as a function of \( Y = F(K, N, L) \) where subscripts i, j, and r are omitted for simplicity.

65 \( L_{ir} \) is based on two factors. That is, for each time period t, the model assumes that effective labour supply is adjusted for efficiency units by \( L_{ir} = L_{ir} \cdot E_{ir} \), with the physical supply of labour input \( L_{ir} \) and efficiency of labour \( E_{ir} \). \( L_{ir} \) is the physical amount of labour (e.g. number of employed people) and \( E_{ir} \) represents their productivity level (e.g. depending on their health or skill).
As in our previous work on the economic effects of inadequate sleep (Hafner et al. 2016), the reduction in effective-labour supply in our model is manifested through two potential channels:

- **Reduced labour productivity**: prolonged periods of sickness temporarily reduce the country’s workforce and may in severe cases lead to permanent reductions in labour efficiency (productivity). As outlined in the literature review in Chapter 3, insomnia is associated with higher levels of work impairment (i.e. productivity loss) due to absenteeism and presenteeism, with potentially large economic losses associated.

- **Increased mortality**: if insomnia increases the risk for all-cause mortality, potential deaths attributable to insomnia would permanently reduce the population size, and this increase in mortality would decrease the working-age population and have a negative impact on economic output. Our review of the literature suggests that the evidence for the relationship between insomnia and all-cause mortality is equivocal (Lovato & Lack 2019). Even in the case of a relationship between insomnia and mortality, we would expect this would impact an older, non-working population. Thus, as a conservative approach, we do not model the potential effects of mortality.
Within the modelling framework, for the baseline scenario we normalise the productivity element to the current chronic insomnia prevalence levels by setting $\bar{E} = 1$. In the counterfactual ‘what-if’ scenarios we estimate the amount of economic output in terms of the additional GDP that could be produced by reducing the prevalence of insomnia so that no one suffers from it. This scenario represents the current total economic burden associated with chronic-insomnia related productivity losses. In this counterfactual scenario the effective labour productivity is raised by $\varepsilon$, resulting in the total efficiency of labour parameter of $E = \bar{E} + \varepsilon$.

To calculate the additional efficiency units of labour $\varepsilon$ related to chronic insomnia, we draw mainly on work-impairment data provided in the literature, where we found that chronic insomnia increases the number of working days lost due to absenteeism and presenteeism (as measured by the WPAI instrument) (Bolge 2009; DiBonaventura et al. 2015).  

5.1.3. Model input data

The base underlying economic data used for the purpose of this analysis is from the Global Trade Analysis Project (GTAP) database.  

This database has been developed by the Center for Global Trade Analysis at Purdue University since 1993. Overall, GTAP covers 140 countries for 57 GTAP commodities and includes all bilateral trade patterns, production, consumption and intermediate inputs of commodities and services. We used the latest version, GTAP 10a, which has a reference year of 2014. From the GTAP database we extracted a Social Accounting Matrix (SAM) for the specific countries and regions included in the analysis. The SAM is a complex table expressed in terms of incomes and expenditures, i.e. a double-entry accounting method. GTAP includes SAMs for individual countries based on national accounts data (e.g. use-supply tables, input–output tables) and information from household survey data and trade data. Because of the sheer amount of work involved, GTAP collects and coordinates country SAMs from researchers across the world and cleans and standardises the data. For the purpose of this analysis we extracted the SAMs for the 15 countries of focus (Australia, Canada, the US, Finland, Sweden, Norway, France, Germany, the UK, Austria, Belgium, Switzerland, Italy, Spain, Portugal) and the rest of the world. In order to make the model tractable we aggregate the different sectors into three industries: agriculture, manufacturing and services. The underlying population data come from the Worldometers data and the World Bank. We divide a country’s population into working-age and non-working-age populations, with the working-age population defined as those aged 18–64. We also use data from the International Labour Organisation on the distribution of educational attainments across countries to divide the working-age population further into skilled and unskilled labour.

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66 In technical terms, $\varepsilon$ is calculated by multiplying the average productivity loss $\rho$ times the prevalence of chronic insomnia in the population, $\eta$: $\varepsilon = \rho \eta$, whereas a decrease in the prevalence of chronic insomnia reduces the number of lost working time associated with chronic insomnia and hence raises overall economic output through increased labour efficiency.

67 Global Trade Analysis Project. As of 20 October 2022: https://www.gtap.agecon.purdue.edu/

68 We did not include Greece as there was only one study on the prevalence of clinical insomnia.
In addition to the underlying economic data, we use insomnia-specific model inputs to determine the effects on labour supply, in particular using existing evidence from the literature on:

- The prevalence of chronic insomnia in the population (as summarised in Chapter 2).
- The level of work impairment associated with chronic insomnia (as summarised in Chapter 3).

