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THE COST OF POOR SLEEP IN THE PORTUGUESE ECONOMY

Dissertation submitted to Universidade Católica Portuguesa to obtain a Master’s Degree in Psychology in Business and Economics

By

Mariana Leitão Bandeira

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November 2021

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Under the supervision of Professor Cátia Reis and co-supervision of Professor Ian Scott

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Acknowledgments

First and foremost, I thank my parents for providing me with the financial and emotional support I needed, for giving me ideas and your perspectives on my dissertation and for always showing interest in my studies as well as my future.

I thank my advisors, Cátia Reis and Ian Scott, for guiding me and for all the patience. Your ideas and advises helped me complete this thesis, and your encouragement to present my own ideas allowed me to complete this thesis. Thank you for guiding me in this unknown path, for pushing me to understand things and write things the best way possible. This dissertation wouldn't have been completed without your help, support and encouragement.

I thank my Master colleagues, Duarte Castelo Branco, Samuel Salvador, Inês Cruz and Diogo Sotto-mayor, for all their help, the sharing of ideas and emotions and the empathy felt in the good and bad times we went through all together.

To everyone who contributed to this thesis, thank you!

Abstract

Sleep is a basic human need and is essential for an individual's attention, social relationships and the execution of simple or complex tasks (Valente et al., 2019) and one of the main purposes of sleep is to repair possible damage from an individual's day to day (Adam & Oswald, 1977). However, poor sleep is a public health problem affecting a great number of people, which can be a consequence of clinical sleep disorders, such as Obstructive Sleep Apnea and Insomnia, and a consequence of sleep restrictions that are related either to work or lifestyle. Therefore, there is both a human cost and an economic cost associated with it, which makes it important to analyze as political decisions are mainly based on numbers and economic data. It is estimated that Portugal has an annual cost of 4.1 billion euros due to excessive daytime sleepiness, which is associated with other conditions that have been considered in this study (i.e. Congestive heart failure, Coronary artery disease, Cerebrovascular disease, Depression, Type 2 Diabetes, Workplace injury and Motor vehicle accidents). These costs were obtained by a Population Attributable Fraction (PAF) calculation and the incidence of the considered conditions in Portugal as well as the prevalence of Obstructive Sleep Apnea (0.89%) and Insomnia (28.1%) in Portugal. Other statistical analyses were conducted, in order to obtain the costs not only for excessive daytime sleepiness, but also for the conditions studied in this dissertation. Conclusions that can be made, are the fact that Portugal, having a population of only 10 million people, has higher estimated costs attributed to sleep when compared with other countries, such Spain or Australia.

Keywords: Sleep; Economy; Productivity; Obstructive Sleep Apnea; Insomnia; Excessive daytime sleepiness; Portuguese economy

Resumo

O sono é uma necessidade humana básica e é essencial para a atenção de um indivíduo, as suas relações sociais e a execução de tarefas simples ou complexas (Valente et al., 2019) e um dos principais objectivos do sono é reparar possíveis danos do dia a dia de uma pessoa(Adam & Oswald, 1977). No entanto, sono insuficiente é um problema de saúde pública que afecta um grande número de pessoas. O mau sono de uma pessoa pode ser uma consequência de distúrbios clínicos do sono, tais como a Apneia Obstrutiva do Sono e a Insónia e, uma consequência de restrições do sono que estão relacionadas quer com o trabalho quer com o estilo de vida. Neste sentido, há um custo humano e um custo económico associado a uma má higiene do sono, o que torna importante esta análise, uma vez que as decisões políticas se baseiam principalmente em números e dados económicos. Estima-se que Portugal tenha um custo anual de 4,1 mil milhões de euros devido à sonolência diurna excessiva, que está associada a outras condições que foram consideradas neste estudo (i.e., insuficiência cardíaca, doença arterial coronária, doença cerebrovascular, depressão, diabetes tipo 2, acidentes de trabalho e acidentes de viação). Estes custos foram obtidos através de um cálculo da *Population Attributable Fractio*n (PAF) e da incidência das condições acima mencionadas em Portugal, bem como da prevalência de Apneia Obstrutiva do Sono (0,89%) e Insónia (28,1%) em Portugal. Foram realizadas outras análises estatísticas, a fim de obter os custos não só da sonolência diurna excessiva, mas também das condições estudadas nesta dissertação. Conclui-se que Portugal, com uma população de apenas 10 milhões de pessoas, apresenta uma estimativa de custos atribuídos ao mau sono mais elevados, quando comparado com outros países, tais como a Espanha ou a Austrália.

Palavras-chave: Sono; Economia; Produtividade; Apneia Obstrutiva do Sono; Insónia; Sonolência Diurna Excessiva; Economia Portuguesa

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1. Literature Review

1.1. What is Sleep

Sleep is acknowledged as a basic human need and is essential for an individual's attention, for social relationships and for the execution of simple or complex tasks (Valente et al., 2019). Although the function of sleep is still a main focus of scientific investigation, it has been assumed that one of the major purposes of sleep is to repair possible damage from an individual's day to day and to restore and recover an individual's health (Adam & Oswald, 1977). It is a neurobehavioral state where there is reduced responsiveness to external stimuli and it is often followed by postural recumbency and behavioral rest (Amorim et al., 2018).

Sleep is, therefore, a combination of physiological and behavioral processes that normally involves postural resting, behavioral inactivity, closed eyes and everything else that is usually associated with sleep (Carskadon & Dement, 2011).

Within sleep two distinctive states have been identified: rapid eye movement (REM) and non-REM (NREM). These two states are different and independent from each other (Chokroverty, 2010).

NREM sleep is generally split into four stages, N1, N2, N3 or Slow Wave Sleep (SWS), delineated along one measurement axis, namely the electroencephalogram (EEG) (Chokroverty, 2010). NREM sleep is when there is discontinuous or minimal mental activity and it can be defined as a "inactive yet actively regulating brain in a movable body" (Olson et al., 2006). On the other hand, REM sleep is characterized by EEG activation, absence of muscle activation and the presence of rapid eye movements (Chokroverty, 2010). The mental activity of human REM sleep is linked with dreaming (Nielsen, 2000). A simple and short definition of REM sleep is, therefore, an activated brain in a paralyzed body (Carskadon & Dement, 2011).

In normal human beings and in normal circumstances, the beginning of sleep starts with NREM sleep, which is a fundamental key in normal human sleep and helps with the distinction of normal and pathological sleep (Carskadon & Dement, 2011).

Sleep occupies 20 - 40% of an individual's day (Grandner, 2017), therefore, factors like cerebral clearance, metabolic homeostasis, good immune functions and an overall good mental and cognitive status are guaranteed by having a good sleep (Amorim et al., 2018).

Poor sleep, on the other hand, has negative impacts on an individual's mental actions and cognitive functions, increasing this way the probability of making errors, when completing tasks (Olson et al., 2006). Other negative effects of poor sleep can be reflected on an individual's health and well-being.

This negative impact, which will further be discussed, can also be seen in companies, due to employees absenteeism that leads to large economic losses. Accordingly, insufficient sleep can be described as a societal problem, since low productivity and higher mortality risks, that are related to insufficient sleep, can lead to economic losses (e.g. estimated $680 billion every year due to insufficient sleep in five OECD countries) (Hafner et al., 2017).

Therefore, taking action in the problem of insufficient sleep represents a "win-win" situation for employers, workers and society (Olson et al., 2006).

When talking about sleep, there are a variety of factors that can influence an individual's sleep quality - these will further be discussed. However, some of these factors include improper exposure to food or light, work and psychological morbidity and lifestyle schedules. These can negatively influence the duration of sleep, leading this way to harmful consequences on an individual's health (Schwartz et al., 1999; Stickgold, 2006; Wulff et al., 2010; Archer and Oster, 2015 cit. in, Amorim et al., 2018).

Therefore, considering an individual's sleep needs and the amount of sleep needed for an adult (7 - 9h hours every day) (Hirshkowitz et al., 2015 cit in., Hafner et al., 2015) is extremely important, as unfortunately people are sleeping less than the recommended time constantly (Ohayon et al., 2017).

1.1. *Factors that influence sleep*

There are a variety of factors that seem to influence an individual's sleep, such as:

Circadian Rhythms

Human beings' life is adapted to the 24-hour solar day and over time the daily cycles of light and dark have been embodied as circadian rhythms, allowing an individual's adjustment to environmental and temporal changes (Vitaterna et al., 2001 & Walker et al., 2020).

Circadian rhythms are different from individual to individual and they can be understood with the concept of circadian typology that is divided into three different chronotypes: morning-type, neither-type and evening-type. Regarding the morning-type, it is related to individual's that both go to bed early and wake up early. These individuals have their best physical and mental performance during the morning. On the other hand, the evening-type consists of the individuals that go to bed late and wake up late as well, these individuals have a better performance at the end of the day and at night (Adan et al., 2012).

Age

Age seems to be an important factor affecting someone's pattern of sleep (Carskadon & Dement, 2011).

Starting with adolescents, insufficient sleep has become common in this age group over the past years (Matricciani et al., 2012). Accordingly, short sleep patterns in adolescents are linked to factors such as social life, consumption of stimulants (e.g. caffeine), artificial light (e.g. cell phones and communication technologies), no bedtime rules as well as lack of physical activity (Chaput et al., 2018).

Therefore, there seems to be a conflict between social time and biological time, that is higher during adolescence than it is at any other age in an individual's life (Adan et al., 2012).

There are common factors modifying sleep when comparing adolescents and adults, namely the aforementioned factors, and other factors that can specifically be associated with insufficient sleep in adults, which include work obligations, health and affective problems, social commitments and responsibilities and family dynamics (Colten & Altevogt, 2006).

Regarding the older population, sleep patterns experience a great amount of quantitative and qualitative changes. Older adults seem to have more difficulties falling asleep as well as staying asleep. This is usually related with a circadian shift to a morning chronotype, which results in early bedtime and awakening time (Edwards et al., 2010). Therefore, the need for sleep does not change, however, the ability to maintain sleep decreases. Normally, in the older population, poor sleep is a consequence of the

comorbidities and related medication that is taken by these individuals, instead of the normal aging process (Chaput et al., 2018).

Drug Ingestion

Benzodiazepines are a turning point in the treatment of anxiety and insomnia and are probably the most prescribed drugs in the world. However, although regarded as safe drugs, benzodiazepines are capable of creating addiction, tolerance, and physical dependence (Wick, 2013). According to the 2004 a report of the International Narcotics Control of Drugs (Organização Internacional de Controlo de Estupefacientes, OICE), Portugal has one of the highest levels of benzodiazepine consumption in Europe (Guedes & Carvalho, 2009). An example is *Alprazolam*, an anxiolytic benzodiazepine of intermediate duration (active substance), which has the highest number of sold packs between 2000 and 2007 representing an average of 39.1% of the total number of packs of anxiolytic benzodiazepines of intermediate duration (Guedes & Carvalho, 2009).

In turn, the high consumption of benzodiazepines as well as other factors have an impact on our economy, which will further be discussed.

1.2. Causes and Consequences of Insufficient Sleep

Sleep is involved with a variety of physiologic systems, therefore both poor sleep quality and duration have been linked with different health outcomes. There's existing literature which describes the impact of Obstructive Sleep Apnea (OSA), Insomnia and sleep duration in individual's (Grandner, 2017).

