The role of sleep in ethnic inequalities in health: Cardiovascular disease and risk factors
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CHAPTER 1

GENERAL INTRODUCTION
Ethnic inequalities in health has been widely acknowledged across the globe. Different studies both in Europe and the United States of America (USA) indicate variations in inequalities in health between ethnic minority groups and the European populations [1]. In the Netherlands, various studies have been conducted and reasonable extensive information on inequalities in health status among ethnic minorities both at regional and national level have been well investigated [2,3,4]. A lot of studies show remarkable variations in health outcomes such as CVD and risk factors (e.g. diabetes, hypertension) and mental health among ethnic minority groups and host European populations [5,6,7,8]. Explanations for the ethnic inequalities in health are unclear and with the increasing minority populations, it is relevant to understand the underlying factors to help guide prevention and treatment initiatives. This thesis focuses on the role of sleep in ethnic inequalities in CVD and risk factors. Sleep and its impact on health is increasingly becoming important but very little is known about its influence on ethnic inequalities in health.

**THE ROLE OF SLEEP IN HEALTH**

By definition, sleep is “a natural periodic state of the body and mind characterized by closing of the eyes, partial or total loss of consciousness and reduced response to external stimuli” [9]. Sleep has a restorative function for the body and mind, and thus helps to maintain health.

Poor sleep quality may result in deleterious health outcomes. The National Sleep Foundation (NSF), American Academy of Sleep Medicine (AASM), and Sleep Research Society, in a joint consensus, recommend 7-9 hours and 10-11 hours of sleep at night as healthy for adults and preschool children, respectively [10]. Inadequate sleep has become a common problem in our modern society. On average, many people fall short of reaching the recommended hours of sleep per night. This can be attributed to the busy schedules that is inherent in our modern society, resulting from long working hours, doing multiple jobs, shift-work, late night use of technology at bed time such as, mobile phones, television, computers and computer games, sedentary lifestyle, lack of physical activity, sleeping with pets; stress, and adoption of some cultural practices which tend to negatively influence sleep duration such as co-sleeping, disregard for napping, and believe that hardworking and successful people require short sleep duration [2,11,12,13,14].
Sleep disruption has been linked to several adverse health outcomes due to its effect on the body’s homoeostasis which regulate human cellular, tissue, organ and system activities. Although sleep disruption affects other vital organs of the body such as the brain [15], sleep affects metabolic and cardiovascular health, as have been reflected in previous studies [16]. The studies have shown that sleep deprivation has serious or major metabolic and cardiovascular consequences, and therefore a risk factor for poor health in the future [16].

Studies highlighting the impact of sleep on health have been conducted among various populations. For instance, Steptoe et al (2006) [17] has shown that short sleep was associated with poor health among young adults from 24 different countries. Also, Cappuccio et al’s (2008) [18] meta-analysis demonstrates that short sleep is associated with obesity in children and adults. Other studies conducted in Europe and the USA have shown that sleep duration is associated with increased risk of CVD risk factors such as obesity [19,20,21], type 2 diabetes [22,23,24], hypertension [25,26], and dyslipidaemia [27-33]. In addition, reports from previous studies indicate that short sleep is associated with CVD such as stroke, myocardial infarction, coronary heart disease (CHD) [34-41], and CVD mortality [42,43].

The mechanism linking sleep with cardiovascular disease and diabetes

Knutson (2012) [44] has formulated a model which shows how sleep deprivation is linked to obesity, diabetes and CVD (Figure 1); as well as other factors (social, cultural and environmental) which may directly or indirectly affect sleep and the associated health outcomes (figure 2).

In this model, three pathways which link inadequate sleep to obesity are shown in figure 1. In these pathways, weight gain/obesity is the result of imbalance between food intake and physical activity (energy expenditure) as reflected in the first pathway.
The second pathway reflects that the more people are awake during the day, the more they tend to eat, hence more likely to be obese. The third pathway indicates a hormonal activity (leptin and ghrelin) in the regulation of appetite resulting in an increased food intake.