In relation to work impairment, two papers reported outcomes using the WPAI (Bolge 2009; DiBonaventura et al. 2015). Di Bonaventura et al. (2015) reported productivity loss among propensity score-matched cohorts of individuals with chronic insomnia compared to those without insomnia from the US (n=36,959) and Europe (n=31,661). We used the overall productivity-loss estimates from this study based on the differences between the matched insomnia and no-insomnia groups; parameter inputs are shown in Table 5.1. For example, in the US the mean difference in overall productivity loss was -19.6% points, or in other words a person suffering from chronic insomnia loses on average 19.6% points of working time due to absenteeism and presenteeism compared to an individual with no insomnia. Note that, in our analysis, for all European countries and Australia we applied estimates from the aggregated values from five European countries.69 For the US and Canada we used estimates from the US.

Table 5.1: Annual productivity loss parameter estimates used in the economic analysis

<table>
<thead>
<tr>
<th>WPAI: Overall productivity loss: absenteeism and presenteeism (% working time)</th>
<th>United States</th>
<th>European Union*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No insomnia</td>
<td>Insomnia</td>
</tr>
<tr>
<td>Mean</td>
<td>11.78</td>
<td>31.39</td>
</tr>
<tr>
<td>95% CI: low</td>
<td>11.09</td>
<td>30.42</td>
</tr>
<tr>
<td>95% CI: high</td>
<td>12.47</td>
<td>32.36</td>
</tr>
</tbody>
</table>

Notes: based on estimates provided in Di Bonaventura et al. (2015). Authors calculated 95% confidence intervals (CIs) based on standard errors provided in the original study. Parameter estimates used are the difference between the insomnia and no-insomnia population groups.

*Includes France, Germany, Italy, Spain and the UK.
5.1.4. Chronic insomnia scenarios

In the analysis we investigated how the economy of a country today (baseline) would change if the negative factors associated with chronic insomnia, such as lower productivity, were removed (counterfactual scenario). For each analysis we ran at least two scenarios (i.e. current and counterfactual prevalence). As described above, we focused on the productivity effects associated with chronic insomnia and assumed in the counterfactual scenario that the current prevalence of chronic insomnia in the working-age population is diminished to zero across the countries studied, meaning that work impairment associated with chronic insomnia is also diminished to zero. This was expressed as the estimated maximal amount of GDP that could be produced if the effects of chronic insomnia were eliminated. We also conducted a sensitivity analysis by using the lower and upper bound of the estimated 95% CIs from Table 5.1 as input parameters.

5.2. The economic impact of productivity loss due to chronic insomnia

Model findings suggest that chronic insomnia is associated with substantial economy-wide productivity losses. Hypothetically, if chronic insomnia were to be eliminated the resulting estimated GDP gains would vary from 0.64% in Austria to 0.73% in Germany, 1.23% in France and 1.31% in Switzerland and the UK (see Figure 5.2). In addition, per-capita productivity loss for working adults suffering from chronic insomnia for each country (which is driven by variations in the country-specific prevalence of chronic insomnia and GDP) ranged from $4,194.6 (Portugal) to $19,349.7 (Switzerland) (see Table 5.2).
Table 5.2: Estimated annual productivity costs associated with chronic insomnia by country—gross domestic product (GDP) effects per capita

<table>
<thead>
<tr>
<th>Country</th>
<th>Estimate</th>
<th>95% CI: low</th>
<th>95% CI: high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>$10,351.8</td>
<td>$8,054.6</td>
<td>$12,706.4</td>
</tr>
<tr>
<td>Austria</td>
<td>$9,286.7</td>
<td>$6,752.9</td>
<td>$11,679.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>$6,582.5</td>
<td>$4,955.0</td>
<td>$8,171.6</td>
</tr>
<tr>
<td>Canada</td>
<td>$8,854.2</td>
<td>$5,566.8</td>
<td>$12,219.3</td>
</tr>
<tr>
<td>Finland</td>
<td>$12,971.2</td>
<td>$10,574.5</td>
<td>$14,230.9</td>
</tr>
<tr>
<td>France</td>
<td>$10,432.1</td>
<td>$6,605.0</td>
<td>$14,308.3</td>
</tr>
<tr>
<td>Germany</td>
<td>$9,978.1</td>
<td>$7,183.2</td>
<td>$12,641.4</td>
</tr>
<tr>
<td>Italy</td>
<td>$6,468.4</td>
<td>$4,343.5</td>
<td>$8,623.2</td>
</tr>
<tr>
<td>Norway</td>
<td>$18,331.7</td>
<td>$11,229.0</td>
<td>$25,535.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>$4,194.6</td>
<td>$2,691.1</td>
<td>$5,650.5</td>
</tr>
<tr>
<td>Spain</td>
<td>$6,285.1</td>
<td>$4,490.5</td>
<td>$8,106.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>$11,677.2</td>
<td>$7,931.2</td>
<td>$15,422.1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>$19,349.7</td>
<td>$12,137.8</td>
<td>$26,455.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$9,391.5</td>
<td>$6,162.2</td>
<td>$12,662.5</td>
</tr>
<tr>
<td>United States</td>
<td>$12,272.6</td>
<td>$8,018.2</td>
<td>$16,478.1</td>
</tr>
</tbody>
</table>

