

Title

Epidemiology of Insomnia: Prevalence, Course, Risk Factors, and Public Health Burden

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Key Words

Insomnia, Sleep Disorders, Epidemiology, Prevalence, Incidence, Risk Factors

Abstract

This paper summarizes recent epidemiological evidence on insomnia, including its prevalence, incidence, and risk factors, as well as its course and consequences. There is now substantial evidence that insomnia is a significant public health problem. It is a highly prevalent condition, both as a symptom and a syndrome, and is often a persistent condition over time. Its persistence is associated with increased risk for mental (major depression), physical (hypertension), and occupational health problems (disability). Chronic insomnia also carries heavy economic burden, both in terms of direct health-care costs and, more importantly, in terms of human resources loss due to the illness and lack of treatment. These findings have direct implications for community-based prevention and intervention programs and for future research including the need for: a) longitudinal, population-based studies aimed at evaluating whether we can prevent insomnia among at-risk individuals; b) clinical studies evaluating whether the morbidity associated with chronic insomnia is reversible; and c) prospective health economic evaluations of prevention programs using different dissemination technologies.

Key Points

- The epidemiology of insomnia has received increased attention in the last decade and investigators have moved from a purely cross-sectional approach to a more prospective and longitudinal approach.
- Progress on the epidemiology of insomnia has been hampered by important methodological shortcomings including, but not limited to, the lack of a consistent case definition and standardized assessment procedures across studies.
- Additional prospective and longitudinal studies are needed to identify early precursors of insomnia and factors moderating its trajectories over time.
- A better understanding of how insomnia evolves over time and what factors trigger an episode or perpetuate it over time is critical for developing effective prevention and treatment programs.

Outline

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Introduction

Insomnia is a significant public health problem that affects large segments of the population at one point or another in life. The burden of chronic insomnia is also widespread both for the individual, in terms of reduced quality of life, and for society at large, in terms of work absenteeism, disability, and healthcare costs. Although significant advances have been made in therapeutics, there is more limited knowledge on its epidemiology, risk factors, long-term course, and prognosis. A better understanding of these critical issues would be informative to develop more effective therapies. This paper summarizes the evidence on the epidemiology of insomnia, including its natural history, prevalence, incidence, and risk factors, as well as its long-term consequences and public health burden. We conclude by outlining some directions for future population-based research and for developing effective prevention programs.

Nature of Insomnia and Updated Diagnostic Criteria

Insomnia is characterized by a spectrum of complaints reflecting dissatisfaction with the quality, duration, or continuity of sleep. The predominant nocturnal symptoms include difficulties falling asleep at bedtime, waking up in the middle of the night, having difficulty going back to sleep, or waking up too early in the morning with an inability to return to sleep [1-2]. These difficulties are not mutually exclusive as a person may experience mixed problems initiating and maintaining sleep. In addition to nighttime sleep difficulties, daytime symptoms represent an integral component of insomnia; these include fatigue or decreased energy, cognitive impairments involving attention, concentration and memory, and mood disturbances (e.g., irritability, dysphoria) [3-5].

These latter symptoms contribute to significant role impairments [6] and are often the primary concern prompting patients to seek treatment [7].

Several important changes have been made to the diagnostic criteria of insomnia in the DSM5 [2] and in the ICSD-3 [8]. For example, the symptom of nonrestorative sleep has been eliminated from the insomnia definition, mainly because this complaint is ill-defined and not specific to insomnia. In the DSM5 [2], the duration threshold for chronic insomnia has also been increased from one to three months, a change based on evidence that three months is a critical period after which insomnia is more likely to persist [9] and its morbidity becomes more noticeable [10]. Likewise, a minimal frequency of three nights per week has been added to further operationalize the definition of clinical insomnia. More importantly, the DSM5 [2] no longer makes a distinction between primary insomnia and insomnia secondary to a psychiatric, medical, or another sleep disorder. This change was predicated on the evidence that when insomnia is comorbid with another disorder (e.g., major depression), it is often difficult, if not impossible to determine which disorder is the cause and which is the consequence. Historically, clinicians generally assumed that insomnia was symptomatic of a more important disorder and that treating the “underlying disorder” (e.g., depression, pain) would necessarily improve sleep; not surprisingly, insomnia was often overlooked and undertreated. There is now solid evidence that insomnia is a prevalent residual symptom even after successful treatment of depression [11] and its persistence increases the risk of relapse of depression [12]. Furthermore, while insomnia has long been conceptualized as a symptom of another disorder, there is strong evidence showing that chronic insomnia is also a precursor or a risk factor for new onset

psychiatric disorders [13]. By moving away from the need to make a causal attribution between insomnia and co-existing disorders, it is hoped that clinicians will pay more attention to insomnia as a disorder on its own. Recent treatment studies have shown that when insomnia is comorbid with another psychiatric or medical disorder, treatment outcome is much better when attending to both insomnia and the comorbid condition than when attending to the comorbid condition alone [14-15].

Prevalence and Correlates of Insomnia

Prevalence. At least 50 epidemiological studies on insomnia were published between the first population-based surveys by Karacan et al [16] and Bixler et al [17] in the 70's and a landmark review paper in 2002 by Ohayon [18] and, since then, at least another 20 studies have been published. Prevalence estimates of insomnia vary widely across studies, partly due to differences in case definitions, assessment procedures, sample characteristics, and length of assessment intervals. With regard to the last point, most studies used point estimates (i.e., past month), although some have relied on longer intervals (i.e., past year or even lifetime). Depending on the specific definitions used (i.e., insomnia symptoms vs. disorder, sleep dissatisfaction), prevalence rates have varied from as low as 5% to as high as 50% [18]. In general, population-based data indicate that about one third of adults (30% to 36%) report at least one nocturnal insomnia symptom (i.e., difficulty initiating or maintaining sleep, non-restorative sleep), but this rate decreases to between 10% and 15% when daytime consequences (e.g., fatigue) are added to the case definition. Rates of sleep dissatisfaction, without regard to specific sleep diagnosis, also vary widely (10% to 25%) in the adult population. When using more stringent and operational DSM [2] or

ICSD [19] diagnostic criteria, prevalence rates tend to cluster between 6% and 10% [6-7, 20-22]. These highly variable estimates underscore the need to rely on operational definitions and standardized assessment procedures to derive accurate and comparable prevalence rates across studies.