There are a variety of factors that can cause or contribute to insufficient sleep, such as lifestyle choices (Suni & Dimitriu, 2021) and lifestyle related sleep disorders (e.g. stress, irregular schedules) (Hafner et al., 2017), poor sleep hygiene, work obligations and sleep disorders such as Insomnia as well as OSA (Suni & Dimitriu, 2021). Therefore, according to Hafner et al., (2017), insufficient sleep is generally a consequence of multiple factors, which makes it impossible to define the contributions of behavioral versus pathological factors that contribute to sleep-loss.

On the one hand, we have behavioral causes of sleep deprivation (Hafner et al., 2017), which are often driven by individual and voluntary choices that lead to a reduced availability to sleep (Suni & Dimitriu, 2021). Work obligations are another common factor

that leads to insufficient sleep (Hublin et al., 2001) - these include for example frequent business travelers, individuals who work multiple jobs or extended working hours and those who work in shifts, as they may work through the night (Suni & Dimitriu, 2021). In a sample for Portuguese workers, the prevalence for excessive daytime sleepiness in regular workers was 37.1%, while in shift workers the prevalence was 61%. The prevalence for shift workers represents a higher prevalence than the one from OSA patients (36.9%) (Reis et al., 2020).

On the other hand, there are the medical and psychological conditions (e.g. sleep disorders) that lead to sleep deprivation, such as Insomnia which is characterized by the difficulty of sleeping at night (Kumar, 2008) and OSA which characterized by a reduction of the air flow while sleeping (Rundo, 2019). Both disorders will be discussed in the chapters ahead.

Both behavioral, medical and psychological causes, which influence an individual's sleep duration, are associated with mortality risks - this was shown long ago in a report that considered 1 million adults in the U.S. and demonstrated the relationship between mortality risk and sleep duration (Hammond, 1964). For this reason, it is possible to conclude that an individual's mortality risk is linked both with short (6 or less hours) and long (9 or more hours) sleep duration (Grander, 2018).

More recently there is also evidence that individuals sleeping between the recommended time per night (7-9h) have the lowest mortality risks (Hafner et al., 2017).

Following this line of thought, in the United States, insufficient sleep was associated with seven of the fifteen leading causes of death (e.g., cerebrovascular disease, cardiovascular disease, hypertension and diabetes) (Kochanek et al., 2014). Also an association with short and long sleep duration and chronic disorders was found for a representative sample of the Portuguese population (Reis et al., 2018) and the prevalence of insufficient sleep in Portugal was found to be 20.7% (Reis et al., 2018). Taking the previous into consideration and according to the NCEP-ATP III[1] criteria, in the United States the prevalence of coronary artery disease is 23.7% and in Portugal 27.5% (Fiuza, 2012). Additionally, in Portugal, the standardized mortality rate from cerebrovascular diseases decreased between 2007 and 2011 from 79.9 deaths per 100,000 inhabitants to

[1] National Centers for Environmental Prediction – Adult Treatment Panel lll

61.9, however, in 2013 the prevalence of cerebrovascular disease was 1.9% (Sousa-Uva & Dias, 2012).

It is, therefore, of extreme importance to highlight that data suggests that not only insufficient sleep is associated with negative outcomes, but also that individual's who sleep more than the recommended time (7-9h) may also have a higher mortality risk and may also show loss of productivity (Chattu et al., 2018).

1.3. Obstructive Sleep Apnea (OSA)

Obstructive Sleep Apnea (OSA) is characterized by the occurrence of frequent episodes of upper airway collapse as well as obstruction during sleep (Rundo, 2019). The definition of OSA varies across laboratories and in the medical literature. However, a consensus statement was reached more than 5 years ago as an effort to standardize criteria in human research (Caples et al., 2005). It is being progressively recognized as an important cause of medical morbidity as well as mortality. The health consequences associated with OSA are abundant and, if not treated, they can lead to cognitive dysfunction, excessive daytime sleepiness, weakened work performance, productivity loss (Osman et al., 2018), and reductions in health-related quality of life (Jordan et al., 2014).

Therefore, OSA is a syndrome that has both an impact on nocturnal sleep as well as daytime consequences (Punjabi, 2007 & Caples et al., 2013). Although there are several typical sleep and daytime symptoms linked with OSA, individuals who suffer from it vary in the number and combination of symptoms stated. Accordingly, OSA occurs in 4% of men and 2% of women who are between 30 to 60 years old. OSA should be suspected in individuals who usually snore, suffer from hypertension and are hypersomnolent. Individuals with a higher risk of having OSA are those who have two of the following criteria: daytime sleepiness or drowsiness while driving, obesity or hypertension and snoring (Flemons, 2002). Snoring is one of the most common symptoms during sleep. On the other hand, common daytime symptoms of OSA include fatigue or excessive daytime sleepiness (Caples et al., 2005). Excessive daytime sleepiness can be described as feeling very drowsy or extremely sleepy at times, whereas fatigue is feeling low on energy, tired as well as unmotivated - not feeling rested despite getting the recommended 7 to 9 hours of sleep is a symptom as well (Rundo, 2019).

OSA is being acknowledged as an independent risk factor for several clinical consequences, such as cardiovascular disease, systemic hypertension, stroke, and abnormal glucose metabolism (Punjabi, 2008). Therefore, there are some factors that have to be considered as they increase the exposure to this disorder (Punjabi, 2007 & Caples et al., 2005).

This leads to the fact that, the risk of OSA is impacted by both unmodifiable and modifiable factors (Rundo, 2019).

Male sex, age and race are an example of unmodifiable risk factors. Also, a family history of OSA or a genetic predisposition as well as craniofacial anatomy that results in narrow airways may lead to a higher risk of OSA (Ho & Brass, 2011). Modifiable risk factors, on the other hand, include obesity, medications that result in muscle relaxation and narrowing of the airway (e.g., opiates, benzodiazepines, alcohol), smoking, nasal congestion or obstruction and endocrine disorders (e.g., hypothyroidism, polycystic ovarian syndrome) (Rundo, 2019).

Obstructive Sleep Apnea is a highly prevalent condition, especially in individuals with settled comorbid conditions and risk factors (Ho & Brass, 2011). However, it is a subtle and dangerous syndrome as patients are often unaware of the associated symptoms, in a recent report it was shown that individuals with a more severe OSA disease were the ones presenting the lowest reported symptoms of daytime sleepiness (Reis et al., 2020), increasing the risk of an underdiagnosed.

Therefore, an early recognition of this disorder as well as suitable therapy may have favorable effects on cardiovascular health and lower the neurobehavioral consequences associated with it (Punjabi, 2008).

A study done by researchers from the University of Wisconsin School of Medicine provided evidence on the fact that there is a high prevalence of undiagnosed OSA, however, in the U.S. the number of patients receiving treatment for OSA has increased. Such that between 2000 and 2010 office visits for OSA have risen from 2 million patients to 2.7 million patients. Accordingly, this study reported that the costs of undiagnosed OSA in U.S. adults was 129.2 billion euros (Watson, 2016).

Studies reveal that OSA is both prevalent and little recognized, as it is estimated that 82% of men and 93% of women in the United States with OSA are undiagnosed (Hafner et al., 2017). In a Brazilian study performed by Tufik et al., (2010), the prevalence

value of OSA, assessed with an objective clinical diagnosis, reached a prevalence value of 32.8%.

Regarding the general population it is estimated that between 10 - 40% of people suffer from OSA (Associação Portuguesa do Sono). According to Rodrigues et al., (2017), the prevalence of OSA in Portugal is unknown, however, considering the high prevalence of obesity in Portuguese adults, a high prevalence of OSA is expected for Portugal.

Therefore, in a 2014 cross-sectional study that was performed using the Portuguese General Practitioner Sentinel Network (Rede Médicos Sentinela) obtained a prevalence value of OSA for individuals aged above 25 (using all the diagnosed and registered in their list) of 0.89%. The male sex had a higher prevalence of 1.47% and in individuals with ages between 65 and 74 years the prevalence was 2.35% (Rodrigues et al., 2017). These are relevant numbers as they influence an individual's everyday activities, such as driving which can lead to motor vehicle accidents. The impact of OSA's prevalence will further be discussed.

1.4. Insomnia

Insomnia is considered the most common type of sleep disorder (Burman, 2017) and it can be described as the ineffectiveness to obtain sleep, which gives the feeling of being unrefreshed and unrested the following day (Kumar, 2008). It is distinguished by the difficulty initiating or maintaining sleep, alongside with symptoms such as fatigue during wakefulness or irritability. Additionally, it is a risk factor as it can lead to a damaged functioning and the development of other mental and medical disorders, as well as increased health care costs (Sateia, 2014).

When referring to insomnia there is a difference between syndrome and symptom - patients who report having insomnia often tend to reveal assorted problems, including sleep that is nonrestorative or unrefreshing as well as the inability both to fall asleep or to remain asleep. Therefore, the duration of an individual's insomnia is important when making a diagnosis as it has implications (Vgontzas & Kales, 1999).

On the one hand, *Transient insomnia* lasts only a few days and it is often a result of medical illness, stress, jet lag or even self-medication (Kupfer & Reynolds, 1997). On the other hand, *Chronic insomnia* has a duration of three months and occurs at least three times a week usually has diverse causes (Sateia, 2014).

The duration of an individual's symptoms is crucial in determining the diagnosis and in assessing secondary problems, including both the use and misuse of drugs and alcohol - which can be a cause and effect of chronic insomnia - and an obsessive concern about an inefficiency to sleep (Buysse, 2013). Therefore, the diagnosis and the medications given for therapy depend on whether symptoms are short term or chronic (Sateia, 2014).

The diagnosis of chronic primary insomnia requires an individual to have difficulty in initiating or maintaining sleep or the presence of around one month of poor sleep that causes visible impact in occupational, social, or other important areas of functioning.

The pathophysiology and etiology of insomnia involve environmental, genetic, behavioral and physiological factors. The diagnosis of Insomnia is, therefore, established by an accurate history of sleep behaviors, psychiatric and medical problems and medications, and it is supplemented by an eventual record of sleep patterns (e.g., sleep diary) (Buysse, 2013).

With age, reports of insomnia tend to increase and they're more prevalent among women, although laboratory studies argue that older men display a more disrupted sleep. There are some other factors that lead to a higher prevalence of insomnia, such as individuals who are divorced, widowed or separated - these report having insomnia more often than those who are married - and a lower socioeconomic status (Vgontzas & Kales, 1999).

According to Kupfer and Reynolds (1997), the course of insomnia can differ throughout time, however, insomnia tends to be more recurrent in both community and clinical samples. Having persistent insomnia is considered a risk factor and a forerunner of mood disorders, such as depression where 4.4% of the world population suffers from it and in Portugal where there's a prevalence of 7.9% (Direção Geral da Saúde, 2014). Accordingly, an efficient treatment of insomnia can be seen as a chance to prevent a major depression.

Furthermore, the authors Kupfer and Reynolds (1997) defend that chronic insomnia, which was discussed above, is also linked with an increased risk of motor vehicle accidents, increased daytime sleepiness and alcohol consumption. This shows how important it is to give serious attention to those who are suffering from insomnia.