Notes: The GDP per working adult suffering from chronic insomnia by country varies because of different country-specific prevalence estimates, as well as varying underlying productivity per-capita levels. Greece was not included due to insufficient data on prevalence estimates. CI=confidence intervals. USD=United States Dollar.
Figure 5.2: Estimated annual gross domestic product (GDP, in 2019 USD $bn and % GDP) loss associated with chronic insomnia-related reduced productivity for identified countries

Note: USD=United States Dollar.
5.3. Summary

5.3.1. Review of key research findings
We used a multi-country CGE model to estimate the indirect costs of chronic insomnia on the working population. The parameters for this model were based on the prevalence of chronic insomnia from the literature review and as predicted from meta-regression, as well as the productivity loss due to absenteeism and presenteeism as identified from the literature. The model estimated the economic gain in terms of GDP in a counterfactual scenario in which chronic insomnia, and thereby its impacts on work impairment, were eliminated for each of the countries of focus, as compared to a baseline scenario.

Key research findings are described in Box 5.1 below.

Box 5.1: Key research findings on the indirect economic cost of insomnia

Chronic insomnia is associated with a substantial annual economic impact due to productivity loss.
By eliminating the effects of chronic insomnia, the model estimated an increase in annual national GDPs ranging from 0.64% of GDP in Austria to 0.73% in Germany, 1.23% in France and 1.31% in Switzerland and the UK.

Economic projections suggest that reducing the effects of chronic insomnia across the working population could result in substantial economic gains.
Absolute monetary gain due to an increase in annual GDP via reduction of chronic insomnia across the population ranged from a mean of $1.8bn in Portugal to $207.5bn in the US, with annual per-capita gains ranging from a mean of $4,194.6 in Portugal to $19,349.7 in Switzerland.

5.3.2. Caveats
This analysis used predicted estimates of chronic insomnia from a meta-regression based on a literature review; we cannot know if these are the true estimates of chronic insomnia for each of the countries of interest. In addition, this analysis relied on estimates for productivity loss from a single study; we applied estimates from the US to Canada and the estimates from select European countries to other European countries and Australia, even though we cannot know if these estimates reflect the true productivity loss due to insomnia within each of these countries. Taken together, the CGE model is based on several assumptions and the accuracy of these assumptions directly impact the accuracy of the model output.
The societal and economic burden of insomnia in adults
6 Discussion

6.1. Summary of findings

This study was conducted to identify and quantify the societal burden of insomnia and its resultant economic impacts both in terms of *intangible* and *indirect* costs. To this end we first conducted a review of the literature to examine the prevalence of insomnia across high-income OECD countries and the factors that influence variations in prevalence, as well as to better understand the societal burden of insomnia, specifically in terms of QoL and workplace-related impacts (i.e. productivity loss due to absenteeism and presenteeism). We then used secondary database analyses to calculate the intangible costs of insomnia, applying the well-being valuation approach to estimate the percentage of per-capita annual household income an individual with insomnia would be willing to trade to achieve the same level of well-being (i.e. life satisfaction) as an individual without insomnia. Finally, we used a multi-country CGE macro-economic modelling approach to quantify the indirect economic costs of insomnia related to productivity loss in the workplace. Specifically, we applied predicted prevalence estimates of chronic insomnia and estimates for productivity loss due to chronic insomnia from the literature review. Our key findings are discussed below.

6.1.1. Prevalence of insomnia

Our review of the published literature found a range of prevalence estimates for each insomnia subtype across 16 high-income OECD countries. Reported insomnia symptom estimates among general adult populations ranged from 17.5% to 51.2%, clinical insomnia estimates ranged from 5.7% to 25.3% and chronic insomnia estimates ranged from 6.0% to 14.8%. Prevalence estimates varied for each country and the geographical regions in which they are located, although there was overall consistency in the magnitude of prevalence estimates for each insomnia subtype, with insomnia symptoms being more prevalent than clinical or chronic insomnia and clinical insomnia being more prevalent than chronic insomnia.

