CHAPTER 1

Epidemiology and Associated Burdens of Insomnia

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Insomnia, the most prevalent sleep disorder, has been recognized as a major public health issue and is associated with a high societal cost. This review has two aims: to understand how the sociodemographic and career characteristics of people with insomnia may influence the economic consequences of this disease, and to show, based on numerous studies, how insomnia affects absenteeism, work productivity, and presenteeism. Reports detailing the impact of insomnia on errors and accidents are summarized, along with evaluations of the direct and indirect costs of accidents. Finally, this review provides a thorough description of the possible links between insomnia and public health concerns to illustrate the certitudes and missing data concerning the consequences of insomnia on work, economics, accidents, and costs.

INTRODUCTION

Insomnia is the most common sleep disorder, affecting millions of people of all ages around the world independently of socioeconomic level or environmental situation. There is no doubt today that insomnia presents a major concern to public health authorities. This is especially apparent seeing that it has not been sufficiently considered in recent years, although it represents a huge societal issue with numerous consequences including accidents, lost lives, lost income, disability, and the loss of educational opportunities. However, it can be difficult to individualize the impact of insomnia, which is intractably associated with psychological, medical, occupational, and societal factors, despite the important steps that have been made in recent decades. Epidemiological studies from multiple countries have clearly shown that millions of adults are chronically ill with various types of chronic insomnia. In adults, insomnia affects 1 in 5 men and 1 in 3 women. In the last decade, several consensus groups have published recommendations about insomnia and its recognition, diagnosis, and treatment.[1-4] Importantly, these groups have highlighted the impact of insomnia on public health and its consequences on work, economics, and quality of life. Nevertheless, insomnia is still poorly recognized as an important disability by health professionals and managers in the workplace.

This chapter provides a thorough description of the epidemiology of insomnia, while also looking at the possible links between insomnia and public health concerns. The intention is to bring light to the certitudes and missing data concerning the consequences of insomnia on work, economics, and accidents.

EPIDEMIOLOGY: THE MAGNITUDE OF INSOMNIA

While discussing the epidemiology of insomnia is beyond the scope of this review, it is necessary to put its prevalence, sociodemographic characteristics, and access to care into a universal and economic perspective. Recent international studies have shown that insomnia affects a large number of individuals everywhere. Independent of the country and the socioeconomic characteristics of the patients, insomnia has common features that are shared around the world, and these features could benefit from a common care solution.

Prevalence

In recent decades, national and international studies have consistently confirmed the high frequency of insomnia in most countries. Generally, the prevalence found in these studies varies from 10% to 20%, which often reflects variations in the methodologies and definitions used to assess insomnia. Referential national studies initially adopted the International Classification of Sleep Disorders, 3rd edition (ICSD-3) and the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) consensus definitions of insomnia.[5-8] For example, Ohayon *et al.*[9] conducted a national survey on insomnia in 2002, in a representative sample of the United Kingdom population comprising 3970 individuals aged ≥15 years and found a high prevalence of insomnia (27.6%). Leger *et al.*[10] also performed a national questionnaire-based survey on insomnia in a representative sample of the French population that included 12,778 individuals, and found an insomnia prevalence of 19%, with 9% presenting severe insomnia (at least two symptoms of insomnia according to the DSM-IV definition). Kim *et al.*[11] found an insomnia prevalence of 21.4% in a sample of 3000 individuals' representative of the general population of Japan. In the United States, the most recent study was conducted by Kessler *et al.*[12] on a national sample of 7428 employed health plan subscribers (≥18 years old), in which 23% of the sample complained of insomnia corresponding to the ICSD definition. In an international setting, Leger *et al.*[13] conducted a survey comparing sleep disorders in representative samples of 3962 North Americans, 5005 Europeans, and 1165 Japanese, which found that insomnia was significantly higher in the United States (39%) than in Europe (28%) or Japan (21%). A major issue highlighted by this work is the need for a better understanding of the cultural differences between people with insomnia, as no criteria is sensitive enough to explain why the Japanese complain less about insomnia than Americans. Most

