Chapter 1

Sleep, health, and society: the contribution of epidemiology

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Introduction

Sleep disturbances and sleep deprivation are common in modern society. Most studies show that since the beginning of the century, populations have been subjected to a steady constant decline in the number of hours devoted to sleep, due to changes in a variety of environmental and social conditions (e.g. less dependence on daylight for most activities, extended shift work, 24/7 round-the-clock activities). The potential detrimental effects to health of sustained sleep deprivation and disruption were first acknowledged by industry (like airlines, long-distance driving, shift-work manufacturing industry, and emergency services). Only recently, however, has the wider implication for the population at large been unveiled. Through the application of epidemiological methods of investigation, sleep deprivation has been shown to be associated with a variety of chronic conditions and poor health outcomes, detectable across the entire lifespan, from childhood to old age. This book is designed to summarize for the first time the epidemiological evidence linking disturbances of sleep quantity and quality to several chronic conditions, to assess the epidemiological evidence for causality, and to explore the public health implications with a view to inform a discourse on possible preventive strategies.

Textbooks of Sleep Medicine have traditionally focused predominantly on the physiology and pathophysiology of sleep (Kryger et al., 2005) with a view to help diagnose and treat a variety of sleep-related conditions. Mainly directed to physiologists, sleep technicians, respiratory physicians, psychiatrists, and paediatricians, these textbooks almost invariably glance at the growing epidemiology of sleep and at the implications for public health. The scope of the present book is to fill a significant gap in the population-based approach to the problem of sleep-related disease risk.

The role of epidemiology

Epidemiology differs from clinical medicine in that the unit of interest is the population, not the individual. Clinical investigations are conducted on sick people, the results relate to patients, and decisions are related to treatment of individuals. Epidemiological research studies the sick and the well, results relate to populations, and decisions are related to public health (Rose, 1985). Epidemiology may be defined as the quantitative study of the distribution, frequency, determinants, and control of health problems and disease in populations (Fig. 1.1).

The purpose of epidemiology is to obtain, interpret, and use health information to promote health and reduce disease. Using this definition, it is clear that epidemiology is concerned with populations, not only death, illness, and disability in populations, but also with more positive health states and with the means to improve health.
Epidemiology is a crucial discipline for the promotion of public health. It provides a set of skills, approaches, and a philosophy which allows causes of health problems to be detected, the association between ill-health and a variety of risk factors to be quantified, treatments and public health interventions to be tested, and changes in states of health over time to be monitored. It is a discipline which allows the distribution of health and ill-health in a population to be described (e.g. what is the problem and its frequency? who is affected? where and when does this health problem manifest in the population?). It also provides the tools to compare the health characteristics of populations. Epidemiology may play a role in identifying the cause of a health problem (e.g. a genetic trait, an infectious agent, a particular behaviour, an environmental exposure). The epidemiological approach provides a framework within which ‘causation’ can be hypothesized and tested. The primary objective in epidemiology is to judge whether an association between exposure and disease or health problem is, in fact, causal. A causal association is one in which a change in the frequency or quality of an exposure or characteristic results in a corresponding change in the frequency of a disease or outcome of interest. Causality is more likely if an association between exposure and disease can satisfy most of the following criteria: strength, consistency, specificity, right time sequence, dose relationship, reversibility, biological plausibility, coherence (Hill, 1965). Making judgements about causality would require an assessment of the validity of the findings and of the likelihood of alternative explanations for the results. It would then require the assessment of the role of chance, the role of bias, and the role of confounding.

Once the disease occurs, epidemiology provides a means for monitoring the course and outcome (natural history) of the condition. It also allows us to answer questions regarding the effectiveness of interventions and therapies and their impact on populations (i.e. how effective are particular interventions for controlling disease in communities? is intervention A more effective than intervention B? what are the outcomes of these two lines of intervention?). Of course, such information needs to be placed alongside other data before the choice of interventions is made (e.g. what are the side effects of the treatments? what are the views of consumers and patients about the procedure? how much does the intervention cost?). Such data may help determine where best to direct resources. Identifying health states in the population may facilitate establishing the need for services and the determination of priorities. Given limited resources, public health practitioners are always under pressure to use resources optimally and to produce the greatest return, in the form of health gain, for a given investment of time, money, materials, and personnel. Epidemiology cannot do this alone: it needs to interact with health services research, health economics, and other social sciences if wise public health decisions are to be made and health promoted on a population level.
Epidemiology thus has many applications and is an essential tool in providing useful information about public health problems, their magnitude and distribution, causation, prevention, prognosis, and treatment, and likely impact of interventions. If epidemiological data are to be of use in policy-making, they need to address questions for which policy-makers require answers, and need to do so in a convincing and compelling way. Yet still, epidemiology is just one contribution to the policy debate. Increasing our understanding of health problems and their determinants and possible solutions places us in a better position to make appropriate policy.