The most common single symptom of insomnia is a problem maintaining sleep, but mixed sleep onset and maintenance difficulties are more prevalent than any single complaint [6-7, 20, 22]. Among subtypes of sleep maintenance problems, both middle-of-the-night awakenings and early morning awakenings are equally prevalent, although the latter is more common among older adults [22-23]. Non-restorative sleep is also a prevalent complaint, but less frequently as a single complaint; it is typically reported in association with other insomnia symptoms and also in association with several other sleep disorders. Its non-specificity has led to its exclusion from the insomnia definition in both DSM5 [2] and ICSD-3 [8].

Insomnia is also highly prevalent in primary care medicine, usually the first entry point to access professional care for insomnia, with about 40% of patients reporting significant sleep disturbances [24]. Patients with more severe and more chronic insomnia, more comorbid medical or psychiatric disorders, and those who are better educated are more likely to seek treatment for insomnia [25].

Correlates of Insomnia. Insomnia is consistently more prevalent among women, middle-aged and older adults, shift workers, and patients with co-existing medical and psychiatric disorders. With regard to gender, a meta-analysis revealed a risk ratio of 1.41 for women versus men [26]. Although insomnia has a greater overall prevalence in middle-aged and older adults, the nature of insomnia interacts with age, such that

sleep maintenance difficulties are more common among middle-aged and older adults whereas sleep initiation difficulties are more frequent among younger adults [6, 18, 22].

Strong associations (ORs = 4.0-6.0) have been reported between insomnia and poor mental and physical health, psychological distress, anxiety and depressive symptoms, as well as with somatic symptoms and poor self-rated physical health [6-7, 20, 27-28]. Insomnia has also been associated with lower socio economic status and with living alone (e.g., single, separated, or widow). Hormonal replacement therapy was found in one study to be a protective factor against insomnia in older adults [23].

Prevalence across Ethnicities and Cultures. In a nation-wide sleep survey in the USA, insomnia in adults was diagnosed in 10% of Whites, 7% of Hispanics, 4% of Asians, and 3% of African Americans [29]. Likewise, insomnia prevalence rates in European-, African-, and Mexican-American adolescents were 5.3%, 5.2%, and 3.5%, respectively [30]. Comparative studies between immigrants and non-immigrants have provided mixed results with some research indicating immigrants report fewer [31-32], more [33], or similar numbers [34] of sleep complaints or insomnia symptoms compared to their non-immigrant counterparts. These discrepancies may be attributed to the differences in sleep attitudes and beliefs reported across diverse ethnicities and cultures, including what individuals believe to be the causes and the consequences of sleep problems [34], as well as the priority placed on obtaining adequate sleep within cultures [32].

While there are few direct cross-cultural comparisons of insomnia, a worldwide study found the highest prevalence rates of insomnia were in Brazil (79.8%), followed by South Africa (45.3%), Eastern Europe (32%), Asia (28.3%), and Western Europe

(23.2%) [35]. In another cross-country survey, the highest prevalence rates of insomnia symptoms were reported in Western Europe (37.2%), followed by the USA (27%), and Japan (6.6%) [36]. Prevalence rates of restless sleep (as opposed to insomnia) across 23 countries in Europe was less than 10% in Mediterranean and Nordic countries, ranged from 11% to 22% in Western European countries and from 25% to 37% in Eastern European countries among working-aged adults [37]. Likewise, the highest prevalence rates of sleep problems were found in the USA (56%), followed by Western Europe (31%), and Japan (23%) [38]. Cross-cultural studies in pediatric samples suggest that toddlers and children from Asian cultures (e.g., Hong Kong, India, Singapore) tend to go to bed at later times, wake up at earlier times, report shorter sleep durations, and are perceived by parents to exhibit more sleep problems compared to children from Caucasian cultures (e.g., Canada, UK, New Zealand) [39-40].

People from different cultures experience, perceive, and understand health problems differently, possibly as a result of religious beliefs (e.g., Ramadan), stigma, reasoning fallacy, differences in symptom presentation, processing, and expressing experiences [41-42]. These cultural differences can affect whether insomnia is perceived as “normal” (part of everyday life) or abnormal. For example, waking up in the middle of the night is sometimes seen as a “gift” among Muslims as it provides an additional opportunity to pray. Further qualitative research would be helpful to better understand cross-cultural and ethnic differences in the phenomenological experience and expression of insomnia as this may help develop more targeted prevention and intervention strategies.

Incidence and Risk Factors

Incidence. There are relatively few longitudinal incidence studies (see Table 1) compared to the large number of cross-sectional prevalence studies. Nonetheless, incidence rates vary extensively across studies, depending on the case definition (e.g., symptoms vs. syndrome) and the interval used to track new onset. For instance, four population-based studies using the same 12-month interval between baseline and follow-up assessments revealed incidence rates of 2.8% in Sweden [21], 6.0% in the USA [27], 7.4% in Canada [43], and 15% in the UK [44], with the variability being partly accounted for by different case definitions across studies. For example, the Canadian study found an incidence rate of 30.7% for insomnia symptoms compared to 7.4% for an insomnia syndrome [43]. Another important variable explaining some of the variability is whether investigators make a distinction between incident cases of first episode (i.e., no prior history of insomnia) and cases of recurrence (i.e., with past insomnia episodes). For example, the 7.4% incidence rates in the LeBlanc et al. [43] study decreased almost by half (3.9%) when only individuals without prior lifetime episode of insomnia were included in the case definition. A similar finding had also been reported (13.1% vs. 8.7%) in a sample of young adults [45].

