Socioeconomic status influences sleep quality and sleep quantity: A case-control study

Authors
Simone Lund Lauritsen, BSc. med.[1] and Mia Lund Madsen, BSc. med. [1]

Supervisor
Henrik Bøggild, M.D., Ph.D.[2]

1 Department of Health Science and Technology, Faculty of Medicine, Aalborg University, Aalborg, Denmark
2 Public Health and Epidemiology Group, Department of Health Science and Technology, Faculty of Medicine, Aalborg University, Aalborg, Denmark

Summary

Baggrund: Søvn har betydning for udvikling af sygdom. Dårlig søvnkvalitet samt en for kort og en for lang søvnlængde har vist sig at øge risikoen for udvikling af adskillige sygdomme, heriblandt diabetes, hjertesygdom, hypertension, fedme, inflammationssygdomme og psykiske lidelser som angst og depression. Social ulighed i sundhed og sygdom er, trods opbygningen af det danske sundhedssystem, fortsat et problem. Fokus har hidtil været på de modificerbare livsstilsfaktorer kost, rygning, alkohol og motion (KRAM) i forhold til sundhedsfremme og forebyggelse af sygdom. Imidlertid er der stigende evidens for, at befolkningens søvnvaner desuden bør indgå som en af disse modificerbare livsstilsfaktor. Ligesom for KRAM-faktorerne tyder resultater i flere studier på, at social ulighed findes i søvn.

Formål: Formålet med dette case-control studie er at undersøge, om socioøkonomisk status, målt på samleverstatus, beskæftigelse, uddannelsesniveau og forskellige indkomstparametre, har effekt på selvvurderet søvnkvalitet og søvnlængde på voksne i Nordjylland, efter justering for mulige confoundere.

Metode: Studiet inkluderer deltagere fra "Sundhedsprofilen 2013", hvor 20.220 indbyggere i Region Nordjylland har deltaget. Der er kun inkluderet deltagere med en alder over 20 år i 2010 med en antagelse om, at socioøkonomisk status således er mere stabil. Yderligere er deltagere diagnosticeret med diabetes, depression, angst, visse kroniske lunge- samt hjertesygdomme ekskluderet ved brug af data fra Danske Nationale Registre. Denne eksklusion er foretaget, da man ved, at disse tilstande direkte influerer på søvn, uafhængigt af socioøkono-

misk status. Afslutningsvis er deltagere med manglende oplysninger om en hvilken som helst variabel ekskluderet, hvorved den endelige population inkluderer 14.212 deltagere.

Oplysninger om socioøkonomisk status er indhentet fra Danske Nationale Registre med 2010 som *exposure year*. De socioøkonomiske faktorer, som er inkluderet i dette studie er samleverstatus, beskæftigelsesstatus, uddannelsesniveau og forskellige indkomstparametre. 2013 er defineret som *outcome year*, hvor data om søvnkvalitet- og søvnlængde er indhentet fra spørgeskemaet "Sundhedsprofilen 2013". Søvnvariable er defineret som henholdsvis søvnkvalitet og søvnkvantitet. Søvnkvalitet er vurderet med afsæt i en søvnkvalitetsscore udviklet af Det Nationale Forskningscenter for Arbejdsmiljø, benævnt NFA-score. Søvnkvantitet er opdelt i kort søvn, defineret som en søvnlængde under fem timer, samt i lang søvn, defineret som en søvnlængde over 9 timer.

Af confoundervariable er følgende medtaget: Alder, køn, body mass index, rygerstatus og selvrapporteret generelt helbred. Oplysninger herom er en del af spørgeskemaet fra "Sundhedsprofilen 2013".

Den statistiske analyse er udført i SAS version 9.4 (SAS Institute Inc. Cary, North Carolina, USA). Der er udført multivariat logistisk regression samt multinominal regression i fire trin. Først er der lavet en ujusteret model. Dernæst er der lavet en model justeret for alder og køn. Den tredje model er yderligere justeret for body mass index og rygerstatus, og i den endelige model er der desuden justeret for selvrapporteret generelt helbred. Alle resultater er angivet som odds ratio og 95% konfidensinterval. Statistisk signifikans er defineret ved en p-værdi < 0,001.