The book

The book is structured in 21 chapters. Chapter 1 is an introduction that builds on the basic science and clinical knowledge of the physiology of sleep and the clinical manifestations of sleep disturbances and explains how the development of this discipline is now in need of an epidemiological approach to fill the gap in knowledge to assess the population and public health implications of sleep disturbances. Chapter 2 is an introduction to the principles of sleep physiology that will allow the reader to grasp the key factors without going too deeply into the subject, extensively covered by existing literature. Chapter 3 describes the epidemiology of sleep deprivation and disruption, their risk factors and markers, and discusses the concept of causality in an epidemiological framework. Chapters 4 to 10 pay attention mostly to new areas of population-based research addressing the relevance of sleep disturbances as potential determinants of ill-health and mortality, cardiovascular, metabolic, and respiratory diseases, and the interplay with depression and neurological conditions, with special attention to manifestations in children. Chapters 11 and 12 focus mainly on new biochemical and genetic mechanisms that might underpin the role of sleep as a determinant, or risk marker, of ill-health. Chapter 13 is new in that it addresses the sociological dimensions of sleep and the personal and societal implications. Chapter 14 is an extensive perusal of the psychosocial and medical consequences of misinterpreting sleep disturbances and, with Chapter 19, makes a plea for improving education and training in sleep medicine and sleep-related disorders not only amongst medical students and doctors but also among health professionals at large. Chapters 15–21 enter into the sphere of public health through an extensive review of the perils associated with shift-work, not only in industrial settings, but also in the medical profession, to both individuals who work in shifts and to those who would benefit from the activities of shift-workers (e.g. the patients served by junior doctors working shifts). The societal and medico-legal implications are also covered, with an overview of the implications in different legal systems worldwide.

The brief to authors was to take a population perspective, and to consider the extent to which their particular area of expertise translates into the population and public health arena. To maximize the take-home messages on the population and public health perspective, most chapters end with a Box summarizing the main points for easy reference.

The intended primary readership of this book is epidemiologists and public health professionals as well as medical students and those of allied professions. We hope our book will also appeal to psychologists, cardiologists, and cardiovascular physicians, specialists in metabolic or respiratory diseases, neurologists, psychiatrists, policy-makers, specialists in medical education, professionals involved in shift-work, occupational health professionals, regulatory bodies and voluntary organizations, as well as patients’ groups.

Brief historical note

As clearly highlighted by William Dement (Dement, 2005), ‘Interest in sleep and dreams has existed since the dawn of history’ and there is a wealth of scholarly work that highlights the interests,
concerns, beliefs, and roles of sleep and associated activities (e.g. dreams, nightmares) over the centuries, from prehistoric ages to our modern society (Thorpy, 1991). Until very recently, sleep had been considered a passive state. In MacNish’s definition of 1834 (MacNish, 1834), ‘Sleep is the intermediate state between wakefulness and death: wakefulness being regarded as the active state of all the animal and intellectual functions, and death as that of their total suspension’. It was not until the end of the nineteenth century and well into the twentieth century that the concept that sleep could be an active and dynamic state gained credence and some scientific support through early experiments in animals (Legendre and Pieron, 1910) and humans (Kleitman, 1939). The discovery that the electrical activity and rhythms of the human brain, using an electroencephalogram (EEG), vary significantly and constantly during wakefulness and sleep (Berger, 1930) sparked an increased interest in unravelling the scientific basis of sleep. The work of Sigmund Freud and his interpretation of dreams arguably contributed to creating an interest in sleep among health professionals.

In the latter half of the twentieth century we witness the start of animal experimentation on sleep, leading to the understanding of some of the deep brain mechanisms underpinning sleep and wakefulness, the modern neuroscience.

At a similar pace it developed the understanding of the pathology of sleep, from insomnia, narcolepsy with cataplexy, and, much later, obstructive sleep apnoea syndrome, firstly described in 1836 by Charles Dickens in the Young Dropsy, a young obese, always sleepy, boy who snored (referred to as Pickwickian syndrome). Similarly the discipline now known as ‘chronobiology’, which for centuries had described the 24-hour rhythmic cycles governing the biological activities of the plant and animal kingdoms, began being applied to the sleep-wake cycles of animals and humans (see also Chapter 2).

Scientific output, measured by the number of publications in the field of sleep research since 1945, provides a crude indication of the exponential growth of knowledge and highlights some milestone discoveries (Fig. 1.2).