extant epidemiological studies, including those performed during the COVID-19 pandemic, have used the ICSD definition. However, more recent epidemiological studies have adopted the newer DSM-5 definition, which restricts insomnia to its previous definition, but adds the phrase "with no link to another sleep or mental disorder." Importantly, this has clearly reduced the prevalence. To our knowledge, only a few studies have described insomnia prevalence in the general population using the current DSM-5 criteria: a study in Norway (N.=40,535) with a prevalence of 7.1%,[14] and a study in Hong Kong (N.=2011) with a prevalence of 10.8%.[15] This apparent contradiction reflects the high prevalence of psychiatric comorbidities, including depression, in insomnia. Depression is both a risk factor and a consequence of insomnia. Non-depressed individuals with insomnia have a twofold risk of developing depression compared with people with no sleep difficulties.[16] In a sample of Swiss primary care patients, 11% to fulfill the DSM-5 criteria of insomnia.[17] However, the All Army Study on a representative sample of 21,499 U.S. Army soldiers revealed that insomnia based on DSM-5 criteria was present in 22.76% of the sample.[18]

Sociodemographic factors contributing to insomnia

Almost all studies have shown an increasing prevalence of insomnia and a greater likelihood of the disorder in women.[9-14, 19, 20] Indeed, Leger *et al.*[10] found in France that severe insomnia was almost twice as high in women as in men (12% *vs.* 6.3%, P<0.0001). In a recent review establishing that insomnia is approximately 1.5 times more common in women than in men, the authors speculated that the sex differences related to insomnia go beyond simple explanations: They are a complicated interaction of biological, psychological, and social factors that play different roles throughout a lifetime.[21] Older subjects typically have more severe complaints regarding insomnia than younger subjects. In a representative sample (N.=5622) of the general population of France aged ≥15 years, Ohayon and Lemoine[22] found that insomnia complaints were twice more prevalent in subjects >65 years *versus* subjects <45 years. Interestingly, epidemiologists in the province of Shandong (China) found that the incidence of insomnia in people ≥60 years old significantly decreased between 2004 and 2015. The authors insisted on greater awareness regarding living arrangement, age, education, occupation, and other factors that have improved the sleep quality of the elderly.[23] It is usually postulated that insomnia is more frequent in people with a low socioeconomic status.[13, 15, 19, 24] However, in the French population, the prevalence of insomnia was highest in the white-collar group (20.8%),[10] with lower rates reported in upper-level executives, professionals, and in farmers. Similarly, Doi *et al.*[25] showed in a cross-sectional study including 4868 daytime white-collar workers that poor sleep was significantly more prevalent in this group (30-45%) than in the general working population of Japan. Importantly, a recent analysis of sleep data from 41,094 participants (51.9% female) with a median age of 57 years identified three distinct trajectories of sleep: healthy sleepers (40.8%), borderline poor

sleepers (31.6%), and poor sleepers (27.6%).[26] Socioeconomic disadvantage, ethnic minority background, shift work, unhealthy lifestyle, poor health, depressive symptoms, and obesity were the main risk factors associated with poor sleep. Approximately one third of the total effect of socioeconomic deprivation on poor sleep was mediated through depressive symptoms. The authors suggest that due to the increased risk of poor sleep, people from socioeconomically deprived groups, particularly females from ethnic minorities, should receive the highest priority for interventions aiming to improve population sleep health.[26]

INSOMNIA IN THE WORPLACE

When considering the associated burdens of insomnia, the impact on work is a crucial issue. Indeed, there is a high prevalence of insomnia in adults, and therefore also in professionals at work. Nevertheless, very few studies have been specifically devoted to insomnia in the workplace. One of the earliest examples is from Riedel *et al.*,[27] who recommended using objective measures of work performance (absenteeism, work limitation, errors, job promotion, *etc.*) to clarify the impact of insomnia on daytime activity. Importantly, insomnia is not a conspicuous handicap in the workplace, and it is difficult for insomniacs to explain their poor sleep situation and need for rest to colleagues and managers. Here, we will first illustrate how insomnia may directly influence job ability, and then discuss the few studies that have recently been devoted to this topic. Insomnia may affect job ability *via* sleep restriction or sleep debt. Depending on the tasks to be performed, it can be more difficult to concentrate on a monotonous task or a difficult problem, or even to avoid mistakes while sleep deprived. Sleep restriction is associated with subjective sleepiness as well as the occurrence of microsleep episodes during the day.[28] In addition, sleep restriction can alter inflammation, metabolic responses, and pain sensitivity.[29-31] Chronic sleep restriction (CSR) induces neurobehavioral deficits in young, healthy people with a morning failure of sustained attention process.[32] Furthermore, sleep restriction increases the risk of sleepiness while driving a vehicle for work.[28, 33, 34] Finally, sleep restriction and insomnia also change your daily mood, irritability, and even your face and the way people perceive you at work.[35, 36]