Moreover, insomnia should be recognized by clinicians due to the effects it has both on health and function. According to Ramakrishnan & Scheid (2007), a detailed and

complete clinical history is often enough to identify factors that contribute to insomnia. Therefore, behavioral treatments should be used, when possible, although hypnotic medications are efficient as well. However, these must be carefully controlled for possible adverse effects.

Insomnia is a significant public health problem because of its high prevalence and management challenges (Ramakrishnan & Scheid, 2007) - with a prevalence of approximately 10% to 20%, with around 50% having a chronic course (Buysse, 2013). However, in the general adult population of Portugal the prevalence is approximately 28.1% according to Ohayon & Paiva (2005), whereas regarding Portuguese adolescents the prevalence is between 4.4% and 13.3% (Amaral et al., 2014). Taking into consideration the prevalence of Insomnia in Portugal, this disease will further be discussed and linked to other relevant topics as there is increasing evidence of a strong association between insomnia and various medical and psychiatric comorbidities (Burman, 2017). All these factors have an impact on the Portuguese economy, which will further be discussed.

1.5. Impact of sleep in Health, Safety and Public well-being

Insufficient sleep is considered a public health problem and as previously discussed, sleep has benefits as it has impact on different levels and is essential for psychological and cognitive well-being, productivity (e.g., performance at school and workplace) and general health (Hafner et al., 2017).

The impact of insufficient sleep is an apparent problem in our society and it represents, therefore, a major public-health concern. This is a problem that may be first addressed by starting with changes in individual behavior, with the support of both public-policy measures as well as employers (Grandner et al., 2010).

As mentioned above, lack of sleep has a negative impact at many levels. Besides affecting an individual's cognitive well-being and productivity, it can also lead to workplace injuries, motor vehicle accidents and medical errors (Pack et al., 1995). (Nuckols et al., 2009 cit in., Hafner et al., 2017).

Insufficient sleep is normally seen as an individual problem, however, it may have an impact and consequences in both an economic and societal level - such as the fact that poor sleep can affect an individual's cognitive processes and therefore increasing the risk

of injuries and fatal accidents, which has a negative impact beyond the individual one (Hafner et al., 2017).

As discussed in a previous section, insufficient sleep leads to daytime sleepiness (Caples et al., 2005), which affects a large proportion of people and is a serious cause of mortality (Hammond, 1964). However, although there's a high prevalence of sleep disorders, their management is frequently ignored by society in general as well as individuals. This leads to an under treatment of sleep disorders and has as consequence tremendous cost implications, which makes it an important health concern (Hossain & Shapiro, 2002).

The costs, which will further be discussed, can be direct or indirect (Hillman et al., 2006), however, not much has been published regarding the economic consequences of sleep disorders.

There is evidence suggesting how cost saving it is to treat, for example, patients with OSA, because of its high prevalence, mortality and health care consumption. Therefore, economic analyses could help with the understanding of the resources available, in order to set priorities and implement management strategies (e.g. sleep medicine education among the population and healthcare professionals and availability of diagnostic and therapeutics). This way costs would be controlled, eventually even reduced, without giving up safety (Hossain & Shapiro, 2002).

1.5.1. *Motor Vehicle Accidents*

Driving a motor vehicle is considered a complex task that demands a variety of skills, such as perceptual, motor, cognitive and decision-making skills. Sleepiness can influence all of these skills, therefore, it isn't surprising that individuals who suffer from excessive daytime sleepiness can have an increased risk for motor vehicle accidents (George, 2007).

Obstructive Sleep Apnea (OSA) has been linked with a high risk for motor vehicle accidents, almost certainly the highest of all risks due to the medical conditions involved (Rodenstein, 2009). Drivers must be capable of examining their surrounding environment, making adjustments in their position and speed and staying in their driving lane, which makes driving a "divided-attention task". As a result, higher rates of motor vehicle accidents are expected in OSA (Shiomi et al., 2002; Horstmann et al., 2000)

There is a considerable amount of research that supports that OSA represents a significant risk for motor vehicle accidents (George & Smiley, 1999). In the USA, the cost of traffic accidents due to OSA has been estimated to be so high that diagnosing and treating all drivers suffering from OSA would be more cost saving and would result in a decline of the costs related to the disease (Rodenstein, 2009).

Driving licenses are provided according to national legislations, however, these licenses are not informed regarding OSA. In the European Union a minimum set of rules is mandatory for all countries. However, OSA is not considered in the minimum as well. Nonetheless, OSA can be reckoned, screened and diagnosed easily and once diagnosed the appropriate treatment allows an individual to perform safe driving (Rodenstein, 2009). Therefore, a step forward would be achieved if OSA would be included in the European traffic license regulations, as safety would be achieved for both patients and healthy people (George, 2007).

Driving while feeling sleepy is considered a risk for public safety in Europe. This conclusion was reached by the European study “Sleepiness at the Wheel across Europe”, published in 2015 and coordinated by the Portuguese researcher Marta Gonçalves, a specialist in Sleep Medicine. In Portugal, 22.3% of drivers have already fallen asleep while they were driving, and of these 1.7% have already been involved in car accidents as a consequence (Gonçalves et al., 2015). In fact, 40% of the Portuguese population has already had a situation of strong tiredness and drowsiness while they were driving. This conclusion was reached by the aforementioned survey by the Portuguese Pneumological Society (2018).

Drivers mentioned a great number of factors that have an impact on their driving. However, a common factor is the fact that they did not get enough sleep the night before or they had a bad night of sleep, as 42.5% of the individuals stated that when the accident happened the cause was falling asleep. Additionally, 34% of individuals stated they repeatedly sleep bad and 1.5% mentioned working in shifts. Another possible reason for this type of driving can be medication (8% of participants). Other conclusions were reached with this study, namely the fact that there’s a higher prevalence of accidents at a younger age (Gonçalves et al., 2015).

1.6. Impact of sleep in Performance

As it is known there isn't an agreement between the quantity of hours slept by workers and the importance of sleep, therefore, occupational health researchers have been studying this topic more frequently (Kucharczyk et al., 2012). Although these studies created very useful findings, a deep understanding of the importance of sleep to workplace behavior and performance hasn't been done yet (Kucharczyk et al., 2012).

However, the quality and quantity of sleep of an individual have considerable implications in motor functioning (Durmer & Dinges, 2005), cognitive performance (Lim & Dinges, 2007), long-term physical health (Strine & Chapman, 2005) and mental health (Benca et al., 1997).

Besides wellbeing and health, research proves that sleep has an important role in regulating an individual's cognitive performance as well as workplace productivity, which suggests that poor sleep leads to less work productivity, medical errors, higher motor vehicle accidents and industrial accidents (Nuckols et al., 2013; Ulmer et al., 2009; Pack et al., 1995).

Accordingly, it is known that insufficient sleep can have a negative impact on all ages, however, among both adolescents and children it can lead to unrepairable long-term consequences, as it affects their performance at school and cognitive ability (Blunden et al., 2000; Owens et al., 2000; Roberts et al., 2009). This makes sleep very important for human learning (Hillman et al., 2006 cit. in, Amorim et al., 2018).

It is, therefore, important to preserve a good cognitive level in workers and in academic students, as it is a public health priority, and can lead to negative consequences on many levels (Magnavita & Garbarino, 2017).

1.6.1. *Academic Performance*

College students are known for their irregular sleep schedules. These schedules combined with other things students normally do (e.g., caffeine consumption and alcohol) are linked with poor sleep hygiene (Brown et al., 2002). Students are known for not having enough sleep during the week, however, they sleep longer during the weekend. Accordingly, twice as many students as individuals in the general population describe having symptoms of delayed sleep phase syndrome (Lack, 1986), that is a sleep condition characterised by a significant delay in the phase of the major sleep period in relation to the

desired or required sleep and wake-up times (Sateia, 2014). This syndrome is described as waking up later both on nonschool or nonwork days, leading to a poor academic performance and excessive daytime sleepiness (Coren, 1994). However, not only school performance is affected by insufficient sleep, so is skill accumulation which can have negative effects in the future (e.g., earnings) (Hafner et al., 2017).

Considering the aforementioned, this is a problem and a threat to academic health, safety and success of academic students as well as an important public health matter (Owens et al., 2014).

In 2010, insufficient sleep in adolescents was recognized as a serious health risk, both by the American Medical Association and The American Academy of Sleep, due to the negative impact insufficient sleep can have on all ages (Owens et al., 2014). Sleep deprivation in both children and adolescents can create long-term consequences that can't be fixed, if those who have poor sleep achieve less than usual at school. Therefore, the literature suggests a clear association between quality and quantity of sleep with cognitive ability and school performance among this school population (Blunden et al., 2000; Owens et al., 2000).

Accordingly, poor sleep quality can lead to psychological distress (Buysse et al., 1989), such as anxiety, depression, general cognitive problems (e.g., attention deficits and poor problem solving), reduced physical health (Pilcher et al., 1997) as well as an increased use of alcohol and drugs (Jean-Louis et al., 1998).

The impact of sleep in academic performance has been discussed by several authors. Fredrisksen et al., (2004), proposes how an additional one hour of sleep in American high school increases students' academic achievement. According to Hafner et al., (2017), the proposition of Fredriksen et al., (2004) combined with the one's from Eaton et al., (2010), which show again that in American high-schools 68.8% students get insufficient sleep, leading to the conclusion and suggestion that over two-thirds of all students could improve their academic performance and results if they slept more (Hafner et al., 2017). However, students are often unaware of how insufficient sleep influences their cognitive functioning (Brown et al., 2002).

Sleep seems to balance and strengthen a variety of memory contents (Diekelmann & Born, 2010) - meaning that both the consolidation of memories and encoding are negatively influenced by insufficient sleep (Yoo et al., 2007). Also, sleep helps with the

generalization of knowledge and makes the understanding of hidden rules easier (Ellenbogen et al., 2007; Wagner et al., 2004). All these abilities are extremely important during academic years, which is often seen as the most challenging and demanding period in an individual's life (Ahrberg et al., 2012).

1.6.2. *Workers Performance*

Until recently, the impact of sleep in human functioning was separated from the organizational psychology literature. Large-scale studies show that on average individuals spend more time sleeping than they do working (Barnes & Wagner, 2009). Therefore, sleep is an important activity in the lives of employees, as there are several negative effects when someone has a poor sleep (Harrison & Horne, 2000; Lim & Dinges, 2010; Pilcher & Hufcutt, 1996 cit in., Barnes, 2012), including the negative impact on organizations (Kronholm et al., 2008).

Health, productivity and wellbeing function in a complex relationship between each other, and poor sleep can act as a moderator. Sleep disturbances, on the one hand, can be the cause of reduced wellbeing and, on the other hand, the consequence of reduced wellbeing. Therefore, sleep disturbances can have consequences in productivity and, in the longer term, in the safety and health of workers (Magnavita & Garbarino, 2017).

In order to investigate the relationship between poor sleep and productivity, research is being done. Bolge et al., (2009), for example, found that insomnia was associated with losses in work productivity. Additionally, when working with data collected from the American Insomnia Survey, Kessler et al., (2012) found that there was an important association between presenteeism and insomnia.