Fig. 1.2 Publication trends in the field of sleep research. 
The first description that rapid eye movements (REMs) occur in sleep (de Toni, 1933) precedes the landmark study that suggested that REMs represented a ‘lightening’ of sleep and might indicate dreaming, due to the close association with irregular respiration and an increase in heart rate (Aserinsky and Kleitman, 1953). A second spark in the research progress in sleep medicine was the discovery of sleep apnoea in 1965 (Gastaut et al., 1965; Jung and Kuhlo, 1965). In the early 1970s, the internal biological clock regulating the sleep-wake cycle and many other rhythmic biological activities (the suprachiasmatic nucleus or SCN) was described (Moore and Eichler, 1972; Stephan and Zucker, 1972) (see also Chapter 2). This autonomous circadian pacemaker has since been intensively studied (Weaver, 1998) and, more recently, its genetic regulation (e.g. Clock genes) has been detailed (see also Chapter 12). The 1980s and 1990s were dominated by studies of the importance of excessive daytime sleepiness (EDS; see also Chapters 15–18) and the discovery and applications of the continuous positive airways pressure (CPAP) for the management of obstructive sleep apnoea syndrome and its complications (see also Chapter 7). Finally, at the end of the twentieth century and at the dawn of the twenty-first century, there was a very sharp increase in the scientific output of sleep research, with a disproportionate representation of population studies on the effect of sleep on health risks and a debate on the public health issues associated with declining trends in the quantity and quality of sleep in the modern society as potential contributing factors to, or risk markers for, ill-health and reduced safety (see also Chapters 4–6, 13, and 15–21).

Sleep, health, and society
Throughout our life we spend approximately a third of our time asleep. We spend more time asleep as babies and children and then settle for a pattern that is of approximately 7- to 8-hour per night. Although subjective sleep duration remains fairly constant with age, sleep patterns, however, directly measured with polysomnography seem to indicate that, with age, total sleeping time, sleep efficiency, and slow wave sleep decline and waking after sleep onset increases (Bixler, 2009). Sufficient sleep is necessary for optimal daytime performance and well-being, yet there is a large difference in how much sleep people report, ranging from <6 hours to >9 hours per night. The epidemiology of sleep duration indicates that a good night’s sleep equates to at least 6 hours and ideally 8 hours of continuous sleep, with changes in sleep duration or continuity being associated with negative impacts on health outcomes. In one study in Britain, the average duration of sleep in an adult population was 7.04 hours per night (standard deviation, SD 1.55 hours) (Groeger et al., 2004). Approximately three-quarters of men and women slept between 6 hours and 8 hours per night. However, another quarter reported sleep time either <5 hours per night (approximately 5% with <4 hours per night) or >9 hours (more than 5% with >11 hours per night), indicating large inter-individual variation within the same population. Adult women report sleeping consistently less than men up to the age of 50–55 years, then the pattern reverses (see also Chapter 13). There are also geographical variations in average sleeping time (whether due to environmental, genetic, or socioeconomic factors). In a study of 18- to 30-year-old university students from countries around the world, the majority reported sleeping between 7 hours and 8 hours per night (Steptoe et al., 2006). Exceptions were students in East Asian countries (Japan, Korea, Taiwan, and Thailand) who slept on average <6 hours per night, and those of some European countries (Spain and Romania) with >8 hours per night. This variation was associated, in short sleepers, with increased self-reported ill-health. Both short and long sleep have been associated with increased all-cause mortality (Cappuccio et al., 2010) and other outcomes from chronic disease (see also Chapters 4 and 5). Many have speculated that the secular increase in chronic diseases, like cardiovascular disease, diabetes, and obesity, have been paralleled by a steady deterioration in sleeping patterns, with an increase in the proportion on
short sleepers, and that these two phenomena might be related. A recent analysis of self-reported sleep hours in the United States between 1975 and 2006 did not detect any significant increase in the odds of short sleep (<6 hours per night) over the 31-year period (Knutson et al., 2010). However, when the analysis was carried out by employment status, a significant increase in the odds (odds ratio, OR = 1.19) was detected amongst full-time workers, with the excess time awake being spent predominantly in working activities. Working overtime and working shifts is associated with negative health outcomes and with reduced performance posing risk to others (see also Chapters 15–18). Lack of sleep should be considered as a potential mediator of these effects since trends in shorter sleep is associated with longer working hours (Knutson et al., 2010). Finally, there is evidence to suggest that reducing the amount of time we spend asleep strongly predicts cardiovascular outcomes (Ferrie et al., 2007) and risk of some types of cancer. On the other hand, increasing sleeping hours over time may be a marker of general ill-health predicting non-cardiovascular mortality (Ferrie et al., 2007).