Additional sources of variation in reported insomnia prevalence estimates included the instrument used to measure insomnia, the total risk-of-bias score and, specifically in relation to chronic insomnia, the percentage of female study participants. Taking into consideration these sources of variation and other study-level characteristics we estimated a 33.8% (95% CI: 28.2%, 39.4%) prevalence of insomnia symptoms, a 14.2% (95% CI: 11.3%, 17.2%) prevalence of clinical insomnia and an 8.2% (95% CI: 6.6%, 9.8%) prevalence of chronic insomnia for a general adult population in 2020 that is 52% female with a mean age of 46 years. Importantly, these values fall within the ranges of prevalence estimates reported from the studies in our literature review and are broadly consistent with prior research and expert opinion, indicating that approximately one-third of the adult population experiences some form of insomnia symptoms in their lifetime (Momin & Ketvertis 2022) and approximately 10% of the adult population suffers from chronic insomnia.
The societal and economic burden of insomnia in adults

Extrapolated to the working-age populations of the 16 identified countries (comprising an estimated 507.7m working-age people aged 15–64), chronic insomnia would be expected to impact nearly 41.6m individuals. Thus, with chronic insomnia being present in approximately 8% of the working-age population this represents a large number of people internationally who experience this condition and its downstream sequelae.

6.1.2. Health-related quality of life and intangible costs

Our review of the published literature identified several studies in six of the 16 identified countries which found that insomnia is associated with poorer HRQoL across all eight domains of SF survey instruments, including physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health. This is consistent with a large body of literature showing that insomnia is associated with negative consequences to individual health and well-being and interpersonal relationships (Fernandez-Mendoza & Vgontzas 2013; Pigeon et al. 2017; Troxel et al. 2007).

Our secondary database analyses complement findings from the literature review, with participants with insomnia in the UK's Longitudinal Household Survey reporting on average lower self-rated life-satisfaction scores than those without insomnia, even after adjusting for numerous other factors including socio-demographics, mental health and sleep duration. Based on this analysis, we estimated that a person with insomnia would be willing to trade approximately 14% of their per-capita annual household income to achieve the same level of well-being (i.e. life satisfaction) as a person without insomnia. Applying this estimate to the other countries of focus, annual intangible costs range from about $3,746.30 to $7,674.80 per person. These findings highlight the considerable burden of insomnia at the individual level and the extent to which individuals are willing to invest in quality sleep. Extrapolated to the working-age population for each country, the annual well-being loss associated with chronic insomnia ranged from $1.5bn in Norway to $127.1bn in the US.

6.1.3. Workplace-related impacts of insomnia and indirect economic costs

Our review of the published literature identified several studies on the association between insomnia and an increased risk of workplace-related errors and accidents leading to injuries and disability. The literature also indicated that insomnia was associated with an increase in the number and duration of absenteeism episodes, working while unwell (i.e. presenteeism) and overall productivity loss. Such impacts may be due to insomnia-related impairments in thinking, memory, concentration and learning, as well as increases in fatigue and mood disturbances (Fortier-Brochu et al. 2012; Wardle-Pinkston et al. 2019). We identified one study from the literature that estimated the impact of chronic insomnia on absenteeism, presenteeism and overall productivity loss in both the US and Europe (DiBonaventura et al. 2015). Extrapolating findings from this study over a year, chronic insomnia was associated with an overall annual productivity loss of 19.6% (44.1 working days) and 23.9% (53.8 working days) in the US and Europe respectively.
We applied these estimates for overall productivity loss, along with predicted prevalence estimates of chronic insomnia from the literature review, to a multi-country CGE macro-economic model. We found that chronic insomnia was associated with a substantial economic impact due to productivity loss. By eliminating the effects of chronic insomnia on workplace productivity the model estimated increases in annual national GDPS ranging from 0.64% in Austria to 1.31% in Switzerland and the UK. In terms of absolute monetary gains this ranged from a mean of $1.8bn in Portugal to $207.5bn in the US, with annual per-capita gains ranging from a mean of $4,194.6 in Portugal to $19,349.7 in Switzerland.

6.2. Putting intangible costs and indirect costs into context

As mentioned earlier in this report, there are several ways to estimate the burden of a condition: direct costs associated with managing and/or treating the condition (e.g. healthcare costs); indirect costs which impact economic transactions outside of the healthcare setting (e.g. costs due to lost productivity in the workplace); and, finally, intangible costs which are not based on economic transactions per se but which nonetheless potentially represent substantial costs relating to a person’s state of well-being or health.

Indirect costs are often measured through COI analyses in which personal out-of-pocket costs (e.g. medical costs) and/or productivity loss are extrapolated to median incomes across the affected population. A macro-economic approach such as the CGE model offers an alternative method which accounts for spill-over effects of productivity loss within and across national economies. In particular this model estimates a baseline scenario in which the condition affects the population of interest and a counterfactual scenario in which the condition and its impacts on productivity are eliminated. This model yields an estimated change in economic output as a function of GDP and provides a more comprehensive estimate of the economic costs than a COI approach.