The relationship between insomnia and productivity loss was not only observed by Bolge et al., (2009), but also by Sarsour et al., (2011). Sarsour et al., (2011) declared that employees suffering from insomnia had 72% higher lost productivity costs than their colleagues without this condition. More recently, Katz et al., (2014) studied the relationship between employee productivity and different lifestyle practices, such as sleep, and they concluded that employees who sleep less than seven to nine hours of sleep have a higher productivity loss.

A study done by Hafner et al., (2017), showed that sleeping both less and more than the recommended number of hours of sleep has a negative impact on an individual's

workplace productivity (working time that is lost, due to presenteeism and absenteeism). According to this study, the influence of insufficient sleep is not only seen at the individual level, where those who are short sleepers are associated with higher risks of certain health conditions, such as obesity, cardiovascular disease (Wolk et al., 2005) (responsible for 31% of all deaths globally (OPAS, 2016)) and diabetes (which has a prevalence value of 13.3% for Portugal (APDP, 2016)). It is also seen at the organizational or employer level, where workers with insufficient hours of sleep tend to be off work (absenteeism) or at work, however, not performing the way they normally perform (presenteeism). This has, of course, costly consequences for employers (Barnes, 2012).

However, insufficient sleep not only has consequences for employers but also in work outcomes and processes, therefore, organizational psychology researchers have started to study it (Barnes & Hollenbeck, 2009). According to Gibson and Shrader (2014), there is a positive association between salaries and sleep duration and if individuals slept one hour more than what they sleep on average during a week wage would increase by 1% in the short term and 4.5% in the long term.

Other factors in the workplace environment that seem to be affected by poor sleep quality and quantity are unethical behavior (Barnes et al., 2011), job satisfaction (Scott & Judge, 2006), a higher risk of work injuries (Barnes & Wagner, 2009) and lack of innovative thinking (Harrison & Horne, 1999). However, researchers (organizational psychology field) are starting to show the importance of sleep as a driver of employee behaviors. Indicating the important impacts and consequences that have been overlooked in the past (Barnes, 2012).

Although people think of sleep as a period of inactivity, research shows that sleep is a period of physiological activity involving restorative processes that are necessary for an individual's brain functioning (Hobson, 2005), therefore attention should be given to sleep and its importance due to the impact it has on a employee's productivity and not only.

1.7. Productivity, Absenteeism and Presenteeism

Productivity stands for the best performance an individual can possibly achieve at the workplace. Therefore, employee efficiency (i.e. time or resources required to do a

specific task), the objectives that are reached and the problems solved, are some of the factors that are considered when talking about employee productivity (Tarro et al., 2020).

Absenteeism has many possible definitions, however, it can be defined as the period of time an employee is away from work, for reasons such as disability or illness (Tarro et al., 2020). Swarnalatha and Sureshkrishna's (2013) definition describes absenteeism as "failure to report to work", suggesting as well that employees who are frequently absent from their workplace are a threat to organizations. Also, according to Senel & Senel (2012) when an employee makes the intentional decision not to go to work, for any reason besides being ill or other valid reasons, it is considered absenteeism.

In many countries, absenteeism is an important problem in human resources management, both in public and private sectors, as employees who work in the public sector take more sick leaves then employees that work in the private sector in very similar positions (Cucchiella et al., 2014). Accordingly, absenteeism can be seen as a burden by managers. Organizations should, therefore, calculate the costs of absenteeism on a regular basis in order to allow managers to be aware of the seriousness of the problem and the impact it has on profits (Grobler et al., 2006), a company 's strategies and other factors (Cucchiella et al., 2014).

According to an employment contract, employees have the obligation to be present at work both regularly and efficiently, however, when they fail to do so it is considered a case of absenteeism (Badubi, 2017), as these absences raise both direct costs and indirect costs. Direct costs include the salaries that are paid to workers even though they are absent from their workplace and indirect costs are the poor quality of services that are offered by a company (Goodman & Atkin, 1984).

Although absenteeism can have a negative impact on companies, excessive presence also increases the risk of making mistakes, which has a negative impact on a company as well (Halbesleben et al., 2014). Following this line of thought, Badubi (2017) states that absenteeism is not good for organizations. However, there are circumstances where not having an employee showing up at work has advantages (e.g., unwell or fatigued doctor). Accordingly, absenteeism has positive and negative impacts at many levels: the individual, the society and the organization (Goodman & Atkin, 1984).

Presenteeism, on the other hand, is described as an individual who is doing the supposed work, however, at a lower level than he usually does during work. Like

absenteeism it affects well-being at work, employee productivity and a company's performance (Ferreira et al., 2019).

Considering the aforementioned, absenteeism and presenteeism can lead to an increase of mistakes at work but also to workplace injuries, as in 2017 there were 2.25 fatal accidents per 100 000 workers in Europe, while in Portugal there's a prevalence of 3.86% workplace injuries (Eurostat, 2020).

It is, therefore, possible to conclude that both absenteeism and presenteeism cannot be understood as a simple phenomenon as they are linked to a variety of other factors and they represent organizational, social and economic inefficiency (Cucchiella et al., 2014). Therefore, adequate and motivating work conditions/ environments are fundamental to decrease absenteeism and presenteeism (Green et al., 2006) and, this way, reduce direct and indirect costs (Tarro et al., 2020). The opposite conditions support both phenomenon's (Green et al., 2006).

According to the World Health Organization (2021), Europe has an average productivity loss of 22.7% and absenteeism from work due to illness represents 11.9 days per employee per year. Regarding Portugal, the prevalence of absenteeism from work due to illness is 12.9% (Pereira, 2020) and 9.4 days per employee per year (World Health Organization, 2021), which has an impact on the Portuguese economy.

1.8. The Economic Impact of Sleep

As sleep is an individual's largest use of time, it influences performance and focus on demanding tasks and memory and, therefore, it is believable to have an impact on economic outcomes (Gibson & Shrader, 2014). As mentioned throughout this dissertation, sleep plays an important role in productivity, as tired doctors make more errors (Ulmer et al., 2009) and unrested students have a poor performance at school (Taras & Potts-Datema, 2005). Accordingly, insufficient sleep not only reduces productivity and increases mortality rates (Cappuccio et al., 2010), but it also creates considerable direct costs on society and sets back the growth of human capital (Gibson & Shrader, 2014).

In the past years, as adults in the United States, for example, have been sleeping less than the recommended time, interest and attention in poor sleep has been growing and it was already characterised as a public health problem (National Sleep Foundation, 2002 cit. in, Mastin et al., 2006). Accordingly, it is estimated that there is a yearly cost of around

10 billions of US dollars to society, as a consequence of sleep problems (Leger, 1994), which raised interest in sleep hygiene and habits (Mastin et al., 2006).

Regarding the European level, there are not many scientific studies that centre their attention on the hours spent sleeping, however, there's data that seems to show that Portugal rests less when compared to other European countries. On the contrary, Denmark, Sweden and Norway seem to be more advanced in the understanding of the importance of sleep.

Following this line of thought, Gibson & Shrader (2014), reached the conclusion that sleep and sleep duration have a crucial impact on a country's economy. It should, therefore, be seen as an important factor of a worker's optimization, as sleep can be considered the third most important determinant of productivity, after human capital and ability.

An example is a paper published by "The Economist" magazine that shows an obvious relationship between a country's wealth and the hours spent sleeping. At the top of the list with more than seven and a half hours of sleep every day are countries like New Zealand, Finland, and the Netherlands - all with a per capita GDP of at least 40 000 euros.

Although economists have tried to study how individuals distribute their time, the time spent sleeping has been frequently ignored (Biddle & Hamermesh, 1989), as there is a failure to understand sleep and its importance, even though it has been shown that sleep and economy are related (Duncan, 1980). Therefore, starting the prevention of sleeping problems at a younger age can positively influence the economic impact and cost of sleeping problems as they can be drastically reduced (Hillman et al., 2006).

1.9. Aims of the Present Study

The primary aim of this dissertation is to analyse the cost of poor sleep in the Portuguese economy, as the consequences of sleep to both an individual's health and the economy have not been profoundly analysed. The present dissertation aims to contribute to the literature as well as our society by demonstrating the importance of sleep and how improving an individual's sleep habits can have both a positive impact on the individual's health and in the economy, as sleep influences a variety of other factors such as productivity at work, other diseases (cardiovascular disease, depression, etc.) and safety while driving.

This aim is reflected throughout the dissertation as a range of topics is discussed and the implications of poor sleep and sleep conditions, like Insomnia and Obstructive Sleep Apnea. These are linked to other variables as a whole and individually contribute to high costs not only to the Portuguese economy, but to all economies. However, Portugal and the Portuguese economy are the main focus of the present thesis.

In order to analyse the cost of poor sleep in the Portuguese economy, an Australian study, "The economic cost of inadequate sleep" (Hillman et al., 2018), was replicated for the Portuguese context using Portuguese indicators in order to obtain the approximate real costs for the Portuguese economy. Therefore, the present thesis consists of a Systematic Literature review, as specific articles and keywords were selected and the research was critically done and considered in order to obtain results regarding the topic in question.

To calculate the costs for the Portuguese economy a Population Attributable Fraction (PAF) calculation was done - which gives the values of what portion of a cost or problem was due to the sleep problem. There were two possible ways of calculating the costs for the Portuguese economy: (1) using the cost of a specific disease in Portugal and the PAF calculation, obtaining this way the real cost of the disease in Portugal; (2) using the estimated cost of a specific disease in Portugal and the PAF calculation.

Finally, the goal of this dissertation is to show that having good sleeping habits and giving to sleep the importance it deserves is more cost-effective to Portugal's economy than ignoring the problem - as there is considerable evidence suggesting it. A problem that is considered a public health problem (National Sleep Foundation (2013), cit in., Hafner et al., 2017). Therefore, as Hossain & Shapiro (2002) state, the availability of diagnostic and therapeutic facilities to treat sleep disorders together with trained health care professionals, and health education measures will reduce the intense socioeconomic implications of untreated sleep disorders.

2. Study Methodology

In order to understand the impact of poor sleep in the Portuguese economy a Systematic Literature Review was conducted, to further make approximate real predictions of how much money is spent every year due to poor sleeping habits and sleep diseases like Insomnia and Obstructive Sleep Apnea.

To do so, research was done around fields such as sleep, the economic impact of sleep, the importance of sleep in performance, how sleep influences an individual's life and the cost of poor sleep in a country's economy. Therefore, platforms like PubMed, Google Scholar, SpringerLink, governmental websites and articles make part of the electronic search strategy, as they were used to obtain the best and most reliable information that follows the goal of the dissertation. After an extensive reading of all articles, including only titles and abstract or based on the full text, that were related to the main objective of this dissertation, a combination of information was created in order to conduct a detailed review on how poor sleep impacts the Portuguese economy.

When doing the research around the fields mentioned above, some eligibility criteria were considered, namely the search for articles both in the Portuguese or English language as the goal is to analyse the Portuguese economy using knowledge and experience from other countries, like Australia, that are one step ahead in the investigation of sleep and the impacts it has both, in the individual sphere and in the society. Additionally, some exclusion criteria were also considered, such as the exclusion of articles that included the sleep basic science and others that are further mentioned, as it does not apply to the main goal of the present dissertation. No exclusion criteria were applied regarding the year of publication of the chosen articles, in order to obtain a proper background on sleep (i.e., past investigation and findings).