Sleep education and awareness

As the world population increases and individuals become larger, the number of individuals suffering from sleep disorders will increase. In the United States, it is estimated that over the next 20 years, the number of Americans suffering from sleep disorders will double. However, the public awareness of the need for adequate sleep both for adults and children and the awareness of sleep-related conditions are poor. Moreover, the physicians who treat them receive minimal training in sleep disorders medicine (Stores and Crawford, 1998) (see also Chapter 14). In fact, they themselves are forced to endure excessive work schedules during their internship and residency training, which desensitizes them to sleep as a fundamental biological necessity, degrades their ability to provide quality patient care and to benefit fully from their training experience, and places them at increased risk of ill-health, injuries, and sleep-related motor vehicle accidents during their training (Landrigan et al., 2004; Barger et al., 2005) (see also Chapters 17 and 18). These difficult, and often conflicting, interests need to be addressed so that the medical field can provide an optimal platform for learning and patient care (Buysse et al., 2003).

In 1993, a national survey of 126 accredited medical schools in the United States indicated that less than 2 hours of total teaching time was allocated to sleep and sleep disorders, on average, with 37 schools reporting no structured teaching time whatever in this area (Rosen et al., 1993). Furthermore, it was reported that only 8% of medical students are trained in the use of sleep laboratory procedures, and 11% have participated in the clinical evaluation of sleep-disordered patients. Over two-thirds of the survey respondents reported that they believed that the provision of teaching time for sleep medicine was inadequate and that more time should be provided. Thus, it would appear that although there is increasing evidence to support the idea that sleep is a fundamental requirement for patient health and well-being, the provision of medical education in this area is currently inadequate.

There has been an increasing awareness of the widening gap between scientific research and clinical teaching in sleep and sleep disorders. The survey of the Taskforce 2000 established by the American Sleep Disorders Association (ASDA) to address the deficiencies in current medical education in sleep (Rosen et al., 1998) (see also Chapter 19) indicated that the majority of respondents (65.2%) are currently involved in teaching sleep to medical students or postgraduate trainees. The average amount of teaching time for sleep reported for undergraduates was only 2.1 hours and that for graduates was 4.8 hours. The results from the survey also indicated that the teaching of sleep laboratory procedures and clinical evaluation of sleep-disordered patients is limited at either an undergraduate or postgraduate level.
A similar situation, with regards to lack of sleep education, exists in Medical Schools in the United Kingdom (Stores and Crawford, 1998). The provision of any medical education on sleep and its disorders varied widely from 6% to 80%. However, the median time reported for such teaching was restricted to 15 minutes for preclinical teaching and zero in clinical teaching. The study concluded that in the United Kingdom, undergraduate medical teaching does not provide an adequate training basis for the development of competence in diagnosing and treating sleep disorders. It was recommended that changes in medical education were required to address this issue. Some examples of dramatic increase in teaching and research in the area of sleep medicine have become available recently (see also Chapter 19 for Warwick Medical School).

The public awareness of the importance of sleep, the need for good sleep hygiene and awareness of sleep disorders in general is poor in both adults and children. Various professional bodies worldwide are attempting to redress the balance, but there is much to do. In the U.K. education system, for example, children are taught about the importance of diet and exercise but sleep education is rarely addressed. Poor sleep habits in early life may have long-term consequences for health (see also Chapters 5, 6, and 10).

Conclusion
Taken together, these issues bring the results of the epidemiology of sleep outside the clinical setting and well within the domain of public health. One of the main questions still to answer is whether in these circumstances, sleep disturbances are the consequence of ill-health, are intermediate markers in the pathways of disease causation, or whether changes in sleep patterns can be causal in the determination of chronic disease and, more generally, ill-health. The bi-directional relationships between sleep duration and disease and their non-linear associations remain important research challenges to overcome towards aetiological answers. A long-term intervention trial of sleep manipulation would be necessary to test the effect of sleep duration on chronic disease outcome. However, this is an unlikely scenario, since such a study would be impractical, large, long, and expensive. This leaves the burden of proof on observational epidemiology to inform potential changes in public health policies. At the same time, the deleterious effects of shift work on several outcomes, like risk of self-harm and harm to others (e.g. medical errors, road accidents, attentional failures in high risk occupations) (Landrigan et al., 2004; Lockley et al., 2004; Barger et al., 2005) (see also Chapters 15–18), which are by and large mediated by excessive sleepiness and fatigue caused by sleep debt, have recently benefited from stronger evidence from randomized clinical trials and are now informing policy changes.

References