Another variable that impacts incidence rates is whether the reported rate includes all cumulative cases emerging between baseline and follow-up assessments (cumulative incidence) or only new cases present at the second assessment (point estimate). Because insomnia is a condition that often fluctuates over time, it is plausible that a new case might emerge after baseline assessment but remit by the follow-up assessment point. A recent study [46] examined the distribution of three subtypes of

acute insomnia as a function of duration and found a significant difference between the 1-month (4.4%) and 3-month (9.2%) incidence rates; in addition, recurrent acute insomnia (3.8%) was more common than first episode of acute insomnia (2.6%) and comorbid acute insomnia (1.4%).

A related issue that may explain some of the variability in incidence rates is the time frame used to assess insomnia. In the Leblanc et al. [43] study, assessment of insomnia at each time point was based on the previous month only, rather than the entire 6- and 12-month intervals, which may have yielded more conservative rates since it did not capture those cases that developed insomnia and subsequently remitted within the follow-up intervals. As insomnia is often waxing and waning, it is plausible that the actual incidence rates have been underestimated in some of these studies.

Risk Factors. Although several insomnia correlates have been identified quite reliably across studies, the data about risk factors predisposing to insomnia are more tentative. Nonetheless, the most commonly hypothesized factors predisposing to insomnia include demographic factors, such as female gender and older age, and a personal or familial history of insomnia. Women are at greater risk for insomnia, and perhaps more so during menopause due to hormonal changes. The risk of insomnia also increases with aging, but this may be the result of increased health problems with aging rather than age per se [47]. The risk of insomnia is also higher among first-degree family members of individuals with insomnia than in the general population [48-49], although it remains unclear whether this link is inherited through a genetic predisposition, learned by observations of parental models, or simply a by-product of

another (psychiatric) disorder. A past personal history of insomnia has also been identified as an important risk for future episodes of insomnia [43].

Psychological and a biological predisposition are two additional factors that have been linked to greater risk to develop insomnia. The psychological vulnerability to insomnia is typically characterized by an anxiety-prone personality, with elevated scores on measures of anxiety and depressive symptoms, worries, perfectionism, introversion, and lower abilities to cope with day-to-day stressful situations [43]. On the other hand, the biological vulnerability is characterized by indices of hyperarousability and elevated HPA axis activity [50]. While this latter hypothesis has been around for quite some time [51-52], it still remains unclear whether hyperarousal is a state that characterizes an individual's response to sleep difficulties or their apprehension, or a more enduring trait that predisposes some individuals to develop insomnia under stressful circumstances.

Insert Table 1 about here

Course of Insomnia – Persistence, Remission, Relapse

The course of insomnia is of significant interest to both epidemiologists and clinicians. The extent to which insomnia is a transient, recurrent, or persistent condition has important implications in terms of whether and when to initiate treatment and long-term prognosis and morbidity.

A number of longitudinal studies have documented the course of insomnia over various time intervals (see Table 1), but the majority of those have used only two assessment points. The evidence is quite clear that insomnia is often a persistent

problem over time, with persistence rates varying as a function of the intervals between assessments. For example, data derived from some of the same longitudinal studies assessing incidence have produced persistence rates over a 1-year period of 31% in the USA [27], 44.4% (syndrome like) in Sweden [21], 69% (symptoms) in the UK [44], and 74% (symptoms and syndromes combined) in Canada [53]. Studies conducted with cohorts of older adults have produced persistence rates of 66.3% [54] for one year, 40% for a 2-year period [55], and 36.1% for a 4-year period [56]. In a cohort of 4467 older adults involved in the Cardiovascular Health Study [57], rates of persistent insomnia over a 1 to 4 year period were 15.4% for trouble falling asleep and 22.7% for frequent awakenings, compared to 13.4% for excessive daytime sleepiness.

Factors associated with persistence of insomnia are often the same as those associated with its incidence, i.e., female gender, older age, and presence of medical and/or mental health problems [54], with depression and mental health problems presenting stronger associations than physical health problems. Insomnia can also be a very persistent condition, independent of mental disorders.

As part of our ongoing longitudinal study [53] we are following 4000 adults annually throughout Canada, and at each assessment these individuals are classified as good sleepers, individuals with insomnia symptoms, or individuals with an insomnia syndrome (disorder). Sleep status is based on information derived from standard assessment instruments (Insomnia Severity Index, Pittsburgh Sleep Quality Index) and is defined by an algorithm using a combination of insomnia diagnostic criteria (DSM and ICD) and the use of sleep-promoting medication [43,53]. For instance, individuals with an insomnia syndrome must report dissatisfaction with sleep, symptoms of initial,

middle, or late insomnia at least three nights per week for a month, and significant distress or daytime impairments. Also included in this group are those taking prescribed sleep-promoting medication three nights or more per week for at least one month. Individuals classified with insomnia symptoms report some of these same symptoms but do not fulfill all diagnostic criteria for an insomnia syndrome. Individuals using prescribed medications fewer than three nights per week or over-the-counter medications for sleep at least one night per week are also classified in this group. Good sleepers have no sleep complaint and do not use medications to promote sleep.