Absenteeism

Absenteeism is a simple and well-recognized means to objectively assess health at work. In a preliminary study,[37] our group specifically surveyed the absenteeism of a group of insomniacs at work compared to a matched group of good sleepers (GS). Insomniacs missed work twice as often as GS. The difference between people with insomnia and GS in terms of absenteeism was particularly high for blue-collar workers (odds ratio [OR] 3.0) and men (OR 2.31). In this survey, we excluded subjects with depression and anxiety or chronic disease (which may interfere with sleep), as well as pregnant women. Additionally,

it seemed more probable that significant differences between people with insomnia and GS reflected the impact of insomnia itself, rather than the effects of comorbidities. In another study on long-term absenteeism in France (including absences of >6 months), the authors compared 986 people with insomnia with 584 controls, and subjects with insomnia (whatever the cause) reported higher absenteeism rates than controls (9.6±31 *vs.* 5.8±19 days, P<0.01).[38] In people with insomnia and depressive complaints associated with insomnia, after logistic regression, absenteeism was shown to reflect depression more accurately than insomnia itself. However, as shown by Sivertsen *et al.*,[39] insomnia itself may be an independent predictor of absenteeism. The authors used a historical cohort design with 4 years of follow-up. They obtained information on sick leave from Norwegian official registry data and merged it with health information from the Hordaland Health Study in Western Norway. From this, they assessed 6892 participants for self-reported symptoms of insomnia; sociodemographic factors; lifestyle behaviors; Body Mass Index; symptoms of sleep apnea, anxiety, and depression; as well as a range of somatic diagnoses, somatic symptoms, and pain. Overall, insomnia was a significant predictor of sick leave (OR 2.2) and the effect remained significant when adjusting for possible confounders (OR 1.51). This effect increased with longer durations of sickness leave. In a Swedish cohort, Akerstedt *et al.*[40] studied long-term (≥90 days) and short-term (14-89 days) sickness absence in subjects with disturbed sleep (1542 individuals) compared with people without disturbed sleep (6824 individuals). They found that disturbed sleep was associated with an increasing risk of both long-term sickness (OR 1.90, 95% confidence interval [CI] 1.44-2.61) and short-term sickness (OR 1.16, 95% CI 1.24-1.72). This link seems to be stronger in women than in men. Daley *et al.*[41] showed the impact of insomnia on absenteeism in a group of 953 French-speaking adults from Quebec, categorized as having insomnia syndrome (SYND) or insomnia symptoms (SYMPT), or as being GS. Absenteeism data were also obtained from the government-administered Quebec Health Insurance Board, revealing that 25.0% of SYND had been absent from work *versus* 17.1% of GS (OR 1.7). Interestingly, in an Iranian nursing team, absenteeism was significantly associated with the insomnia severity scale score.[14] In Australia, sickness absenteeism was also independently associated with insomnia (OR 2.5).[15] A large survey in Japan focused on 17,828 construction/civil engineering workers (15,837 men and 1991 women) aged 40-74 years. The questionnaire consisted of sociodemographic characteristics, information on work productivity (work performance and absence), and specific insomnia symptoms (difficulty initiating sleep [DIS], difficulty maintaining sleep [DMS], and early morning awakening [EMA]). Absenteeism during the study period was associated with DIS in blue-collar workers and both DIS and DMS in white-collar workers, but not with EMA in either group.[16] Using collection data from 2798 U.S. employees, Espie *et al.*[17] also found a significant relationship between insomnia symptoms and hours missed from work (absenteeism; rho=-0.124).