The intangible costs estimated in this study (ranging by country from $3,746 to $7,675 per person annually) are slightly lower than the annual costs estimated for some other diseases in a UK study using the same source data and similar methodology (Howley 2017). For example, comparing our estimated CIV of $4,883 (2019 USD) for chronic insomnia in the UK, Howley (2017) reported higher CIVs\(^\text{70}\) for heart failure ($21,152.4), chronic bronchitis ($12,971), cancer ($9,802), diabetes ($9,095), but lower CIVs for stroke ($2,116), asthma ($2,323) and arthritis ($3,957).

Regardless of comparisons to other diseases, the MRS (i.e. 14%) and associated CIV for chronic insomnia for each country represent sizable hidden costs which individuals with insomnia would be willing to trade to achieve the life satisfaction of a person without insomnia. Extrapolated to the entire working-age population of a country with chronic insomnia, these intangible costs range from $1.5bn to $127.1bn annually, depending on the size of the underlying population and the prevalence of chronic insomnia.

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\(^{70}\) Conversion to 2019-equivalent USD was performed by applying an annualised exchange rate of GBP to USD in 2016 of 1.355673 and a USD inflation rate between 2016 and 2019 of 1.07.

\(^{71}\) A table comparing all conditions reported in Howley (2017) with insomnia is included in Annex J.
The indirect economic costs associated with productivity loss due to chronic insomnia as a percentage of a country’s annual GDP ranged from 0.64% to 1.31% across 15 countries, which translated to total annual indirect costs ranging from $1.8bn to $207.5bn (2019, USD). This is somewhat lower than the estimates identified in the RAND report on insufficient sleep (Hafner et al. 2016), which found an impact on GDP in five OECD nations, ranging from 1.3% to 2.3% and translating to total annual indirect costs from $21.4bn to $411.0bn (2015, USD) or $23.1bn and $443.9bn, respectively, in 2019-equivalent USD.

Whereas the economic costs of chronic insomnia appear to be lower than those for insufficient sleep, comparisons are complicated given that these conditions are related (i.e. insufficient sleep includes individuals with insomnia disorder and those without, and insomnia disorder includes individuals who have insufficient sleep and those with sufficient sleep). Thus, it is difficult to tease apart costs attributed to poor-quality sleep as compared to poor-quantity sleep.

Nevertheless, the indirect economic costs due to chronic insomnia reported in our study are higher than costs reported in the literature. For example, a Canadian study found that the cost of clinical insomnia due to absenteeism and presenteeism was $4,311 (2002, CAD) per person annually, or $3,898 in 2019-equivalent USD (Daley et al. 2009a). By comparison, we found that productivity loss due to chronic insomnia in Canada was associated with an indirect economic cost of $8,854 (2019, USD) per person annually. Similarly, in a US study Kessler et al. (2011) reported that lost productivity due to clinical insomnia cost the US economy $63.2bn (2010, USD) annually, or $73.9bn in 2019-equivalent USD. By contrast, we found that chronic insomnia in the US was associated with a total loss of $207.5bn (2019, USD) annually. Differences between indirect costs estimated in the literature and our study could be due to two factors. First, estimates from the literature are based on clinical insomnia whereas ours are based on chronic insomnia, and we would expect chronic insomnia to have a more pronounced impact on productivity loss than clinical insomnia (which also includes acute insomnia). Secondly, estimates from the literature are based on COI analysis and do not account for spill-over effects within and between national economies. We would therefore expect our estimates to be more comprehensive than those calculated from more traditional methods.

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72 Canada, Germany, Japan, the UK and the US.
73 Conversion of 2015 to 2019 USD was calculated based on an inflation rate of 1.08.
74 Conversion from CAD to 2019 equivalent USD was calculated based on an annualised exchange rate in 2002 of 0.636723 and a USD inflation rate between 2002 and 2019 of 1.42.
75 Conversion of 2010 to 2019 USD was calculated based on an inflation rate of 1.17.
6.3. Recommendations

Based on the findings from this study, we provide recommendations below for policy, clinical practice and research with the overarching goal of mitigating the impact of insomnia disorder on the individual, as well as its societal burden and indirect economic costs. Although recommendations are specified based on each of these domains (policy, clinical practice and research), there is some overlap, with recommendations falling into multiple domains.