The screening and selection process of articles included many steps - beginning with a vast number of studies (i.e. 500 studies) and reducing to 119 studies, which were the ones that followed the main purpose of this dissertation, namely the understanding of the costs of poor sleep in the Portuguese economy. Excluded articles were the ones that did not focus on this purpose or articles from countries that had little or no similarities to Portugal, which didn’t make sense to include.

The included articles were the ones that brought rich information on the topic that is being studied - including information such as the factors that modify sleep, why sleep is

so important in an individual’s life, how costly is sleep, etc. All the included articles were considered as they focused on specific topics of each of the sections of the dissertation, such as the impact of sleep in academic and workers performance. Keywords were identified when choosing the included articles in order to filter which articles were valuable and which weren’t, these are mentioned in the systematic search of the dissertation.

In order to proceed in the Methods section, PRISMA guidelines were followed (e.g., Moher et al., 2009).

2.1. Method

Review question. This systematic literature review aims to answer the following broad question: “What is the cost of poor sleep in the Portuguese economy?”.

Inclusion criteria. The following inclusion criteria guided both the study screening and selection:

Context. Field studies, peer-reviewed journals and databases.

Types of sources. All types of studies published in English or in Portuguese in peer-reviewed journals, including sources such as Google Scholar, PubMed Central (U.S. National Institutes of Health's National Library of Medicine), Springer Link, as well as governmental entities and scientific associations websites (e.g. Direção Geral da Saúde, World Health Organization, Direção Geral da Saúde, Associação Protetora dos Diabéticos de Portugal, Organização Pan-Americana da Saúde, Eurostat).

Exclusion criteria. For the present dissertation the following exclusion criteria guided the study screening and selection: (1) Sleep physiology. (2) The economic cost of sleep in countries that have no similarities to Portugal. (3) Study is not reported in English or Portuguese. (4) Study is not reported in a peer-reviewed journal or a governmental entity or scientific association.

Search strategy.

Systematic search. As previously mentioned, platforms like Google Scholar, PubMed Central, SpringerLink and governmental entities (websites) were used for the search and keywords such as “sleep”; “economic impact of sleep”; “cost of sleep”, “Insomnia”; “OSA”; “sleep and health”; “well-being”; “performance” and “productivity”; “presenteeism”; “absenteeism”; “benzodiazepines”; “sleep and age”; “direct and indirect

costs”; “motor vehicle accidents”; “cerebrovascular disease”; “diabetes”; “depression”; “coronary artery disease”; “congestive heart failure”; “workplace injuries”; “sleep patterns”; “Portugal” were used in order to obtain the articles that apply to the aim of this dissertation. In the majority of the cases two keywords were combined with each other (e.g. “sleep and age”, “Insomnia and Portugal”). The search started in January 2020 and was an ongoing process until the delivery of the present work.

Manual search. A manual search was not conducted.

Study screening.

Based on title and abstract. 500 records were screened based on the journal’s title and abstract within Mendeley. In order to do this, the studies were added to the Mendeley library in a specific folder according to the topic of the article. Afterwards a selection of the items that would be included in the next stage of screening, based on the compatibility considering both the inclusion and exclusion criteria, was conducted. Based on this, 212 records were considered and included in the next stage of the screening process. Furthermore, the full text of all articles was downloaded, when available, and each of the studies was listed in an Excel file with 119 studies.

Based on the full text. Each study was full-text screened according to the aforementioned exclusion criteria resulting, therefore, on 119 included studies.

Data extraction. The data extraction process occurred by the tracking of specific categories of each study. Categories such as: Definition of sleep; What is sleep; Factors modifying sleep; Impact of sleep in an individual's life, here, encountering a variety of other factors (e.g. performance, motor vehicle accidents, health, productivity, absenteeism, presenteeism); Impact of sleep in the economy (e.g. direct and indirect costs; treating sleep would cost-saving); Characteristics of insufficient sleep and how it is caused; Consequences of insufficient sleep; Characteristics related to sleep diseases (e.g. Insomnia, OSA and their prevalence values); Impact of Insomnia and OSA in an individual’s life; Sleep disorders and other conditions (e.g. diabetes, depression, cerebrovascular disease etc. and it’s prevalence values); Characteristics related research practices (whether the study was open access, or, accessible from Portugal; whether the characteristics of the study apply to Portugal).

Presentation of results. In line with the purpose of this dissertation a table listing all the studies included in the final review is presented in supplementary (Appendix A).

The inclusion of this table allows other researchers to see which studies were included in this dissertation and it helps them carry out other future analyses. Appendix A includes the following indicators: DOI; 1st Author; Year; Title; Journal.

2.2. Data Collection

In order to analyse the costs of poor sleep in the Portuguese economy, the same protocol as an Australian study, "The economic cost of inadequate sleep" by Hillman et al., (2018), was used. However, using indicators that apply to Portugal only and using Portuguese values in order to obtain the approximate real costs in the Portuguese economy.

In order to do so, an Excel document including all the considered indicators (Congestive heart failure, Coronary artery disease, Cerebrovascular disease, Depression, Type 2 Diabetes, Workplace injury, Motor vehicle accidents) was created. Research was done in order to obtain the prevalence of each of these indicators for Portugal (Appendix B)as well as the cost of each of these indicators for Portugal, therefore, sources like Portuguese Sleep Association; Associação Protetora dos diabéticos de Portugal (APDP) (2016); The Wake-up Bus Study by Gonçalves et al., (2015); Direção Geral da Saúde (2014); (Fonseca, 2017), (Eurostat, 2020), (OPAS, 2016), (Fiuza, 2012); (Sousa-Uva & Dias, 2012) were used. The prevalence for insufficient sleep (Reis et al., 2018) and the prevalence for excessive daytime sleepiness both in regular workers and shift workers (Reis et al., 2020) were also obtained through research papers.

However, it was not always possible to find the costs of some diseases in Portugal. In these cases, values from another country, namely Spain or Australia, were used as proxy values as this dissertation follows the same protocol as the Australian study "The economic cost of inadequate sleep". How this calculation was done will be explained in the Statistical Analyses section.

2.3. Statistical Analysis

To obtain the costs for the Portuguese Economy the Population Attributable Fraction (PAF) was calculated. The PAF gives the values of what portion of a cost or problem is due to a sleep problem (Hillman et al., 2018). When calculating the PAF three variables were considered, namely the portion of people in Portugal with a particular

disease (e.g. Depression), the portion of people in Portugal with a particular sleep disorder (e.g. OSA or Insomnia) and the odds ratio (OR), which shows the likelihood of an individual having the disease when he has the sleep disorder.

As previously mentioned, research was done in order to find out the prevalence of the conditions included in this dissertation, focusing on Portugal (e.g. Congestive heart failure, Coronary artery disease, Cerebrovascular disease, Depression, Type 2 Diabetes, Workplace injury and Motor vehicle accidents) (Appendix B). Additionally, the prevalence of OSA and Insomnia was also searched (0.89% and 28.1% respectively), as these were the two sleep disorders considered in this dissertation. The odds ratio for each of the studied conditions was taken from an Australian article, "The costs of inadequate sleep" by Hillman et al., (2018).

Once having the prevalence for the conditions that are being studied, the prevalence for OSA and Insomnia and the odds ratio values, the PAF calculation was done. This calculation was done using *R*, and considering the prevalence of a condition in Portugal (p1), the prevalence of a sleep disorder in Portugal (s1) and the odds ratio (Table 1.).

The PAF calculation was done in order to obtain the portion of a cost or problem that is due to a sleep problem and the values that were obtained were further used, together with the cost of a disease in Portugal, in order to obtain the costs of excessive daytime sleepiness. This will further be explained.

A search was undertaken for the cost of each of these conditions in Portugal. These costs were searched for relating to Portugal, because when multiplicated with the values obtained from the PAF calculation, they provide the cost of a disease in Portugal due to excessive daytime sleepiness. Therefore, the PAF values which were the first values that were calculated were always used throughout the calculation of the costs.

However, it was not possible to find the cost of the studied conditions in Portugal and, for that reason, estimated values were calculated from alternative countries. To do so other factors had to be considered while doing the calculation. The following variables were considered: cost of the condition in another country (e.g. Spain or Australia); population of another country (e.g. Spain or Australia); population of Portugal; incidence of condition in another country (e.g. Spain or Australia), incidence of condition in Portugal; health care expenditure per person in another country (e.g. Spain or Australia; 3123€ and 4480€ respectively); health care expenditure per person in Portugal (2918€)

(Health Care Expenditure and Financing, OECD). Once obtaining each of the values, for Portugal, Spain and Australia respectively, an estimate of the cost of the studied conditions in Portugal was obtained (Appendix F).

As there are no existing studies in Portugal that calculate the cost of each of the conditions, values from other countries had to be used as a proxy. Therefore, existing values from Spain (e.g., prevalence of disease, cost of disease) were used, as Spain and Portugal have a similar health care expenditure per person. In the cases where values for Spain weren't available as well, Australian values were used.

Table 1. PAF calculation

	p1 - Prevalence of disease in Portugal	**s1 - Prevalence of sleep disorder Portugal**	**Odds Ratio**	**Sleep disorder**	**PAF**
Congestive Heart Failure	4.36	0.89	1.6	OSA	0.5
Coronary Artery Disease	27.5	0.89	3.2	OSA	0.88
Cerebrovascular Disease	1.9	0.89	2.9	OSA	1.58
Type 2 Diabetes	13.3	0.89	1.63	OSA	0.45
Depression	7.9	0.89	2.6	OSA	1.15
	7.9	28.1	2.1	Insomnia	21.34
Workplace Injury	3.86	0.89	1.5	OSA	0.42
	3.86	28.1	2.4	Insomnia	26.89
Motor Vehicle Accident	1.7	0.89	2.5	OSA	1.26

All the costs that were obtained for Congestive heart failure, Coronary artery disease, Cerebrovascular disease, Depression, Type 2 Diabetes, Workplace injury and Motor vehicle accidents were then multiplicated with PAF value that had already been calculated (Table 1). This way, the cost of these conditions due to excessive daytime sleepiness were obtained (Table 2).

While doing these calculations another factor was considered, namely the currency of the costs. When using values from Australia, these were in dollars, therefore, a conversion to euros was done using the currency available in *Banco de Portugal*.

Once calculating PAF, the general cost of studied conditions (i.e. Congestive heart failure, Coronary artery disease, Cerebrovascular disease, Depression, Type 2 Diabetes, Workplace injury and Motor vehicle accidents), and the cost of a condition due to excessive daytime sleepiness it was possible to make estimations of how much money is spent in Portugal. These will be discussed in the Results and Discussion sections of this dissertation.

Another statistical analysis relating to OSA was performed, as the total prevalence of OSA in Portugal is unknown and the costs obtained were calculated with a prevalence of 0.89% of OSA. However, this prevalence value was based in the Portuguese General Practitioner Sentinel Network surveillance records and might be under representative. Therefore, in order to prove the assumption that with a higher prevalence of OSA, higher costs would have been obtained the PAF calculation was also performed for a 32.8%, which represents the prevalence of OSA in Brazil calculated for a representative sample of Brazilians with a confirmed clinical diagnose of OSA (Tufik et al., 2010) (Appendix D). When doing this PAF calculation for 32.8% of OSA, all the previous prevalences of the conditions as well as odds ratio were used.