Preliminary data from a subsample of 388 participants completing the first three annual follow-ups showed that 46% of individuals with insomnia (symptoms or syndrome) at baseline continued to report insomnia (symptoms or syndrome) at the 3-year follow-up, and for the remaining 54% who went into remission at some point in time, half of them eventually relapsed [53]. Different insomnia trajectories were observed across severity levels with individuals presenting an insomnia syndrome at baseline showing a more persistent course over time, whereas individuals with subsyndromal insomnia had a more fluctuating trajectory, with a greater likelihood of remission status at a subsequent follow-up.

This study has also shown that insomnia status may change considerably even within a 12-month period. For example, an individual with insomnia at baseline may become a good sleeper 6 months later and again have insomnia 12 months later. This fluctuation over time underscores the need to adopt a more microscopic approach in longitudinal studies of insomnia. To examine this issue, we conducted monthly evaluations over a 12-month period with a subgroup of 100 individuals [9]. At baseline,

42 participants were classified as good sleepers, 34 met criteria for insomnia symptoms, and 24 for an insomnia syndrome. There were significant fluctuations of insomnia over time, with 66% of the participants changing sleep status at least once over the 12 monthly assessments. Sleep status changes were more frequent among individuals with insomnia symptoms at baseline ($M = 3.55$) than among those initially classified as good sleepers ($M = 2.14$).

Among the subgroup with insomnia symptoms at baseline, 85.3% reported improved sleep (i.e., became good sleepers) at least once over the 12 monthly assessments compared to 29.4% whose sleep worsened (i.e., met criteria for an insomnia syndrome) during the same period. Among individuals classified as good sleepers at baseline, risks of developing insomnia symptoms and syndrome at least once over the subsequent months were respectively 14.4% and 3.2%. Of significant interest, an interval of 6 months was found most reliable to estimate incidence rates while an interval of 3 months proved the most reliable to estimate persistence rate. These results suggest significant sleep variability over a 12 month period and highlight the importance of conducting repeated assessment at a shorter than the typical yearly interval in order to reliably capture the natural course of insomnia over time.

CONSEQUENCES AND BURDEN OF INSOMNIA

Insomnia is associated with significant short- and long-term consequences. Although the essential features of insomnia are the nocturnal complaints, daytime impairments and distress over daytime functioning are also defining criteria of insomnia [1-2] and this component has been identified as a research priority by insomnia expert panels [58-59].

Short-term Consequences of Insomnia

Short-term, daily consequences include physical discomfort upon awakening and fatigue and tiredness, unpleasant body sensations (e.g., heavy eyes), hypersensitivity to noise and light, and low energy/motivation throughout the day [60]. Insomnia is associated with mood disturbances (e.g., irritability), heightened emotional reactivity [60-61], negative interactions with children [62] and partners [63], reduced optimism and self-esteem [64], and overall poor quality of life (e.g., vitality) [61].

In a recent qualitative study, participants with insomnia symptoms reported feeling segregated and misunderstood by others (e.g., friends, physicians), described daily life as an “effort” or “struggle”, and raised concerns over the cumulative and long-term impact of insomnia on physical and mental health, occupational and vocational functioning, as well as on social domains [60]. While subjective complaints are not always corroborated with objective measurements, a recent meta-analysis found subtle and selective, yet reliable deficits in studies using objective cognitive functioning measures [5]. For instance, individuals with insomnia demonstrate deficits in cognitive performance, most notably in attention, concentration, and memory-related tasks; all of which can produce pervasive consequences in every aspect of daily life. It is, therefore, not surprising that daytime complaints are recognized as a primary determinant of help-seeking among individuals with insomnia [7].

Long-term Consequences of Insomnia

Psychological Health. In addition to the strong association between insomnia and poor mental health derived from cross-sectional studies, prospective studies indicate that persistent insomnia is also a risk factor for worsening of mental health and

the development of several psychiatric disorders [28, 45, 65]. Persistent insomnia is associated with two times higher likelihood of future anxiety [44] and four times greater likelihood of future depression in adults [45, 66], adolescents [67] and children [68]. A meta-analysis summarizing the findings of 21 longitudinal studies found that participants with insomnia had a twofold greater risk to develop depression than participants without sleep complaints [13]. One putative mechanism hypothesized to explain the link between persistent insomnia and depression is the alteration of the arousal system and its subsequent impact on affective and cognitive systems [65].

The relationship between insomnia and depression can be bi-directional such that insomnia may be the cause or the result of depression and vice versa, and this relationship may change over time. In a prospective population-based study, non-depressed participants with insomnia at baseline had a six times greater risk of developing depression at follow-up compared to counterparts without insomnia. Likewise, depressed participants without insomnia at baseline also had six times more risk of developing insomnia 11 years later [69] compared to non-depressed participants. In addition, insomnia and sleep disturbances are associated with increased risk for suicide intentions, attempts, and successes in both clinical [70] and non-clinical samples [71]. In a longitudinal study conducted with 75,000 adults from Norway over a 20-year follow-up period, the age- and sex- adjusted hazard ratios for suicide were 1.9, 2.7, and 4.3 for reporting sleeping problems sometimes, often, or almost every night, respectively, compared to participants who reported no sleeping problems. Associations were stronger in younger (< 50 years) participants, but even after adjusting for mental

disorder and alcohol use at baseline, participants with the worst sleep patterns remained at a two-fold increased risk of suicide [72].

Physical Health. In addition to its association with mental health problems, insomnia is linked with poor physical health as well. Evidence from cross-sectional studies indicates that various medical conditions (e.g., hypertension, diabetes, obesity) are more common among individuals with insomnia relative to those without insomnia [73]. Individuals with chronic insomnia also show poorer immune functioning (e.g., lower natural killer cell activity) compared to good sleepers [74]. Further, insomnia symptoms are linked with alterations in appetite-regulating hormones [75] and notably, the subsequent development of metabolic syndrome [76]. A recent longitudinal study showed individuals with insomnia had a 40% to 60% increased risk of developing headaches such as migraines and tension-type headaches, respectively over 11 years after adjusting for age, sex, and sleep medication [77].