The pathways which link inadequate sleep to cardiometabolic diseases (example, type 2 diabetes) partly overlaps with the mechanisms leading to obesity (through insulin resistance and CVD), as obesity is a risk factor for CVD. In addition, the impact might also be more direct. The figure shows that inadequate sleep may lead to reduced utilization of glucose by the brain, which in turn, promotes reduction in glucose tolerance, and insulin resistance resulting in type 2 diabetes. Also, changes in the concentration of growth hormone and cortisol affect glucose metabolism, causing insulin resistance. Increase in the levels of growth hormone triggers transient insulin resistance, with accompanying decrease in glucose uptake, increased blood glucose levels, and insulin resistance and diabetes. On the other hand, increased evening cortisol concentration can lead to reduced morning insulin sensitivity which causes impaired glucose tolerance [26]. Inadequate sleep
might also affect cardiometabolic disease through increased sympathetic nervous activity [27,28]. Increased sympathetic nervous activity at the level of pancreas may give rise to a decrease in the secretion of insulin. Also unfavourable changes in the metabolism of glucose may lead to insulin resistance predisposing to diabetes mellitus.

The last pathway illustrates how increased sympathetic nervous activity may result in increased blood pressure and development of hypertension and CVD.

**Determinants of inadequate sleep**

The factors considered as determinants of inadequate sleep have been well studied by Knutson (2012). As highlighted in figure 2, Knutson illustrated various factors and their respective domains which determine inadequate sleep duration.

**Fig. 2 Adapted from Knutson 2012 [44]:** Factors associated with biology, culture and environment which can impact and interact with sleep to increase vulnerability to obesity and its health consequences.

The mechanism described in figure 1 depends on three domains illustrated in figure 2, including biology and culture and environment.

While sleep duration decreases as one advances in age [45,46], also variations such as in sex, gynaecological status in women (menstruation cycle/menopause), secretion of melatonin (sleep-promoting hormone), and
cortisol (from hypothalamo-pituitary-adrenocortical (HPA) axis, have been shown to influence sleep duration [47]. Also, culture, affects sleep owing to its influence on the belief, perception and attitudes of people towards sleep, in a manner likely to reduce sleep duration. Environmental factors including light, noise, temperature, poor air quality, and poor neighborhood have the potential to disrupt sleep directly or indirectly.

Sleep and ethnic inequalities in health

Little is known about ethnic inequalities in sleep duration and their impact on ethnic inequalities in health. The limited evidence, however, seems to suggest that some ethnic minority groups in North America have poor sleep quality than their European counterparts. For instance, in one USA based-study, sleep quality was poorer in African Americans than in White Americans [48]. In addition, the same study revealed that African Americans exhibit less night time decrease in blood pressure dipping than Whites Americans. The study posited that excessive sympathetic activity, rather than ethnic differences in sleep quality accounted for the observed dip in blood pressure. In Europe, data on the role of sleep on ethnic inequalities in health are lacking. Europe has different ethnic groups compared to US necessitating the need for more studies in Europe. Besides, the environments in which the ethnic groups live as well as the culture may also differ between the two continents and may influence their sleep patterns. This can lead to different sleep patterns among the various ethnic groups which may contribute to differences in cardiovascular outcomes among the various ethnic groups.