Interestingly, the average time missed from work each week associated with DIS was calculated to be 0.94 hours (t=-6.18, P<0.0001), while DMS was 0.32 hours (t=-2.15, P=0.031) and EMA was 0.35 hours (t=-2.32, P=0.020). Women workers had a slightly higher sleep-related absenteeism rate than males. Workers in the factory and retail sectors reported significantly more sleep-related absenteeism than office-based workers ($F_{(22786)}$=8.47, P<0.0001). Kessler *et al.*[18] also reported absenteeism associated with insomnia in a national sample of 7428 employed health plan subscribers interviewed using the World Health Organization Health and Work Performance Questionnaire (HPQ). Conversely, they did not find any insomnia or association between insomnia and absenteeism (χ^{21}=3.2, P=0.07).

Work limitation and other occupational characteristics

Few authors have tried to assess insomnia-related impairment directly in the workplace. The main difficulty involves comparing the respective work contents of insomniacs and GS. In a preliminary study comparing 240 severe insomniacs (SI) to 391 GS, we explored the work consequences of insomnia[37] and found that 15% percent of SI *versus* 6% of GS (P<0.001) reported having made errors at work in the previous month, which could have resulted in serious consequences. For 6% of SI *versus* 2% of GS, errors occurred more than once in the previous month (P=0.0032). Moreover, 18% of SI *versus* 8% of GS (P=0.0004) felt that they had exhibited poor efficiency at work. In a sizable group of 19,711 adults from the 2005 U.S. National Health and Wellness Survey (comprising 5161 insomniacs and 14,550 non-insomniacs), people with insomniac had significantly higher activity impairment scores (+18.04) than people without insomnia.[19] Workers with insomnia also claimed higher impairment at work (+13.20) and work productivity loss (+10.33) scores than those without insomnia. Researchers in Norway showed that insomnia was a strong predictor of permanent work disability (OR 4.56), and this effect remained significant after controlling for sleep duration as well as other possible confounders (OR 1.88).[20] This study demonstrates the need to better recognize insomnia as an independent factor of work disability for disabled workers claiming disability pensions. The Work Limitation Questionnaire (WLQ) assesses the on-the-job impact of chronic health problems and/or treatment ("work limitations") and includes 25 items and four dimensions (difficulty with time management, physical demands, mental-interpersonal demands, and output demands, along with work productivity loss) over a 2-week reporting period. These responses indicate that the higher the work limitation of employees, the worse the productivity.[21] Yang *et al.*[22] tested health-related outcomes associated with a variation of insomnia severity, based on the Insomnia Severity Scale (ISI) and the WLQ. Higher ISI scores (indicating more severe insomnia) were significantly associated with higher probabilities of a negative outcome.[23] Individuals with a 6-point score reduction in ISI scores (corresponding to 1.5 standard deviations) were 46% less likely to be "unable to think clearly." In the

previously cited survey of 2798 US employees,[17] Espie *et al.*[24] assessed productivity with the presenteeism and daily activity item impairment of the Work Productivity and Impairment questionnaire (WPAI). In this study, employees were asked the following question concerning presenteeism: "Over the past 2 weeks, how much did poor sleep affect your productivity while you were working?" They could answer on a scale ranging from 0 (no effect) to 100 (unable to work). The authors tested the simple association between insomnia symptoms and loss of work productivity at the level of the whole population and a substantial inverse correlation was observed, suggesting that more insomnia symptoms (*i.e.*, a low SCI-2 Score) and work productivity problems are related (r=-0.489, P<0.0001, R^2=23.9%). The relationship between insomnia symptoms and loss of work productivity was similar in men and women, and those with difficulty falling asleep, remaining asleep or early awakening all reported a greater impact on productivity loss than those that did not report any sleep problems (t=-11.2, -10.3, and -7.05, respectively; all P<0.0001). Kessler *et al.*[25] also used presenteeism to assess productivity loss associated with insomnia in work performance (HPQ). The HPQ uses self-reports on presenteeism, which was defined on a separate 0-100 scale, where 0 means doing no work at all on days at work and 100 means performing at the level of a top worker. Given information about salary, the authors could transform the measures of lost work performance from a time metric into a salary metric for purposes of estimating human capital loss associated with insomnia. Furthermore, insomnia was significantly associated with lost work performance due to presenteeism (χ^{21}=39.5, P<0.001), with an annualized individual-level association of insomnia where presenteeism was equivalent to 11.3 days of lost work performance. This estimate decreased to 7.8 days when controls were introduced for comorbid conditions.[25]