6.3.1. Recommendations for policy

1. **Governments and healthcare systems should provide access to and reimbursement for safe, evidence-based, affordable and cost-effective treatments for chronic insomnia.**

   Cognitive behavioural therapy (CBT) is currently considered the first-line therapy for the treatment of insomnia (i.e. CBT-I); however, this treatment remains under-utilised for a variety of reasons, including issues of access to qualified providers and reimbursement for services. New modalities of delivery of CBT-I, including teletherapy or digital health platforms, may help to enhance access, and policymakers should create avenues to promote access to and reimbursement for these services. However, given that not all patients respond to CBT-I (Trauer et al. 2015; Muench et al. 2022), and to satisfy diverse patient preferences, innovative behavioural and pharmacological treatments for chronic insomnia are needed that are safe and effective for long-term use. Finally, there is a critical need to identify effective strategies to improve scalability and dissemination of existing and new treatments, particularly in socio-economically disadvantaged populations and among racial/ethnic groups most vulnerable to health disparities.

2. **Workplace interventions are needed to better identify insomnia and mitigate its impacts.**

   As our research shows, chronic insomnia can impact the entire economy of a country in terms of its GDP output, but its immediate effects are likely to be felt most acutely within the workplace. Thus, policies to mitigate the impacts of insomnia should start at work. For example, employers (especially human-resource departments) and employees should be educated on the symptoms and signs of insomnia, its impact on cognitive function, health and well-being and its risks related to workplace-related errors, accidents and injuries. Employees, as part of an overall ‘wellness package’, should receive evidence-based resources for managing insomnia, such as access to CBT-I. These interventions are particularly important for employees in high-risk work environments in which errors or accidents could result in severe life-threatening injuries to themselves, co-workers, consumers or other members of the public. Workplaces should also foster a culture that promotes sleep health, such as limiting email traffic after working hours and adopting policies that support work-family balance (e.g. flexible schedules, family-leave policies), given that life events such as a death in the family or the birth of a new child can trigger insomnia (Lancel et al. 2020). Changes to the workplace environment, such as using circadian-effective lighting or providing workplaces with windows (offering exposure to daylight), have also been shown to improve employees’ mood and sleep quality and may therefore be an important preventive strategy (Boubekri et al. 2014).
3. **Public health campaigns should emphasise the importance of sleep quality in addition to sleep quantity.**

While insufficient sleep duration has negative impacts on an individual’s well-being and on a nation’s total economic output (Hafner et al. 2016), increasing evidence points to the unique public health impact of poor sleep quality and insomnia. For example, through our analyses we found that insomnia was associated with lower life satisfaction, independent of sleep duration. Furthermore, a sizeable portion of the population has little control over their sleep duration, and an exclusive emphasis on sleep duration can be a stressor that contributes to further sleep problems. Indeed, current conceptualisations of sleep health emphasise its multi-dimensional nature, including sleep quality, duration, timing, regularity and daytime functioning. Thus, public health campaigns should include ways to improve the quality of sleep, such as maintaining a consistent sleep-wake schedule, removing technology from the bedroom and avoiding alcohol and caffeine. Initiatives to disseminate such knowledge should be encouraged (Altena et al. 2020; Baglioni et al. 2020).

6.3.2. **Recommendations for clinical practice**

1. **Screening for insomnia disorder should be incorporated into routine clinical visits.**

Chronic insomnia is an under-diagnosed condition, and delays in its diagnosis and treatment may lead to more severe and intractable symptoms. Such delays may result in patients requiring more aggressive management than would be needed if insomnia was addressed earlier in the clinical course. Accordingly, routine screening for sleep problems and disorders, including insomnia, should occur in the primary care/general practice setting to improve diagnosis and treatment. Early detection of sleep disorders and their related causes can ultimately reduce downstream health and productivity consequences, as well as the burden on the healthcare system, and may also enhance patient engagement (Croker et al. 2013).

2. **Medical school and graduate medical training should be revised to include a more in-depth focus on sleep health and the identification and clinical management of sleep disorders, including insomnia.**

Sleep occupies a major proportion of our lives, and yet sleep education in the medical school curriculum is woefully lacking. In fact, a multi-nation survey of medical schools found that the average amount of time spent on sleep education was just under 2.5 hours, while a striking 27% of respondents indicated that their medical school provided no sleep education to future physicians (Mindell et al. 2011).

3. **Providing ongoing education regarding evidence-based treatments for chronic insomnia is critical to address physician knowledge gaps and improve the identification and management of insomnia.**

Without knowledge or awareness of the signs and symptoms of insomnia or effective behavioural or pharmacological treatment options, providers must rely on their best judgment or prior experiences, rather than making evidence-based clinical decisions. Thus, efforts are needed to educate and disseminate information on insomnia and evidence-based treatments that have been proven to be safe and effective in the long-term to improve patient care.
4. **The relationship between insomnia and other health conditions is often bidirectional and requires a holistic approach to management and treatment.**

Chronic insomnia is often co-morbid with numerous other physical and mental-health conditions. While chronic insomnia should be treated as an independent condition, there are benefits to treating co-occurring conditions. For example, some pharmacological and non-pharmacological treatments for anxiety and depression can help reduce symptoms of insomnia and vice versa (Hertenstein et al. 2022). Conversely, failure to treat insomnia has been shown to predict poorer treatment response (Troxel et al. 2012) and a greater likelihood of the recurrence of depression (Inada et al. 2021). Holistic treatment strategies should take a ‘person-centred’ rather than a ‘disease-centred’ approach. Furthermore, some evidence suggests that treating insomnia may be a ‘gateway’ to the treatment of other mental-health conditions among otherwise treatment-reluctant populations (e.g. the military), as sleep disorders tend to be less stigmatised than mental-health conditions (Troxel et al. 2015).