Resultater: Studiet finder at 13,93 % af deltagerne har en dårlig søvnkvalitet. 6,45 % har en kort søvnlængde mens 5,56 % af deltagerne har en lang søvnlængde. Den tredje model viser et generelt billede, hvor der er forhøjede odds for en dårlig søvnkvalitet og en uhensigtsmæssig søvnlængde iblandt de, der har single samleverstatus, er ubeskæftigede, kun har folkeskoleuddannelse samt lave indkomstparametre. Af den endelige model fremkommer, at selvrapporteret generelt helbred forklarer en del af sammenhængen, men fortsat ses det, at en dårlig søvnkvalitet er associeret med single samleverstatus, arbejdsløshed samt lav husstands- og ækvivaleret husstandsindkomst. For søvnkvantitet viser den fuldt justerede model, at arbejdsløse, deltagere kun med en folkeskoleuddannelse, en lav husstands- samt ækvivaleret husstandsindkomst, har øgede odds for en kort søvnlængde. Studerende, deltagere kun med

folkeskoleuddannelse, deltagere med en lav personlig- og husstandsindkomst har øgede odds for en lang søvnlængde.

Desuden viser den endelige model et generelt mønster, hvor højere indkomstniveauer mindsker oddsene for en uhensigtsmæssig søvnlængde.

Konklusion: En dårlig søvnkvalitet og en uhensigtsmæssig søvnlængde har vist sig at have multiple konsekvenser for helbredet. Social ulighed findes i adskillige aspekter af diverse livsstilsfaktorer, hvorved dette bidrager til ulighed i sundhed og sygdom. Hypotesen i dette case-control studie er, at folk af lav socioøkonomisk status har en højere forekomst af en dårlig søvnkvalitet samt en uhensigtsmæssig søvnlængde. Resultaterne viser, at selvrapporteret generelt helbred forklarer en del af sammenhængen, men fortsat ses et mønster, hvor det at være single og have lave socioøkonomiske parametre, er associeret med en dårlig søvnkvalitet og en uhensigtsmæssig søvnlængde. Dette identificerer risikogrupper, hvor der kan interveneres med præventive tiltag.

Abstract

Introduction: Sleep quality and quantity influence health. As for other lifestyle factors social inequalities seem to exist in sleep quality and quantity. Cross-sectional studies found that socially disadvantaged people had a higher degree of poor sleep quality and abnormal sleep duration compared to their socially better off counterparts.

The aim of this study was to evaluate if socioeconomic factors influence sleep quality and sleep quantity, divided into short sleep (< 5h) or long sleep (> 9h) in a case-control study.

Methods: 14,212 participants who answered the sleep questionnaire in *North Denmark Health Profile 2013* were included. Participants diagnosed with physical chronic diseases, depression and anxiety were excluded. Data on participant's socioeconomic status were drawn from the Danish Administrative Registers with 2010 as exposure year. Marital status, employment status, education length, and measures of income were included. Multivariate logistic and multinominal regression analysis examined whether four proxy measures of socioeconomic status in four models were associated with sleep parameters. The final model adjusted for age, gender, body mass index, smoking status and self-reported general health.

Results: 13.93% reported poor sleep quality. 6.45% and 5.56% had short and long sleep duration respectively. Poor sleep quality was associated with being single, unemployed and having low income parameters. Short sleep duration was associated with being unemployed, basic school educated and having low income parameters. Long sleep duration was associated with being a student, basic school educated and having low income parameters. Higher income levels decreased the odds of abnormal sleep duration. Adjusting for self-reported general health attenuated the results.

Conclusion: Single marital status and low socioeconomic status were associated with poor sleep quality and abnormal sleep duration. All results were influenced by self-reported general health. This knowledge identifies groups at risk and is beneficial in order to intervene towards better sleep hygiene.

Introduction

Sleep epidemiology has been a topic for decades[1]. Prior studies have shown that sleep is associated with the development of disease. Poor sleep quality and abnormal sleep duration have shown to increase the risk of multiple diseases such as diabetes, heart disease, hypertension, obesity, inflammatory diseases and psychiatric diseases such as anxiety and depression[2–4]. Evidence suggests sleep quantity to be a U-shaped risk factor with the optimal amount of sleep being seven to eight hours[1,4].

Social inequalities in health and disease is partly explained by socioeconomic differences in the KRAM-habits (Danish abbreviation for diet, smoking, alcohol and exercise) which is a target of preventative approaches in order to promote health and prevent disease[5]. As evidence that sleep plays an important part of health is rising, sleep might as well be a potential factor one could target aligned with the KRAM-factors[6].