Chronic insomnia is associated with elevated nocturnal systolic blood pressure and reduced day-to-night blood pressure dipping [78]. Chronic insomnia is also considered a significant risk factor in the development of mild to moderate hypertension [79, 80]. Yet the insomnia-hypertension relationship remains equivocal as Phillips and colleagues [81] found insomnia complaints (e.g., difficulty initiating sleep) did not predict hypertension 6 years later, and actually reduced the risk in an older cohort of Non-African American men (average age of 73).

Additional evidence suggests insomnia is a risk factor for future cardiac events including acute myocardial infarction [82] and coronary heart disease [83], even among individuals free of cardiovascular disease [80]. Individuals reporting multiple insomnia

symptoms (i.e., difficulties initiating/maintaining sleep, early morning awakening) at baseline showed increased incident rates of coronary heart disease compared to those with only one or without any symptoms at baseline [84]. In particular, frequent reports of difficulty initiating and maintaining sleep, as well as nonrestorative sleep were associated with increased hazard ratios of 1.45, 1.30, and 1.27, respectively, for acute myocardial infarction [82]. Further, insomnia symptoms are significantly associated with cardiovascular- and all-cause mortality up to 17 years after the insomnia symptoms are detected [85]. This effect is most conspicuous among males with objectively determined short sleep duration [86]. A recent meta-analysis found that those endorsing insomnia symptoms have a 45% increased risk of cardiovascular morbidity and mortality [87]. However, other studies with shorter follow-up assessments (e.g., 6-year) and additional covariates (e.g., sleep duration, depression) [88-89] did not identify insomnia as a significant risk factor for future cardiovascular disease or all-cause mortality [90].

Difficulties initiating or maintaining sleep are associated with 57% to 84% increased risk, respectively, of incident diabetes [91] up to 22 years later [85]. This is especially more pronounced among individuals with *frequent* reports of sleep disturbances [92]; however, similar risk for diabetes were not found in a study of older women [93] or in a more recent study of middle-aged Chinese adults [28].

Occupational Health. Insomnia is often associated with role impairments, particularly in the work environment. Workers with insomnia syndrome report reduced productivity, are absent 8.1 h more per 3-month period, [94], and have a greater tendency to show up to work late than do those without insomnia [95]. Insomnia is

associated with a reduced likelihood of future professional advancements (e.g., promotion, salary increase) [96-98] and increased risk of permanent work disability , even after controlling for baseline exposure to disability and sick leave, sleep duration, and other possible confounders [97-98]. Compared to good sleepers, those with sleep disturbances report more intentions of switching occupations, have reduced job satisfaction and fewer adaptive coping skills, rely more on emotion-oriented coping strategies than problem-solving strategies, and report lower feelings of mastery [99]. Insomnia is, thus, recognized as a significant barrier in the achievement of career/life goals.

Insomnia is closely linked with greater cognitive failures in everyday activities [5], and, thus, is also associated with increased proneness for occupational mishaps. In the workplace, insomnia is associated with an increased risk for accidents or errors [100]. Daley and colleagues [101] found patients with insomnia syndrome were almost twice more likely to have experienced personal and work-related accidents than were good sleepers. Among the elderly, insomnia (and not hypnotic use) has been shown to predict falls over a 5 to 7-months observation period, with the highest risk noted among residents who remained untreated or remained unresponsive to treatment at follow-up [102]. Drivers reporting insomnia symptoms, poor sleep quality, prolonged wakefulness, and or sleepiness also have an increased risk of being involved in nocturnal [103], and diurnal automobile accidents, irrespective of circadian influences [104].

Economic Burden of Insomnia

Insomnia carries significant economic burden for the healthcare system. One

study projected that the costs for medical expenditures (i.e., claims for in/outpatients, pharmacy, emergency room services) would \$934 more for young to middle-aged adults with insomnia (18 to 64 years) and \$1143 more for older adults with insomnia (>65 years) compared to well-matched individuals without insomnia [105]. Insomnia severity and frequency also show a dose-response effect with direct costs, such that annual health care costs among members of a health plan in the USA are estimated to be \$1323 for those with moderate to severe insomnia, \$907 for sub-threshold insomnia, and \$757 for good sleepers [106]. In a similar study, participants with frequent complaints of insomnia symptoms reported higher annual medical costs (\$2552) than did those with less frequent insomnia symptoms (\$1510) [107]. In a population-based sample, Daley and colleagues [94] reported the annual per-person insomnia-related direct costs were \$293 for individuals with an insomnia syndrome, \$160 for those with insomnia symptoms, and \$45 for good sleepers. Cost-benefit analyses for insomnia treatment estimated lower monthly health care costs and increased quality-adjusted life year among remitted patients compared to their non-remitted counterparts [108-109].

The indirect costs of insomnia can also add to the economic burden of society. Using an administrative database, annual mean incremental costs for sick leave, short- and long-term disability, and workers compensation was \$567 more for employees with insomnia compared to those without insomnia [110]. The estimated expenditures of employed health plan members due to absenteeism [105] and presenteeism (i.e., attending work while ill leading to low work performance) were significantly more among employees with insomnia than among those without insomnia [111]. Costs for reduced productivity were highest for employed health plan members with moderate to severe

insomnia, followed by those with insomnia symptoms, and those without insomnia [106]. Similar reports were documented in a population-based sample for overall indirect costs, with the highest cost per person for those with an insomnia syndrome estimated to be at \$4717 annually, followed by those with insomnia symptoms at \$1271, and lastly, good sleepers at \$376 [94]. The annual indirect costs for resources lost were nearly 10 times higher than the costs specific to treating insomnia [94]. While insomnia carries a significant economic burden, it is difficult from the available evidence to separate expenses that are due specifically to insomnia from those expenses driven by common co-occurring conditions such as depression and pain.