3. Results

In order to obtain the results, previous calculations had to be done (i.e. PAF calculation and the estimated cost of a condition in Portugal).

The prevalences found for Portugal for each of the conditions were the following: Congestive heart failure 4.36%; Coronary artery disease 27.5%; Cerebrovascular disease 1.9%; Type 2 Diabetes 13.3%; Depression 7.9%, Workplace injury 3.86%, Motor vehicle accident 1.7% (Appendix B). Regarding the prevalence of the sleep disorders in Portugal, OSA has a prevalence of 0.89% and Insomnia has a prevalence of 28.1% (Appendix B).

All these prevalences together with the odds ratio (Table 1), were used to calculate the PAF. The PAF for each of the conditions was the following: Congestive heart failure 0.5; Coronary artery disease 0.88; Cerebrovascular disease 1.58; Type 2 Diabetes 0.45; Depression with OSA 1.15, Depression with Insomnia 21.34; Workplace injury with OSA 0.42; Workplace injury with Insomnia 26.89; Motor Vehicle accident 1.26. It is important to highlight that each of these PAF values were obtained with the prevalence 0.89% of OSA, except for depression and workplace injury were besides OSA, where the incidence value for Insomnia was also used (28.1%) (Table 1).

As mentioned in the Statistical analysis section of this dissertation, values from other countries (e.g. Spain or Australia, respectively "Reference country" in Table 2) were used to estimate the cost of a condition in Portugal (Figure 1). Therefore, the costs obtained were the following: Congestive heart failure 305 million euros; Coronary artery disease 5.4 billion euros; Cerebrovascular disease 496 million euros; Type 2 diabetes 1.7 billion euros; Depression 2.3 billion euros; Workplace injuries 12.9 billion euros and Motor vehicle accidents 720 million euros. These represent the annual costs in Portugal for each of the conditions studied in this dissertation.

Once obtaining these costs, the PAF calculation together with these costs was used in order to obtain the cost due to excessive daytime sleepiness (EDS), obtaining the following costs for EDS: Congestive heart failure 2 million euros; Coronary artery disease 48 million euros; Cerebrovascular disease 8 million euros; Type 2 Diabetes 8 million euros; Depression with OSA 27 million euros; Depression with Insomnia 499 million euros; Workplace injury with OSA 55 million euros; Workplace injury with Insomnia 3.5 billion euros; Motor vehicle accidents 9 million euros. Once again, each of these costs was

obtained with the prevalence 0.89% of OSA, except for depression and workplace injury were besides OSA, the value of Insomnia (28.1%) was also used (Table 2).

Therefore, the total cost of EDS related to the studied conditions is 4.1 billion euros (Table 2).

Regarding the prevalence of OSA in Brazil (32.8%), the PAF for each of the conditions was the following: congestive heart failure 15.65; coronary artery disease 28.87; cerebrovascular disease 37.59; type 2 diabetes 14.6 (Appendix D). Hereby, the costs obtained for excessive daytime sleepiness were higher: congestive heart failure 48 million euros; coronary artery disease 1.5 billion euros; cerebrovascular disease 186 million euros; type 2 diabetes 253 million euros (Appendix E).

This study attempted to answer one main hypothesis: "Has Portugal higher costs due to poor sleep, in comparison to other countries?", which is possible to answer taking into consideration the main results that were obtained. The discussion of the results obtained can be found in the discussion section of this dissertation.

Table 2.

Costs of conditions in Portugal due to EDS and estimation of costs of condition in Portugal

Condition	Cost of this condition in Portugal	Cost due to excessive daytime sleepiness	Type of EDS-SD	Reference Country	Cost of this disease in other country
	MEUR	MEUR			MEUR
Congestive Heart Failure	305	2	OSA	Australia	777
Coronary Artery Disease	5 414	48	OSA	Australia	2 200
Cerebrovascular Disease	496	8	OSA	Australia	5 000
Type 2 Diabetes	1 736	8	OSA	Spain	5 120
Depression	2 337	27	OSA	Spain	6 145
	2 337	499	Insomnia	Spain	6 145
Worplace Injury	12 993	55	OSA	Australia	61 800
	12 993	3 494	Insomnia	Australia	61 800
Motor Vehicle Accident	720	9	OSA	Spain	5 900
Total cost EDS		4 148			

4. General Discussion

4.1. Discussion

Poor sleep is a public health problem affecting a considerable number of individuals, which can be a consequence of clinical sleep disorders (e.g. Insomnia and OSA) and a consequence of sleep restrictions that are related to work or lifestyle. There is, therefore, both a human cost (e.g. wellbeing, health, safety and productivity) and an economic cost, which is presented and visible with the results obtained in this dissertation.

During the statistical analysis of this dissertation, values from other countries (e.g. Spain or Australia, respectively "Reference country" in Table 2) were used to estimate the cost of a condition in Portugal (Appendix C; Appendix F). These costs do not represent the costs associated with a sleep disorder, they represent the cost of the condition in Portugal. When comparing the costs obtained for Portugal with the costs from the Australian study "The cost of inadequate sleep by Hillman et al., 2018, it is possible to conclude that Portugal has higher costs than Australia in each of the conditions.

In the case of congestive heart failure Portugal has an annual cost of 305 million euros, whereas Australia has a cost of 7.9 million euros. Portugal has an annual cost of 5.4 billion euros with coronary artery disease, while Australia has a cost of 67.2 million euros. Regarding cerebrovascular disease, Portugal spends 496 million euros every year, whereas Australia spends 41.1 million euros. In the case of type 2 diabetes, Portugal has an annual cost of 1.7 billion euros, while Australia has a cost of 10.5 million euros. In Portugal 2.3 billion euros are spent every year with depression, in Australia the cost of depression is 234.8 million euros. The cost of workplace injuries in Portugal is 12.9 billion euros, and in Australia the cost is 365.6 million euros. Regarding motor vehicle accidents, in Portugal there is an annual cost of 720 million euros, and in Australia there's a cost of 206.3 million euros (Hillman et al., 2018).

When comparing the Portuguese total cost due to excessive daytime sleepiness, associated with a sleep disorder (e.g., OSA or Insomnia), with the total cost in Australia, it is possible to conclude that Portugal has higher costs due to EDS. This dissertation followed the same protocol as the study done by Hillman et al., (2018), therefore, direct comparison can be made. Both in this dissertation and in the study by Hillman et al., (2018) the total cost of EDS was obtained through the costs of the conditions that had been previously calculated together with the PAF value that had been calculated. Therefore,

when comparing, Portugal presents an annual cost of 4.1 billion euros due to excessive daytime sleepiness, whereas Australia presents a cost of 1.1 billion euros.

Once making a comparison between the total cost in Portugal due to a sleep disorder (e.g. OSA and Insomnia) and the costs in Australia it is impossible to answer this dissertation's hypothesis by saying that Portugal has higher costs than Australia. Portugal presents higher costs both on each of the conditions considered in this dissertation, as well as in the total costs due to excessive daytime sleepiness associated with a sleep disorder.

When looking at the results, the prevalence of OSA should always be kept in mind.

The total prevalence of OSA in Portugal is unknown and the costs obtained were calculated with a prevalence of 0.89% of OSA, which is not representative of the Portuguese population. Portugal may have a high number of individuals that haven't been diagnosed OSA. However, if the total prevalence of OSA would be known we might assume that higher costs due to excessive daytime sleepiness would have been obtained. This was shown by the researchers from the University of Wisconsin School of Medicine when they reported that the costs of undiagnosed OSA in U.S. adults was 129.2 billion euros (Watson, 2016). Therefore, if with a prevalence of 0.89% for OSA such high costs were obtained, it might be possible to estimate even higher costs, if the prevalence value for Portugal was based on a representative sample. It is important to highlight that the prevalence value of OSA pointed out by a Brazilian study, assessed with an objective clinical diagnosis, reached a prevalence value of 32.8% (Tufik et al., 2010). This might suggest that the value available for Portugal might be underestimated.

In order to prove the assumption that higher costs would be obtained with a higher prevalence for OSA, a PAF calculation with a prevalence for OSA of 32.8% (Tufik et al., 2010) was calculated (Appendix D). Hereby, the costs obtained for excessive daytime sleepiness were even higher: congestive heart failure 48 million euros; coronary artery disease 1.5 billion euros; cerebrovascular disease 186 million euros; type 2 diabetes 253 million euros (Appendix E).

Sleep is a basic human need and is essential for an individual's attention, social relationships and the execution of simple or complex tasks (Valente et al., 2019). It has been assumed that one of the major purposes of sleep is to repair possible damage from an individual's day to day and to restore and recover an individual's health (Adam & Oswald, 1977). Therefore, the importance of studying "The costs of poor sleep in the Portuguese

economy" lies in the fact that political decisions are mainly based on numbers i.e. economic data.

There are various costs in our society that are a consequence of poor sleep, such as the development of other health conditions that could have been prevented if the sleep disorder (e.g. OSA and Insomnia) would have been both identified and treated sooner (e.g. Cerebrovascular disease). Another example are the economic costs that are a consequence of sleep-related accidents, as excessive daytime sleepiness has a negative impact on productivity at work and can lead to workplace accidents (Shneerson, 2005) that represent enormous economic costs in the Portuguese economy.

Individuals in the society are not aware of the importance of sleep, as there's no education on sleep and good sleep practices. However, sleep should be addressed as early as possible, starting with children and adolescents at schools. Insufficient sleep in adolescents and children can create long-term consequences that reach a point where they can no longer be fixed. Therefore, as suggested by the literature, sleep hygiene practices should be implemented in order to avoid poor cognitive ability and improve school performance (Blunden et al., 2000; Owens et al., 2000).

Policymakers now have the chance to implement measures that promote a good quality and quantity of sleep, avoiding both economic and human costs. They now have the chance to create awareness on the importance of sleep, which can be a win-win situation both for the Portuguese economy and to the Portuguese population. The results obtained in this dissertation prove the importance of giving sleep the proper value it deserves.

Economic evaluations which represent the costs of sleep in Portugal are important and needed, as political decisions are based on numbers. Therefore, the available resources in Portugal should be used, such as the educational psychologists in schools and the organizational psychologists in companies. Psychologists not only can as they should implement good sleep practices in schools and organizations, preventing this which can be considered a "sleep pandemic".

As discussed, sleep has a major effect on an individual's productivity, which has negative consequences in a company's productivity as well as financial outcomes. Therefore, education on sleep and good sleep practices should be given to companies as well as top managers, as they are above regular employers. This would represent, again, a

win-win situation both for a company's financial outcomes and performance as well the company's employers, as their health would be promoted in a safe space.

Sleep is as fundamental as nutrition (Hafner et al., 2015), however awareness for sleep importance in not generally recognized. Consequently, the implications of treating sleep disorders like OSA and Insomnia and the degree of sleep-related problems is not well traced yet (Hossain & Shapiro, 2002). The recent pandemic situation faced since 2019 (COVID-19) had increased the prevalence of sleep problems worldwide. The costs presented in this thesis were based in sleep problems prevalence values before the pandemics so, these costs are expected to be even higher. In a time where the world and Portugal in particular is facing so many economic problems, sleep should be an important issue to address, acting preventively, in order to reduce costs to the Portuguese economy. The purpose of this dissertation is, therefore, to create awareness and show policymakers how cost saving it would be to implement measures that promote the importance of sleep and to act preventively.