5. **Clinical-care pathways should be established within healthcare systems to ensure that patients have timely access to diagnosis and treatments.**

Clinical-care pathways from screening to diagnosis of insomnia – and ultimately to management and treatment – may vary between national, regional and local healthcare systems. Healthcare systems should consider establishing and/or standardising this pathway so that patients receive timely diagnosis and treatment. Healthcare systems should also consider the continuity between primary and secondary care so that general practitioners (GPs) either know how to diagnose and manage insomnia (see the recommendation above on education and awareness of insomnia among clinicians) or are able to refer patients to specialists for this purpose. Indeed, a lack of awareness of viable referral pathways to specialist care for complex cases has been identified as a critical barrier in GPs’ management of insomnia (Haycock et al. 2021).

6. **3.3. Recommendations for research**

1. **More research is needed on the prevalence of chronic insomnia and its societal and economic impacts.**

This report identified relatively few studies on chronic insomnia (i.e. the current definition of insomnia disorder based on contemporary disease classification and coding systems). More studies are needed to understand the burden of this disorder, especially the prevalence of chronic insomnia among underserved groups and in the context of other physical and mental-health conditions. In addition, more research is needed to examine the societal impacts and economic costs of chronic insomnia and to address other potential mechanisms linking insomnia with economic outcomes, such as the impact of insomnia on workforce retention and employee satisfaction and other detrimental effects on daytime functioning.

2. **Survey instruments need to be designed and validated to measure chronic insomnia.**

The lack of studies on chronic insomnia is, in part, due to the fact that currently available datasets and the validated instruments that measure its symptoms are designed to capture insomnia disorder defined according to outdated diagnostic criteria. Thus, future research is needed that uses validated survey instruments specifically designed to measure chronic insomnia as defined by contemporary disease classification and coding systems.
3. **A better understanding is needed of the interrelationship between COVID-19, physical health, mental health and sleep.**

The COVID-19 pandemic has been associated with fundamental changes to society, including where we live and how we work, as well as when and how well we sleep. Research has shown the negative consequences of the pandemic on physical health, mental health and sleep (Gualano et al. 2020; Jahrami et al. 2021; Kokou-Kpolou et al. 2020; Pizzonia et al. 2021). Given that COVID-19 is likely to be an enduring fact of life, more research is needed to examine the interrelationships between physical health, mental health and sleep in the context of the newer ways of living and working resulting from the pandemic. Research is also needed on how ‘long COVID’ symptoms have lasting impacts on sleep and the downstream societal and economic impacts.

4. **Well-designed studies are needed to test the long-term efficacy of current and emerging pharmacological and behavioural interventions for chronic insomnia on societal and economic outcomes.**

There is a critical gap in evidence concerning the long-term benefits and harms of commonly prescribed pharmacological agents used to treat insomnia disorder (De Crescenzo et al. 2022; Schutte-Rodin et al. 2008) and a need to identify safe and effective pharmacological agents that are appropriate for long-term use. Furthermore, given that CBT-I is considered first-line treatment, randomised controlled trials or high-quality observational studies are needed to examine the long-term benefits and risks of pharmacotherapy compared to, and/or in combination with, CBT-I (Edinger et al. 2021). In particular, such trials should incorporate societal and economic outcomes, in addition to clinical outcomes, in order to understand how treatments can benefit not only the individual but also society as a whole.

5. **There is an urgent need to better understand the social and environmental determinants of sleep-health inequalities and identify scalable interventions to treat populations who may be most vulnerable to insomnia yet remain underserved in the healthcare system.**

Because insomnia disproportionately impacts certain groups within society it is critical that future research is dedicated to understanding populations most at-risk and underserved by the healthcare system, as well as opportunities for prevention and intervention in these populations. In particular, more research is needed in diverse racial and ethnic groups, among caregivers and healthcare workers, and in those with chronic co-morbidities. This research is particularly important in light of the COVID-19 pandemic, which has exacerbated existing disparities in health, including the risk for insomnia (Jackson & Johnson 2020).