Community/Public Health Education and Prevention of Insomnia

Despite the considerable health, social, and economic burden of insomnia, it is often under-recognized and untreated in both pediatric [112] and adult populations. While there is solid evidence showing the efficacy of insomnia therapies [113] and strong incentives for prevention strategies, methods for preventing insomnia remain under-developed [114-115]. As such, it is imperative to find appropriate strategies for the prevention of insomnia.

While some risk factors are *unmodifiable*, (e.g., age, sex, genetics), others are modifiable (e.g., maladaptive sleep practices). Unmodifiable risk factors can be used to identify at-risk individuals, while education and behavioral interventions that are practical and easily sustainable [116] can be used to alter modifiable risk factors. For example, given the greater likelihood of insomnia within a family due to genetic predisposition, shared environment, or a blend of both influences [48-49], prevention approaches can be particularly helpful to alter lifestyle behaviors (e.g., maintain a

regular sleep schedule, reduced intake of stimulants) and sleeping environment (e.g., reduced noise level); all of which may have a significant impact on the general population, but particularly among vulnerable populations.

From a public health perspective, an important step in insomnia prevention involves raising awareness on the importance of healthy sleep and on the debilitating effects of insomnia [114-115]. Some individuals hold misconceptions or lack knowledge about healthy sleep and sleep disorders (e.g., causes, consequences, treatment), which, in turn, can contribute to poor sleep practices. Public health education campaigns can prove very beneficial to raise awareness about the importance of sleep and about behavioral practices to prevent sleep problems. While it is recognized that healthcare professionals should routinely evaluate sleep and provide some sleep education as part of patient care, many professionals rate their own sleep knowledge as fair or poor [117]. Furthermore, during consultations, healthcare professionals do not typically initiate inquiries about their patient's sleep, unless the patient, a family member, or patient's caretaker presents sleep-related concerns [112, 117]. Thus, an important step is increasing education and training on sleep for healthcare professionals [114].

Sleep counseling may lead to changes in patients' attitudes, knowledge, and behaviors towards sleep. Borrowing successful strategies from other prevention programs may also lead to changes. For instance, providing accurate information about the importance of sleep and differences in sleep needs as a function of different age groups may bring people to make sleep more of a priority in their life. Likewise, making simple and specific behavioral recommendations (e.g., reduce time spent awake in bed

and get up at the same time every morning), can be quite effective to alleviate insomnia before it reaches clinical threshold. Although the relation between sleep knowledge and sleep practices is mixed, sleep education remains an essential step in promoting healthy sleep. Indeed, general education interventions targeted at children [118] and parents [119] have yielded promising results.

Given the heavy burden that insomnia places on the individual and society, implementing prevention strategies at the community level is important. Recently, Kraus and Rabin [115] proposed launching a public-wide awareness campaign entitled “Sleep America” with specific aims to 1) promote insomnia education using various mediums (e.g., web-based initiatives), 2) increase accessibility of insomnia treatments (e.g., behavioural sleep medicine), and 3) monitor and potentially refute misleading claims about non-evidence based insomnia treatments. Future research is needed to evaluate the cost-effectiveness of prevention strategies that focus on modifiable risk factors, emphasize knowledge translation on sleep education, and can be delivered at the individual and societal level. This should be implemented, particularly, among at-risk populations for an effective campaign that improves public health.

Key Points and Suggestions for Future Epidemiological Studies

The epidemiology of insomnia has received increased attention in the last decade and investigators have moved from a purely cross-sectional approach of estimating prevalence of insomnia and its correlates to a more prospective and longitudinal approach aimed at documenting its natural history, risk factors, and long-term consequences. There is now substantial evidence that insomnia is a highly prevalent condition, both as a symptom and a syndrome, and it is often a persistent condition over

time. Further, its persistence is associated with increased risk for mental (major depression), physical (hypertension), and occupational health problems (disability). At least half a dozen studies have documented the economic burden of insomnia, with the main finding being that insomnia is a costly health problem and, more importantly, that it is much more costly in human resources loss due to the illness than the direct cost for treating insomnia (i.e., professional consultations, medications, sleep promoting aids).

Recent findings concerning the epidemiology of insomnia have direct implications for clinical studies including: a) the need for large, population-based studies aimed at evaluating whether we can prevent insomnia in cohorts of at-risk individuals; b) clinical studies that evaluate whether we can reverse the morbidity associated with chronic insomnia; and c) prospective health economic evaluations (i.e., cost-benefit, cost-utility, cost-effectiveness) of different therapeutic approaches and treatment delivery models (e.g., individual vs. group vs. self-help therapies). Such studies might have the greatest impact on decision-makers and the allocation of health care resources for insomnia.

Progress on the epidemiology of insomnia has been hampered by important methodological shortcomings including, but not limited to, the lack of a consistent case definition and standardized assessment procedures across studies. Naturally, these methodological problems have contributed to produce extensive variability in estimates of prevalence, incidence, and persistence rates of insomnia. It will be essential in future studies to rely on standard case definition and assessment procedures in order to derive more reliable estimates of insomnia. Given the recent efforts to harmonize insomnia diagnostic criteria between the DSM and ICSD nosology, it may be easier for investigators to follow this recommendation. Studies attempting to quantify the

economic burden of insomnia have also produced very variable and imprecise cost estimates because investigators have not separated the costs driven specifically by insomnia from those costs attributable to frequently comorbid psychiatric or medical disorders.