Insomnia and accidents

The impact of sleep disorders on automobile accidents is a crucial issue from a public health point of view. Public authorities are usually well informed about the risk of accidents from sleepiness at the wheel associated with sleep debt and sleep disorder (such as sleep apnea or hypersomnia). However, very few data are available on the risk of accidents associated with insomnia. Insomnia may indeed increase the risk of accidents in different ways, including sleep deprivation, lack of attention, and side effects of hypnotics. This section addresses data on both motor vehicle accidents (MVA) and work accidents (WA). In a preliminary French study comparing 240 SI to 391 GS,[26] WA were eight times more common in the past 12 months in SI (8%) than in GS (1%) (P=0.0150), with an average number of 0.07±0.25 accidents for SI *versus* 0.01±0.11 for GS (P=0.0550). However, there was no significant difference for MVA in the past 12 months between the groups (9% *vs.* 10%). The authors explained the discrepancy between WA and MVA by the fact that SI may have avoided driving or driven shorter distances given that 65.8% of SI drove a car *versus* 72.5% of GS. Daley *et al.*[41] did not find

any difference in the rate of MVA in the last 6 months between people with insomnia and GS, in a group of 930 adults in Quebec. However, 23.5% of drivers reporting an accident felt that insomnia played an important role in the event. Moreover, 39.5% of participants saw a link between their sleep difficulties and other types of accidents (P<0.001). In Japan, a study on occupational injuries in 1298 workers from small-scale manufacturing firms found that insomnia symptoms were significantly associated with occupational injuries in both genders (OR 1.64, 95% CI 1.23-2.18).[27] In an international survey (EQUINOX) conducted on 5293 subjects across 10 countries comprising subjects with sleep disturbances, primary care physicians administered a questionnaire that included sleep disturbance and accidents (motor vehicle, work, and home) related to sleep problems. Patients with insomnia had significantly higher rates of home, car, and WA related to sleep disturbances than subjects with no insomnia, independently of any adverse effects of hypnotic treatments. Reduced total sleep time may be one factor explaining the high risk of accidents in individuals who complain of insomnia.[28] Another survey focused on the prevalence and impact of insomnia on MVA and near-miss accidents (NMA) in 949 truck drivers in Italy. Insomnia affected 27.5% of the sample. Compared with other drivers, in the 3 years prior to the study, truck drivers with insomnia reported a significantly higher number of MVA, as well as a greater number of NMA in the previous 6 months. After correction for the presence of obstructive sleep apnea, excessive daytime sleepiness, short sleep duration, and other concurrent diseases, insomniac truck drivers had an almost twofold risk of driving accidents (OR 1.82, 95% CI 1.33-2.49), and a more than threefold increased risk of NMA (OR 3.35, 95% CI 2.06-5.45) compared with non-insomniac drivers.[29] Regarding treatment effects on driving ability, it is usually admitted that long-term half-life hypnotics (medium long-term benzodiazepines and antihistamines) may induce a risk of accidents while driving in the morning, and a risk of falls during the night in the elderly. The vast majority of hypnotics in Europe have a label indicating the possible risk of accidents due to the treatment. However, minimal information has been published on the side effects of common hypnotics on driving ability. Partinen *et al.*[30] performed a double-blind, randomized, placebo-controlled, three-treatment and three-period cross-over study to investigate the effects of zolpidem (10 mg) and temazepam (20 mg) *versus* a placebo in 18 people with insomnia in real-life conditions on driving performance. After polysomnography at baseline and at each night of treatment, 5.5 hours after drug intake at 7:30 a.m. the next morning, patients underwent a STISIM driving simulator test. There was no difference between treatments for the primary outcome measure (mean time to collision; baseline: 0.120 seconds, P=0.124, t=0.118, z=0.124; P≥0.12 for all pairwise comparisons). Furthermore, there was no difference in speed deviation and reaction time to tasks for the treatments. However, lane position deviation was greater after administration of zolpidem compared with both placebo and temazepam (P=0.025 and 0.05, respectively). The authors