4.2. Limitations and Recommendations for Future Research

The major limitation of this study was it being a study based on previous prevalence values obtained for Portugal and several times those values were not available in the literature which leads us to use other countries as proxy precluding direct comparisons.

The present dissertation makes its conclusions based on predictions obtained with the calculation of the costs of poor sleep in the Portuguese economy. Therefore, the estimated costs presented do not represent the actual real costs for the Portuguese economy. This leads to the fact that this dissertation is a Systematic Literature Review and not an observational study where it might be possible to present values and costs representative of the Portuguese population for sleep diseases, sleeping habits as well as the consumption of medication in Portugal or any other indicators.

Regarding recommendations for future research, it is, therefore, advised to conduct an Experimental study, using a representative sample of the Portuguese population, such as Gonçalves et al., (2015) did with the prevalence of Motor Vehicle Accidents in Portugal. This way it is possible to obtain values that represent the real costs of poor sleep in our economy and not only predictions.

It wasn't possible to calculate the total cost of insufficient sleep in our economy, due to the lack of data and values such as the total prevalence of excessive daytime sleepiness in Portugal, as the only available data refers to regular workers and shift workers. The values available for insufficient sleep are self-reported values and they're non-separate for working days and nonworking days, therefore, these values should be obtained for both work and free days as well as recurring to objective measures like actimetry.

This represents a limitation, however a future recommendation as well. Therefore, it is advised to have values for excessive daytime sleepiness in Portugal without the influence of a sleep disorder as well as the prevalence of individuals with EDS that complained of insufficient sleep, which are representative of the Portuguese population. These values together with the prevalence of insufficient sleep in Portugal (20.7%) make it possible to calculate the total cost of insufficient sleep in Portugal (% of insufficient sleep - % of individuals with EDS that complained of insufficient sleep * total prevalence % of EDS).

This way a more complete analysis of the impact of sleep in our economy would be obtained.

4.3. Conclusion

The annual estimated costs of excessive daytime sleepiness to the Portuguese economy are high. Sleep is fundamental in an individual's life. It is considered a public health problem, affecting a considerable number of individuals and creating negative consequences both in individuals and to the Portuguese economy. Political decisions are based on numbers and economic costs, therefore, policymakers now have the chance to implement advantageous measures for individuals and our economy. Portugal should recognize the importance of sleep to the economy and has the chance to follow other countries that are leading in the importance of sleep, such as Australia.

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Appendices

APPENDIX A

List of all included studies

DOI	**First author**	**Year**	**Title**	**Journal**
N.A.	Adam	1977	Sleep is tissue for restoration	Journal for the Royal College of Physicians
10.3109/07420528.2012.719971	Adan	2012	Circadian typology: A comprehensive review	Chronobiology international
10.1016/j.jpsychires.2012.09.008	Ahrberg	2012	The interaction between sleep quality and academic performance	Journal of Psychiatric Research
10.1016/s0212-6567(14)70090-3	Amaral	2014	Sleep patterns and insomnia among Portuguese adolescents: A cross-sectional study	Atención Primaria
10.3389/fnagi.2018.00375	Amorim	2018	Poor Sleep Quality Associates With Decreased Functional and Structural Brain Connectivity in Normative Aging: A MRI Multimodal Approach	Frontiers in Aging Neuroscience
N.A.	APDP	2019	Relatório anual do Observatório Nacional da Diabetes – 2016	Associação Protetora dos Diabéticos de Portugal
10.18775/jibrm.1849-8558.2015.26.3004	Badubi	2017	A Critical Risk Analysis of Absenteeism in the Work Place	Journal of International Business Research and Marketing
10.1093/sleep/zsw066	Barazzetta	2016	Family income and material deprivation: Do they matter for sleep quality and quantity in early	Sleep

			life? evidence from a longitudinal study	
10.1177/2041386612450181	Barnes	2009	Working in our sleep	Organizational Psychology Review
10.1016/j.obhdp.2011.01.009	Barnes	2011	Lack of sleep and unethical conduct	Organizational Behavior and Human Decision Processes
10.1016/S1087-0792(97)90005-8	Benca	1997	Sleep and Mood Disorders	Sleep Medicine Reviews
N.A.	Biddle	1989	Sleep and the allocation of time	National Bureau of Economic Research
10.1076/1380-3395(200010)22:5;1-9;ft554	Blunden	2000	Behavior and neurocognitive performance in children aged 5-10 years who snore compared to controls	Journal of Clinical and Experimental Neuropsychology
10.1007/s11136-009-9462-6	Bolge	2009	Association of insomnia with quality of life, work productivity, and activity impairment	Quality of Life Research
10.1080/08964280209596396	Brown	2002	Relationship of sleep hygiene awareness, sleep hygiene practices, and sleep quality in university students	Behavioral Medicine
N.A.	Burman	2017	Sleep Disorders: Insomnia	N.A.
10.1001/jama.2013.193	Buysee	2013	Insomnia	JAMA
10.1016/0165-1781(89)90047-4	Buysee	1989	The Pittsburgh Sleep Quality index: A new instrument for psychiatric practice and Research	Psychiatric Research

N.A.	Caples	2005	Obstructive Sleep Apnea	American College of Physician
N.A.	Caples	2013	Review Obstructive Sleep Apnea	N.A.
N.A.	Cappuccio	2010	Sleep Duration and All- Cause Mortality: A Systematic Review and Meta-Analysis of Prospective Studies	Sleep
N.A.	Carskadon	2011	Normal Human Sleep: An Overview	Principles and Practice of Sleep Medicine
10.2147/nss.s163071	Chaput	2018	Sleeping hours: What is the ideal number and how does age impact this?	Nature and Science of Sleep
10.5935/1984-0063.20180013	Chattu	2018	Insufficient Sleep Syndrome: Is it time to classify it as a major noncommunicable disease?	Sleep Science
N.A.	Chokroverty	2010	Overview of sleep & sleep disorders.	Indian Journal of Medical Research
N.A.	Colten	2006	Sleep disorders and sleep deprivation: An unmet public health problem	Institute Medicine
10.3109/00207459408986068	Coren	1994	The prevalence of self-reported sleep disturbances in young adults	International Journal of Neuroscience
10.1016/j.sbspro.2014.09.131	Cucchiella	2014	Managing absenteeism in the workplace: the case of an Italian multiutility company	Procedia - Social and Behavioral Sciences.
10.1038/nrn2762	Diekelmann	2010	The memory function of sleep	Nature Reviews Neuroscience

N.A.	Direção Geral da Saúde	2014	Saúde Mental em números - Programa Nacional para a Saúde Mental	Direção Geral da Saúde
10.1055/s-2005-867080	Durmer	2005	Neurocognitive Consequences of Sleep Deprivation	Seminars in Neurology
10.1016/j.jadohealth.2009.10.011	Eaton	2010	Prevalence of insufficient, borderline, and optimal hours of sleep among high school students – United States, 2007	Journal of Adolescent Health
10.1055/s-0030-1265902	Edwards	2010	Aging and sleep: Physiology and pathophysiology	Seminars in Respiratory and Critical Care Medicine
10.1073/pnas.0700094104	Ellenbogen	2007	Human relational memory requires time and sleep	Proceedings of the National Academy of Sciences
N.A.	European Statistics	2020	Navigation. Database - Eurostat	Eurostat
10.1037/str0000114	Ferreira	2019	How daily negative affect and emotional exhaustion correlates with work engagement and presenteeism-constrained productivity	International Journal of Stress Management
10.1016/j.repc.2012.09.005	Fiuza	2012	Síndrome Metabólica e Doença Coronária	Revista Portuguesa De Cardiologia
N.A.	Flemons	2002	Obstructive Sleep Apena	The New England Journal of Medicine
N.A.	Fonseca	2017	For the improvement of Heart Failure treatment in Portugal - Consensus statement	Revista Portuguesa De Cardiologia

10.1111/j.1467-8624.2004.00655.x	Fredriksen	2004	Sleepless in Chicago: Tracking the effects of adolescent sleep loss during the middle school years	Child Development
10.1164/rccm.200605-629pp	George	2007	Sleep apnea, alertness, and motor vehicle crashes	American Journal of Respiratory and Critical Care Medicine
N.A.	George	1999	Sleep apnea and automobile crashes	Sleep
N.A.	Gibson	2014	Time Use and Productivity: The Wage Returns to Sleep	National Science Foundation
10.1111/jsr.12267	Gonçalves	2015	Sleepiness at the wheel across Europe: A survey of 19 countries	Journal of Sleep Research
N.A.	Goodman	1984	Effects of absenteeism on individuals and organization	Journal of Economic Psychology
10.1016/j.jsmc.2016.10.012	Grandner	2017	Sleep, Health and Society	Sleep Medicine Clinics
10.1016/j.sleep.2009.10.006	Grandner	2010	Who gets the best sleep? ethnic and socioeconomic factors related to sleep complaints	Sleep Medicine
10.1080/09585190600581279	Green	2006	The impact of strategic human resource management on firm performance and HR professionals' work attitude and work performance	The International Journal of Human Resource Management

N.A.	Grobler	2006	Human resource management in South Africa	London: Thomson Learning
10.7249/rr1791	Hafner	2017	Why sleep matters -- the economic costs of insufficient sleep: A cross-country comparative analysis	N.A.
10.1016/j.hrmr.2013.09.001	Halbesleben	2014	A dialectical theory of the decision to go to work: Bringing together absenteeism and presenteeism	Human Resource Management Review
10.2105/ajph.54.1.11	Hammond	1964	Some preliminary findings on physical complaints from a prospective study of 1,064,004 men and women	American Journal of Public Health and the Nations Health
10.1006/obhd.1999.2827	Harrison	1999	One night of sleep loss impairs innovative thinking and flexible decision making	Organizational Behavior and Human Decision Processes
10.1126/science.1128898	Heckman	2006	Skill formation and the economics of investing in disadvantaged children	Science
10.1093/sleep/29.3.299	Hillman	2006	The economic cost of sleep disorders	Sleep
10.4081/ni.2011.e15	Ho	2011	Obstructive Sleep Apena	Neurology International
10.1038/nature04283	Hobson	2005	Sleep is of the brain, by the brain and for the brain	Nature
10.1093/sleep/23.3.1e	Horstmann	2000	Sleepiness-related accidents in sleep apnea patients	Sleep

10.1055/s-2002-32322	Hossain	2002	The prevalence, cost implications, and management of sleep disorders: An overview	Sleep And Breathing
10.1093/sleep/24.4.392	Hublin	2001	Insufficient sleep - A population-based study in adults	Sleep
10.2466/pms.1998.87.2.507	Jean-Louis	1998	Mood states and sleepiness in college students: Influences of age, sex, habitual sleep, and substance use	Perceptual and Motor Skills
10.1016/S0140-6736(13)60734-5	Jordan	2014	Adult obstructive sleep apnea	National Institute of Health
10.3389/fnhum.2014.00242	Katz	2014	Differential effect of motivational features on training improvements in school-based cognitive training	Frontiers in Neuroscience
10.5665/sleep.1884	Kessler	2012	Insomnia, Comorbidity, and Risk of Injury Among Insured Americans: Results from the America Insomnia Survey	Sleep
N.A.	Kochanek	2015	Mortality in the United States	NCHS Data Brief
10.1111/j.1365-2869.2008.00627.x	Kronholm	2008	Trends in self-reported sleep duration and insomnia-related symptoms in Finland from 1972 to 2005: A comparative review and re-analysis of Finnish population samples	Journal of Sleep Research
N.A.	Kucharczyk	2012	The occupational impact of sleep quality and insomnia symptoms	Sleep medicine reviews