While there is extensive evidence about the prevalence and incidence of insomnia, there is less information about its natural history and long-term course and prognosis. We know also very little about moderating and mediating variables that modulate the course of insomnia (i.e., remission, relapse). Additional prospective and longitudinal studies are especially important to identify early precursors and precipitating factors of insomnia. It is also important to monitor these factors at regular intervals in relation to onset, remission, and relapse. While there is evidence that insomnia is a condition that may “wax and wane”, it is difficult to predict whether an acute insomnia episode will be transient or develop a more chronic course. Previous studies have not examined course modifiers (e.g., treatment initiation). Additional research is needed to achieve more precise identification of moderating and mediating factors likely to be associated with natural course changes. Information about life events, health status, treatment and products used to alleviate sleep problems, would help to characterize more precisely the natural history of insomnia and potential course modifiers and, ultimately, improve treatment and prevention efforts. A better understanding of how insomnia evolves over time and what factors trigger an episode or perpetuate it over time is critical for developing effective prevention and treatment programs.

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Table 1
Summary of Prevalence, Incidence, and Persistence Rates of Insomnia in Population-Based Longitudinal, Prospective Studies

Author	Sample	Follow-up	Case Definition	Prevalence	Incidence	Persistence
Ellis et al. [46]	<ul style="list-style-type: none"> • General population • N=1095 • 32.72 	1 month 3 months	<ul style="list-style-type: none"> • Acute insomnia: previous/ongoing problems with initiating/maintaining sleep, early awakenings, feeling unrefreshed on waking (3 days to 3 months) • DSM-V + prolonged sleep onset, WASO, reduced quality of life • First onset: acute insomnia, no prior sleep problem, no comorbidity. • Recurrent episode: first onset with prior sleep problem. 	Acute insomnia <ul style="list-style-type: none"> • 7.9% First onset <ul style="list-style-type: none"> • 33.7% Recurrent <ul style="list-style-type: none"> • 48.8% 	Acute insomnia 1 month <ul style="list-style-type: none"> • 4.37% 3 months <ul style="list-style-type: none"> • 9.15% DSM-V 1 month <ul style="list-style-type: none"> • 3.4% 3 months <ul style="list-style-type: none"> • 7.8% First onset 1 month <ul style="list-style-type: none"> • 61.1% 3 months <ul style="list-style-type: none"> • 44.4% 	--
LeBlanc et al. [43]	<ul style="list-style-type: none"> • General population • N=464 (good sleepers) • 18+ 	6 months 1 year	<ul style="list-style-type: none"> • Symptoms: Initial, maintenance, or late insomnia \geq 3 nights per week or use of medication to promote sleep. • Syndrome: dissatisfied with their sleep, initial, maintenance, or late insomnia \geq 3 nights per week for at least a month + daytime impairment or use of prescribed medication \geq 3 nights per week. 	--	Overall Symptoms (no prior insomnia) <ul style="list-style-type: none"> • 30.7% (28.8%) 6 months <ul style="list-style-type: none"> • 14.4% (5.77%) 1 year <ul style="list-style-type: none"> • 13.5% (6.82%) Overall Syndrome <ul style="list-style-type: none"> • 7.3% (3.9%) 6 months <ul style="list-style-type: none"> • 2.37% (1.57%) 1 year <ul style="list-style-type: none"> • 4.52% (2.09%) 	--

Ford & Kramer [27]	<ul style="list-style-type: none"> • Community sample • N=7954 • 18-65+ 	1 year	<ul style="list-style-type: none"> • Diagnostic Interview (DSM-III) • Report difficulty initiating/maintaining sleep, or early awakening (2 weeks+) in past 6 months 	• 10.2%	• 6%	• 31%
Roberts et al. [47]	<ul style="list-style-type: none"> • General population • N=2380 • 50-102 	1 year	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep in past 2 weeks 	• 23.4%	• 9%	• 13%
Fok et al. [54]	<ul style="list-style-type: none"> • Community sample • N=656 • 65+ 	1 year	<ul style="list-style-type: none"> • Report trouble sleeping over past month 	• 44.7%	• 21.4%	• 66.3%
Jansson & Linton [120]	<ul style="list-style-type: none"> • General population • N=1530 • 20-60 	1 year	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep, early awakening + daytime problems (≥ 3 nights/week) in past 3 months 	• 10%	• 6%	--
Morphy et al. [44]	<ul style="list-style-type: none"> • General population • N=2363 • 18-98 	1 year	<ul style="list-style-type: none"> • Symptom: Report difficulty initiating/maintaining sleep, nocturnal awakenings (on most nights) in past month • Syndrome: symptom + wake up tired 	Overall • 36.8% Symptoms • 30.4% Syndrome • 13.2%	Overall • 14.6% Symptoms • 13.3% Syndrome • 6.8%	Overall • 69.2% Symptoms • 67.9% Syndrome • 54.8%
Jansson-Frojmark et al. [21]	<ul style="list-style-type: none"> • General population • N=1746 • 20-60 	1 year	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep, early awakening + daytime problems (≥ 3 nights/week) in past 3 months 	• 6.8% to 9.7%	• 2.8%	• 44.4%
Jansson-Frojmark & Lindblom [121]	<ul style="list-style-type: none"> • General population • N=1498 • 20-60 	1 year	<ul style="list-style-type: none"> • Report sleep problem + difficulty initiating/ maintaining sleep (3 nights/wk) in past 3 months 	• 15%	--	• 14%