For instance, the pathway of sleep deprivation to obesity (as shown in Fig 1), may differ from one ethnic group to another due to cultural practices such as adoption of earlier or later bedtimes, bed sharing/communal sleeping habits, sleeping with pets, and levels of physical activity. Also factors such as values and expectations attributed to sleep, affecting perception and value of habits attributed to sleep, may differ among the various ethnic groups. These include: the values and attitude which people have regarding sleep (positive or negative), sleep-related rituals such as the belief that less intake of food and water or liquids before bedtime may affect sleep quality, praying before sleeping, sleeping position, attaching significance to dreams etc. For instance, there is the believe by segments of Turkish people that “time spent sleeping is a wasted time, hence sleep time ought to be short” [49], others believe that successful people invest much time being busy,
and therefore require short sleep [50], and yet, others disregard the need for napping. Individuals having these beliefs are prone to be short sleepers, and likely to be at risk for short sleep associated problems [49]. On the other hand, individuals who believe that sleep restores or refreshes the body, and that daytime sleep (napping) is important tend to have increased sleep duration, and are less likely to be at risk of short sleep associated health problems. In addition, psychosocial stressors including depression which is more common among ethnic minority groups may affect sleep duration. However, the level of depression could also differ and may influence the sleep patterns between ethnic groups.

According to Knutson (2012) [44], other important factors which determine inadequate sleep lie within the biological domain including certain hormones such as melatonin, and those associated with HPA axis [44,47]. Differences between groups in prevalence of the hormones, as well as hormonal activity levels, which, when at different physiological states, may have differential influence on sleep patterns and may differ across various ethnic groups. Secretion of melatonin (a sleep promoter by the pineal gland of the brain) stimulates sleep, whereas its under-secretion decreases sleep duration. In addition, high level secretion of hormones of the HPA axis, notably cortisol has been shown to impair sleep [47].

Other factors within the environment which may determine inadequate sleep include light, ambient temperature, residential areas (high traffic, noise, pollution (bad air quality), neighborhood crime levels). Ethnic minority groups could be disproportionately affected by these factors as they usually congregate in similar residential areas, usually with low socioeconomic status (SES), and poor neighbourhoods associated with noise and crimes, and these may not only expose them to inadequate sleep, but also provoke anxiety and stress which can impair sleep duration or quality [44].

In sum, there appears to be insufficient evidence for the difference in sleep quality or patterns among ethnic minorities and their role on ethnic inequalities in health outcomes. Hence the purpose of this thesis is to investigate ethnic differences in sleep duration and its role on ethnic differences in CVD and risk factors.
CONCEPTUAL MODEL OF THIS THESIS

The conceptual model derived from Knutson (Fig. 1) [44], which guided the studies contained in this thesis, is shown in Fig. 3. This is based on the concept that ethnicity may shape sleep duration, meaning that ethnicity influences whether an individual sleeps short or healthy through a differential distribution of risk factors (A), and ethnicity is an effect modifier for the relationship between sleep duration and CVD risk factors (B), in the sense that this association differs between ethnic groups.

Fig. 3: Conceptual model of this thesis
OBJECTIVES OF THIS THESIS

The increased prevalence of CVD and risk factors among ethnic minority groups requires that adequate measures are taken to reduce the increased risk through prevention and proper management of the contributing factors. However, the known risk factors of CVD do not entirely explain ethnic inequalities in CVD. It therefore becomes imperative to identify novel modifiable risk factors to contribute to the prevention and management efforts. This thesis aims to assess differences in sleep, and the role of sleep in ethnic differences in CVD and risk factors through the following research objectives:

1. To assess inequalities in sleep duration in the Netherlands between ethnic groups in both adults and pre-school children, and to explore possible factors that explain these inequalities.

2. To assess the associations between short sleep duration and cardiovascular risk factors among ethnic groups in both adults and preschool children.

3. To assess the association between short sleep duration and CVD among ethnic groups, and to quantify how much short sleep contributes to ethnic differences in CVD.

ETHNIC MINORITY GROUPS IN EUROPE AND THE NETHERLANDS

A steady increase in migration flow towards Europe has been observed in the last few decades. The late 1980s witnessed a two times increase in the number of first generation ethnic minority groups [51]. At the beginning of 2016, the number of migrants living in the European Union member (EU 28) states was 20.7 million, equivalent to 4.1% of the total population [52].