N.A.	Kumar	2008	Sleep and sleep disorders	The Indian Journal of Chest Diseases & Allied Sciences
N.A.	Kupfer	1997	Current Concepts: Management of Insomnia	N.A.
10.1080/07448481.1986.9938970	Lack	1986	Delayed sleep and sleep loss in university students	Journal of American College Health
N.A.	Leger	1994	The cost of sleep-related accidents: A report for the National Commission on Sleep Disorders Research	Sleep
10.4249/scholarpedia.2433	Lim	2007	Sleep deprivation	Scholarpedia
10.3390/ijerph14111347	Magnavita	2017	Sleep, Health and Wellness at Work: A Scoping Review	International Journal of Environmental Research and Public Health
10.1007/s10865-006-9047-6	Mastin	2006	Assessment of sleep hygiene using the sleep hygiene index	Journal of Behavioral Medicine
10.1016/j.smrv.2011.03.005	Matricciani	2012	In Search of Lost Sleep: Secular trends in the sleep time of school-aged children and adolescents	Sleep Medicine Reviews
10.1371/journal.pmed1000097	Moher	2009	Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement.	PLoS Med
N.A.	Nielsen	2000	A review of mentation in REM and NREM sleep: “Covert” rem sleep as a possible reconciliation of two opposing models.	Behavioral and Brain Sciences

N.A.	Nuckols	2013	The Effects of Quality of Care on Costs: A Conceptual Framework	The Milbank Quarterly
10.1016/j.sleep.2005.03.006	Ohayon	2005	Global sleep dissatisfaction for the assessment of insomnia severity in the general population of Portugal	Sleep Medicine
10.1016/j.sleh.2016.11.006	Ohayon	2017	National Sleep Foundation's sleep quality recommendations: First report	Sleep Health
10.1007/s11205-006-9030-1	Olson	2006	Sleep and psychological well-being	Social Indicators Research
N.A.	OPAS	2016	Doenças Cardiovasculares	Organização Pan-Americana da Saúde
10.2147/nss.s124657	Osman	2018	Obstructive sleep apnea: Current perspectives	Nature and Science of Sleep
10.1097/00004703-200002000-00005	Owens	2000	Sleep habits and sleep disturbance in elementary school-aged children	Journal of Developmental & Behavioral Pediatrics
10.1542/peds.2014-1696	Owens	2014	Insufficient Sleep in Adolescents and Young Adults: An Update on Causes and Consequences.	Pediatrics
10.1016/0001-4575(95)00034-8	Pack	1995	Characteristics of crashes attributed to the driver having fallen asleep	Accident Analysis & Prevention
N.A.	Pereira	2020	Absentismo e engagement nos enfermeiros do Centro Hospitalar do norte de Portugal	Associação de Politécnicos do Norte

10.1016/s0022-3999(97)00004-4	Pilcher	1997	Sleep quality versus sleep quantity: Relationships between sleep and measures of health, well-being and sleepiness in college students	Journal of Psychosomatic Research
N.A.	Psacharopoulos	2004	Returns to investment in education: A further update	Education Economics
10.1513/pats.200709-155MG	Punjabi	2007	The Epidemiology of Adult Obstructive Sleep Apnea.	National Institutes of Health Grants
N.A.	Ramakrishnan	2007	Treatment options for Insomnia.	N.A.
10.5935/1984-0063.20180036	Reis	2018	Sleep duration, lifestyles and chronic diseases: A cross-sectional population-based study	Sleep Science
10.1111/jsr.13073	Reis	2020	The prevalence of excessive sleepiness is higher in shift workers than in patients with obstructive sleep apnea.	Journal of Sleep Research
10.1016/j.adolescence.2009.03.007	Roberts	2009	Sleepless in adolescence: Prospective Data on sleep deprivation, health and functioning	Journal of Adolescence
10.1159/000222811	Rodenstein	2009	Sleep apnea: Traffic and occupational accidents - Individual risks, socioeconomic and legal implications	Respiration
10.1016/j.rppnen.2017.01.002	Rodrigues	2017	Obstructive sleep apnea: Epidemiology and portuguese patients profile	Revista Portuguesa De Pneumologia

10.3949/ccjm.86.s1.02	Rundo	2019	Obstructive Sleep Apnea Basics	Cleveland Clinic Journal of Medicine
10.1093/sleep/34.4.443	Sarsour	2011	The Association between Insomnia Severity and Healthcare and Productivity Costs in a Health Plan Sample	Sleep
10.1378/chest.14-0970	Sateia	2014	International Classification of Sleep Disorders - Third Edition	Contemporary Reviews in Sleep Medicine
10.1177/0149206306289762	Scott	2006	Insomnia, emotions, and job satisfaction: A Multilevel Study	Journal of Management
N.A.	Senel	2012	The cost of absenteeism and the effect of demographic characteristics and tenure on absenteeism	Interdisciplinary Journal of Contemporary Research in Business
10.1046/j.1440-1819.2002.01004.x	Shiomi	2002	Falling asleep while driving and automobile accidents among patients with obstructive sleep apnea-hypopnea syndrome	Psychiatry and Clinical Neurosciences
10.1016/j.sleep.2004.06.003	Strine	2005	Associations of frequent sleep insufficiency with health-related quality of life and health behaviors	Sleep Medicine
N.A.	Suni	2021	Sleep deprivation: Causes, symptoms, & Treatment.	Sleep Foundation
N.A.	Swarnalatha	2003	Absenteeism – a menace to organization in building job satisfaction among employees in automotive	International Journal of Scientific Research

N.A.	Taras	2005	Sleep and student performance at school.	Journal of School Health
10.3390/ijerph17061901	Tarro	2020	Effectiveness of Workplace Interventions for Improving Absenteeism, Productivity, and Work Ability of Employees: A Systematic Review and Meta-Analysis of Randomized Controlled Trial	International Journal of Environmental Research and Public Health
10.1016/s1389-9457(09)70043-7	Tufik	2010	Obstructive sleep apnea syndrome in the Sao Paulo Epidemiologic Sleep Study.	Sleep Medicine
N.A.	Ulmer	2009	Cost Implications of Reduced Work Hours and Workloads for Resident Physicians	The New England Journal of Medicine
10.20344/amp.11468	Valente	2019	Quality of sleep among Portuguese anaesthesiologists: A cross-sectional study.	Acta Médica Portuguesa
N.A.	Vgontzas	1999	Sleep and its disorders.	Annual Reviews
N.A.	Vitaterna	2001	Overview of Circadian Rhythms.	N.A.
10.1038/nature02223	Wagner	2004	Sleep inspires insight.	Nature
10.1038/s41398-020-0694-0	Walker	2020	Circadian rhythm disruption and mental health.	Translational Psychiatry

10.5664/jcsm.6034	Watson	2016	Health Care Savings: The Economic Value of Diagnostic and Therapeutic Care for obstructive sleep apnea.	Journal of Clinical Sleep Medicine
10.4140/tcp.n.2013.538	Wick	2013	The history of benzodiazepines.	The Consultant Pharmacist
10.1016/j.cpcardiol.2005.07.002	Wolk	2005	Sleep and Cardiovascular Disease	Current Problems in Cardiology
N.A.	World Health Organization	N.D.	Absenteeism from work due to illness, days per employee per year	World Health Organization
10.1038/nn1851	Yoo	2007	A deficit in the ability to form new human memories without sleep.	Nature Neuroscience

APPENDIX B

Prevalence of conditions in Portugal

Indicator	Prevalence of condition	Reference
Insomnia	28.1%	(Ohayon & Paiva, 2005)
OSA	0.89%	(Rodrigues et al., 2017)
Congestive Heart Failure	4.36%	(Fonseca et al., 2017)
Coronary Artery Disease	27.5%	(Fiuza, 2012)
Cerebrovascular Disease	1.9%	(Sousa-Uva & Dias, 2012)
Type 2 Diabetes	13.3%	(APDP, 2016)
Depression	7.9%	(Direção Geral da Saúde, 2014)
Workplace Injury	3.9%	(Eurostat, 2020)
Motor Vehicle Accident	1.7%	(Gonçalves et al., 2015)
EDS in Regular Workers	37.1%	(Reis et al., 2020)
EDS in Shift Workers	61%	(Reis et al., 2020)
EDS in OSA patients	36.9%	(Reis et al., 2020)

APPENDIX C

Values used for calculations and estimated cost of condition in Portugal

Population Other Country	Population Portugal	Incidence of disease in country	Incidence of disease in Portugal	Health care expenditure per person other country	Health care expenditure per person in Portugal	Estimated cost of condition in Portugal
				EUR	EUR	
26 000 000	10 000 000	4	4,36	3 123	2 918	305
26 000 000	10 000 000	2,8	27,5	4 480	2 918	5 414
26 000 000	10 000 000	4,8	1,9	4 480	2 918	496
47 000 000	10 000 000	7,8	13,3	3 123	2 918	1 736
47 000 000	10 000 000	4,1	7,9	3 123	2 918	2 337
47 000 000	10 000 000	4,1	7,9	3 123	2 918	2 337
					2 918	2 337
26 000 000	10 000 000	4,6	3,9	4 480	2 918	12 993
26 000 000	10 000 000	4,6	3,9	4 480	2 918	12 993
47 000 000	10 000 000	2,8	1,7	3 123	2 918	720

APPENDIX D

PAF calculation with OSA prevalence of 32.8%

	p1 - Prevalence of disease in Portugal	s1 - Prevalence of sleep disorder Portugal	Odds Ratio	Sleep disorder	PAF	PAF with OSA prevalence from Brasil
Congestive Heart Failure	4,36	32,8	1,6	OSA	0,5	15,65
Coronary Artery Disease	27,5	32,8	3,2	OSA	0,88	28,87
Cerebrovascular Disease	1,9	32,8	2,9	OSA	1,58	37,59
Type 2 Diabetes	13,3	32,8	1,63	OSA	0,45	14,6

APPENDIX E

Costs due to EDS with OSA prevalence of 32.8%

Condition	Cost of this condition in Portugal	Cost due to excessive daytime sleepiness	Cost due to EDS with OSA of 32.8%	Type of EDS-SD
	MEUR	MEUR		
Congestive Heart Failure	305	2	48	OSA
Coronary Artery Disease	5 414	48	1 563	OSA
Cerebrovascular Disease	496	8	186	OSA
Type 2 Diabetes	1 736	8	253	OSA

APPENDIX F

Estimation of costs using another country

$$\textbf{Estimated health care cost portugal (of a given disease)} = \left(\frac{\textit{Health care cost of disease Australia}}{\textit{Population Australia}} \cdot \textit{Population Portugal}\right) \cdot \left(\frac{\textit{Incidence of disease Portugal}}{\textit{Incidence of disease Australia}}\right) \cdot \left(\frac{\textit{Helath care expenditure per person Portugal}}{\textit{Health care expenditure per person Austaralia}}\right)$$