Skapinakis et al. [122]	<ul style="list-style-type: none"> • Adults • N=2406 • 16-74 	1.5 years	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep in past month 	• 57.7%	• 15.8%	--
Kim et al. [55]	<ul style="list-style-type: none"> • Community sample • N=909 • ≥65+ 	2 years	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep • Symptoms: 1-2 nights/week over month • Syndrome: ≥3nights/week over month 	Overall • 27% Symptoms • 32% Syndrome • 21%	Overall • 23% Symptoms • 37% Syndrome • 20%	Overall • 40% Symptoms • 38% Syndrome • 41%
Komada et al. [123]	<ul style="list-style-type: none"> • General population • N=1434 • 20+ 	2 years	<ul style="list-style-type: none"> • PSQI cut-off score of ≥5.5 	• 30.7%	• 12.9%	• 18.7%
Morin et al. [53]	<ul style="list-style-type: none"> • Population-based • N=388 • M=44.8 years (13.9) 	3 years	<ul style="list-style-type: none"> • Symptoms: Initial, maintenance, or late insomnia ≥ 3 nights per week or use of medication to promote sleep. • Syndrome: dissatisfied with their sleep, initial, maintenance, or late insomnia ≥ 3 nights per week for at least a month + daytime impairment or use of prescribed medication ≥ 3 nights/week. 	--	--	Symptoms • 1 year 23.4% • 2 years 8.4% • 3y 37.2% • At least 1 year 69.0% Syndrome • 1 year 11.3% • 2 years 9.0% • 3y 66.1% • At least 1 year 86.4%
Breslau et al. [45]	<ul style="list-style-type: none"> • HMO group • N=1007 • 21-30 years 	3.5 years	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep, early morning awakening (2 weeks) • Lifetime history of insomnia 	Lifetime history • 24.6% Insomnia (no comorbidity) • 16.6%	Overall • 13.3% Lifetime history • 45% No lifetime • 8.7%	--

Morgan & Clark [56]	<ul style="list-style-type: none"> • Eldery adults • N=1042 • 65+ 	4 years	<ul style="list-style-type: none"> • Report sleep problem 'often' or 'all the time' in past week 	--	<ul style="list-style-type: none"> • 3.1% (weighted) 	<ul style="list-style-type: none"> • 36.1%
Zhang et al. [28]	<ul style="list-style-type: none"> • Adults • N=2316 • 46.3 years 	5.2 years	<ul style="list-style-type: none"> • Report difficulty initiating/maintaining sleep, early morning awakening, daytime symptoms • Symptom: 3/week over 1 year • Syndrome: symptoms + daytime symptoms 	Symptoms <ul style="list-style-type: none"> • 7.1% Syndrome <ul style="list-style-type: none"> • 4.8% 	Overall <ul style="list-style-type: none"> • 5.9% Symptoms <ul style="list-style-type: none"> • 3.6% Syndrome <ul style="list-style-type: none"> • 2.3% 	Overall <ul style="list-style-type: none"> • 36.5% Symptoms <ul style="list-style-type: none"> • 29.5% Syndrome <ul style="list-style-type: none"> • 47.0%
Fernandez-Mendoza et al. [124]	<ul style="list-style-type: none"> • Random general population • N=1395 • >20+ 	7.5 years	<ul style="list-style-type: none"> • "Poor sleep": moderate/severe difficulty initiating/maintaining sleep, early final awakening, daytime symptoms • Insomnia: insomnia complaint \geq 1 year 	Poor sleep <ul style="list-style-type: none"> • 32.3% 	Poor sleep <ul style="list-style-type: none"> • 18.4% Poor sleep -> insomnia <ul style="list-style-type: none"> • 16.8% 	<ul style="list-style-type: none"> • 38.4%
Vgontzas et al. [125]	<ul style="list-style-type: none"> • Random general population • N=1395 • >20+ 	7.5 years	<ul style="list-style-type: none"> • Complaint of insomnia \geq 1 year 	<ul style="list-style-type: none"> • 11.9% 	--	<ul style="list-style-type: none"> • 43.6%
Singareddy et al. [126]	<ul style="list-style-type: none"> • Random general population • N=1395 • >20+ 	7.5 years	<ul style="list-style-type: none"> • "Chronic insomnia" do you feel you have insomnia with duration of at least 1 year 	<ul style="list-style-type: none"> • 10.6% 	<ul style="list-style-type: none"> • 9.3% (weighted) 	--
Silversen et al. [69]	<ul style="list-style-type: none"> • Population-based • N=24,715 • 19-80 	11 years	<ul style="list-style-type: none"> • DSM-IV + daytime symptoms in past month • Onset, terminal, late insomnia 	<ul style="list-style-type: none"> • 5.1% 	<ul style="list-style-type: none"> • 6.5% 	<ul style="list-style-type: none"> • 19.2%

Buysse et al. [66]	<ul style="list-style-type: none"> • Population sample • n=278 (all six interviews) • baseline age 20 	20 years	<ul style="list-style-type: none"> • Based on symptom, duration + frequency of episodes in past year • 1 month: sleep difficulties for at least 1 month + daytime impairments • 2-3 week: at least once over past year • Recurrent brief: <2 weeks recurring at least monthly over past year • Occasional brief: <2 weeks' duration occurring less than monthly 	Cumulative weighted	--	<ul style="list-style-type: none"> At any future interview 1 month • 39% 2-3 week • 31% Recurrent brief • 40% Occasional brief • 30%
				1 month		<ul style="list-style-type: none"> • 19.8%
				2-3 week		<ul style="list-style-type: none"> • 9.7%
				Recurrent brief		<ul style="list-style-type: none"> • 20.6%
				Occasional brief		<ul style="list-style-type: none"> • 17.5%