The Netherlands is an increasing ethnically diverse country. In 2016, the number of inhabitants in the Netherlands with a migrant background was 3.8 million, which represent 22.1% of the total population [53]. Of the 3.8 million inhabitants, 2.1 million had background from low and middle income countries, whereas 1.7 million had a western background. Nearly half of those with background from low and middle income countries were either second generation or born in the Netherlands [53]. This percentage
doubled since 1972, when only 9% of the Dutch population belonged to an ethnic minority group [54]. Of the ethnic minorities, 9.8% is of Western origin and 12.3% of low and middle income countries (mainly from Turkey, Morocco, Suriname, the Netherland Antilles and other non-Western) [53]. In the upcoming decennial, the ethnic minority population is expected to grow even further. Prognostic analysis show an increase from 21% towards 31% in 2060. The growth will be most profound among ethnic minorities with background from low and middle income countries, from 12% in 2012 towards 18% in 2060. Presently, the age distribution among ethnic minority groups with background from low and middle income countries is relatively low, only 4% of them are ≥65 years of age. Prognostic study estimate that in 2060, 22% of all ethnic minority groups with background from low and middle income countries are ≥65 years of age, which will be only slightly less than within the ethnic Dutch population [55]. As CVD is a condition of the elderly, and seem to be negatively influenced by short sleep duration, reducing ethnic inequalities in CVD will become even more important in the future, hence it also becomes important to investigate the role of sleep in ethnic inequalities in CVD.

**Definition of ethnic background**

In this thesis, ethnic background is defined by using the country of birth and parental country of birth. The full description has been reported elsewhere [56]. A person from an ethnic minority group is considered as first generation if born abroad with at least one of the parents born abroad, whereas a second generation ethnic minority is born in the Netherlands with at least one of the parents born abroad. Those with both parents born in the Netherlands are considered as ethnic Dutch or Dutch throughout this thesis. We included ethnic minorities from Suriname, Turkish, Moroccan, and Ghanaian origins, as they are the largest groups residing in the Netherlands. Suriname is a previous Dutch colony located in South America. The Surinamese population is ethnically diverse, and made up of people originating from West Africa (30%), India (37%), Java (15%), China (1.5%), and people of mixed origin [57]. They all migrated to the Netherlands due to political instability in Suriname in 1975 and 1980. Ghanaians migrated to the Netherlands between 1974 and 1983 predominantly for economic reasons, and others such as drought, political instability and the deportation of Ghanaians from Nigeria in the early 1990s. Turkish and Moroccans migrated to the Netherlands in the 1960s
and early 1970s to fill labour shortages which were lacking in unskilled occupations. In 1970-1980, Turkish and Moroccans guest workers brought their spouses and children to the Netherlands.

OUTLINE OF THIS THESIS

Chapter 1 gives a general introduction of the entire contents of this thesis. In chapter 2, ethnic differences in sleep duration among residents in the Netherlands, stratified by ethnicity and gender are discussed. Chapter 3 reports on the ethnic differences in sleep duration among 5 year olds, and its relationship with overweight and blood pressure using the Amsterdam Born Child and their Development (ABCD) Study. Chapter 4 examines the relationship between short sleep duration and cardiovascular risk factors such as obesity, diabetes, hypertension, total cholesterol, high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, and triglycerides among ethnic minority groups and the Dutch host population. In chapter 5, the relationship between short, or long sleep duration and arterial stiffness among ethnic groups stratified by gender is investigated. Chapter 6 examines the association between short sleep duration and CVD among the ethnic groups, and the contribution of short sleep to ethnic inequalities in CVD. Chapter 7 examines the association between depression and sleep duration among various ethnic groups, and the contribution of depression to ethnic differences in sleep duration. Chapter 8 is the general discussion in which the main findings of this thesis are discussed. In addition, the implications of the findings as well as the recommendations for further research are suggested. Lastly, a summary of this thesis is presented.
Table 1: Summary/overview of the thesis showing the determinants and outcomes as presented in this thesis

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<td>Ethnic differences in sleep duration at 5 years old, and its relationship with overweight and blood pressure (ABCD) study</td>
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REFERENCES