6. **Person-generated digital health data (PGHD) offer innovative opportunities for identifying population-level health problems, including prevalence, risk factors and the consequences of insomnia.**

Deriving from the wide availability of consumer devices such as smartphones and ‘wearables’ (e.g. commercial sleep-tracking devices), the explosion of PGHD may facilitate the early detection and identification of insomnia, and also help identify social and environmental determinants of insomnia. However, most large-scale investigations to date using PGHD data rely on ‘bring-your-own-device’ designs, which may systematically under-represent socio-economically disadvantaged populations and those from marginalised racial/ethnic groups. Nevertheless, such large-scale data offer important opportunities for surveying the prevalence, determinants and consequences of insomnia, but such research should
be conducted within a health-equity lens. Research should also investigate the potential iatrogenic effects of such sleep-tracking devices among some populations, including increasing worry about sleep, potentially leading to an increased insomnia risk.

6.4. Limitations & strengths

Within each of the relevant chapter summaries we describe caveats to the research approach and interpretation of findings. These bear repeating here, albeit briefly. First, whilst the literature review described in Chapter 2 and Chapter 3 was conducted systematically and intended to be comprehensive, we searched only one database (PubMed), with a supplemental search of Google Scholar. Important articles may therefore be missing, including those published after the search was conducted. In addition, comparator studies did not often control for a comprehensive set of confounding variables and these studies were often cross-sectional in nature; thus, associations between insomnia and outcomes should be not interpreted as causal relationships.

Secondly, whilst we used meta-regression to examine sources of heterogeneity, other factors not measured by study authors could potentially further explain differences in prevalence estimates. For example, co-morbid physical and mental conditions were seldom reported even though many of these conditions are known risk factors for insomnia.

Thirdly, meta-regression was used to predict the prevalence of insomnia subtypes conditional on study-level covariates, with the primary goal of feeding this information into the well-being valuation approach and macro-economic model. The strength of meta-regression is that it draws on information across studies. However, predicted values should be interpreted cautiously, as study-reported prevalence estimates were missing for some country-specific insomnia subtypes (particularly chronic insomnia). In addition, as described for the literature, unmeasured confounding is also a potential concern for the meta-regression.

Fourthly, estimates for the MRS described in Chapter 4 were derived from a study using a representative sample of UK residents, and this value was then extrapolated to other high-income OECD nations even though we cannot be certain that the MRS or the resultant CIVs are the same across all country contexts. Similarly, in Chapter 5, we applied estimates of productivity loss from the US to Canada and those from a small number of Europe countries to other European countries and Australia. We cannot, however, be certain that productivity loss is the same across all country contexts.

Because our study focused on insomnia in general populations within 16 high-income OECD countries, we cannot know if findings are generalisable to other populations or other country contexts. Given the known associations between insomnia prevalence and age and co-morbid conditions, we caution against applying these estimates to other groups. Similarly, given the association between insomnia and various lifestyle factors, we would not expect that our findings can be extrapolated to middle- or low-income countries.

Despite these limitations, this study has several important strengths. First, we used both a literature review and secondary database analyses to collect data related to the prevalence of insomnia and/or its societal impacts. Secondly, we used innovative methods to calculate intangible costs (i.e. the well-being valuation approach) and indirect economic costs (i.e. the CGE
model). Both methods have advantages over traditional costing methods. Taken together, this study provides novel insights into the costs associated with insomnia. Thirdly, where possible, we made conservative assumptions when building statistical models or applying model findings to populations within and across countries. Lastly, this study benefited from the insights of a steering committee whose members were selected based on their objectivity and content-area expertise.

### 6.5. Conclusions

Insomnia affects a significant proportion of the general adult population across the 16 high-income countries identified in this report, with on average approximately 8% to 14% of individuals predicted to suffer from chronic or clinical insomnia, representing approximately 41.6–72.1m working-age adults. Insomnia is associated with a host of downstream consequences, with cascading effects on both the individual and society as a whole. In particular, insomnia is strongly linked with poorer QoL and lower life satisfaction. Expressed in terms of intangible well-being costs, an individual suffering from insomnia would on average be willing trade an estimated 14% of their annual per-capita household income in order to recuperate the well-being loss associated with insomnia. At the national level this translates to between $1.5bn and $127.1bn in hidden costs due to chronic insomnia annually. Chronic insomnia is also associated with reduced productivity in the workplace due to absenteeism and presenteeism, resulting in an average of 44–54 working days lost per year and an estimated loss in annual GDP ranging from 0.64% to 1.31%, or approximately $1.8bn to $207.5bn in indirect economic costs.

Given the substantial societal and economic impact of insomnia, strategies are needed to better mitigate its burden through policy, clinical practice and future research with the aim of positively impacting the health, well-being and productivity of individuals and society as a whole.
References