As it applies to the KRAM-habits, studies have shown that social inequalities exist in sleep quality and sleep duration[7,8]. This has been investigated in different populations[2,3,8–11]. When investigating the influence of socioeconomic status (SES) on sleep, different objective measures have been used. Income is commonly used as a proxy of SES though no consistency exist for the measure of this parameter. Despite these measuring differences, the majority of studies find a relationship between low income and poor sleep[2,12,9–11,13–24]. In 2011 Ryu et al. find in a study with 4,411 Korean adults that people with low average monthly income tend to have either short (≤ 6h) or long (≥9 h) sleep duration[19]. For sleep quality, Friedman et al in 2007 analyze data in a population of 94 American women aged 61 or above and find that income predicts not only low Pittsburgh Sleep Quality Index (PSQI) score but also objectively measured poor sleep efficiency[11]. Another used measure of SES is education classified as the highest educational level achieved. The association between educational level and sleep quantity have been investigated by Whinnery et al. who in a study from 2014 conducted on 4,850 American adults find that education lower than completed college is associated with both very short (≤ 5h) and short sleep (5-6h)[22]. Additionally, an association between education and sleep quality has been corroborated[12,9,11,14,18,20,21,25,26]. Furthermore, employment status as measure of SES is commonly used in literature. Park et al. in a study from 2010 conducted on 6,510 Korean adults find that when investigating sleep duration, unemployed are more prone to have short or long sleep duration[17]. Further, Grandner et al. in 2010 analyze a population of 159,856 American adults and report that unemployed have more subjective sleep

complains when compared to their employed counterparts[18]. Lastly, more studies have found that married people are better sleepers with regards to both sleep quality and quantity[10,17–19,21,25–27].

Further, gender, age, body mass index (BMI), smoking habits and self-reported general health (SGH) have been found to influence sleep quality and quantity[3,8,12,11,15,16,19,25–28]. Chronic conditions such as diabetes, anxiety, depression, extreme obesity or extreme underweight, respiratory and cardiovascular disease increase the risk of poor sleep quality and abnormal sleep duration[2,8,12,11,15,17,19,24,25,27,29,30].

Common to existing literature is that the majority consists of cross-sectional studies and also different measures of sleep and SES have been used[3,8,12,9–11,13–26,28,29,31–33]. Furthermore, some of the cited studies have small sample sizes or investigate specific populations groups[2,9–11,14,15,20,21,30,31]. Only a few studies investigate Northern European populations[8,23,26,33] (literature search available in appendix A).

The present study aims at investigating if SES when measured by income, education, employment status and marital status influence sleep quality and sleep quantity in adults in Northern Region of Denmark. This study investigates if people of low SES have poorer sleep than their better off counterparts when adjusted for confounders. Authors hypothesize that people of low SES are more prone to have short sleep (< 5h) or long sleep (> 9h) when compared to people of higher SES and further that people of low SES have worse self-reported sleep quality compared to people of higher SES.

Methods

Study design and setting

This was a case-control study with exposure to SES in year 2010 and sampling of sleep measures in 2013. Data from the questionnaire in the *North Denmark Health Profile 2013* were used for the present analysis. The questionnaire originally aimed at investigating the distribution of health and disease throughout the population in 11 municipalities in North Denmark Region. Questionnaires were obtained between 30th of January and the 1st of May 2013.

The participants were randomly selected by the National Institute of Public Health on condition that each municipality had at least 2000 citizens included with the excep-

tion of Læsø Municipality. The questionnaires were sent by postal mail to 35,700 citizens. Of those 20,220 participated giving a response rate of 56.6%. The questionnaire contained information on e.g. sleep, BMI, smoking habits and SGH. Further information can be found in *North Denmark Health Profile 2013*[34].

Data sources

All participants had a Danish Civil Registration Number. This made it possible to identify participants throughout different registers whereby personal data could be collected. The following registers were used: The Danish National Prescription Registry containing data on all prescription drugs sold in Denmark since 1994[35], The Danish National Patient Register containing data on hospital diagnoses and surgical procedures since 1977[36], Danish registers on personal income and transfer payments including data from 1970[37], The Danish Education Registers containing information regarding education from 1974 and the DREAM database covering public transfer of any kind registered every week a year since 1991[38,39].

Variables

Sleep measures

Measures of sleep quality and quantity were based on subjective reports.

Sleep quality

Participants were asked to describe their sleep during the past month on a 4-item questionnaire. The four questions were the following: 1: Do you have trouble falling asleep? 2: Do you wake up multiple times at night and have subsequent troubles falling asleep? 3: Do you have early morning awakenings without being able to fall asleep afterwards? 4: Do you sleep poor and restlessly?

The questionnaire was a part of the NFA (The National Research Centre for the Working Environment) sleep score. Question 1-4, originally 2-5 in the *North Denmark Health Profile 2013* were chosen for the purpose of this study since they were questions derived from Karolinska Sleep Questionnaire (KSQ). Further the 1-4 graduation system was inspired from the PSQI[40–43]. The KSQ and the PSQI have been extensively used throughout literature and have been a well accepted measure of subjective sleep quality[21,40,44].

The scoring system accessing all answers was as follows: 1 = Not during the past four weeks, 2 = Less than once a week, 3 = One or two times a week, 4 = Three or more times a

week. Each answer weighted from 0-100%; 1 = 0%, 2 = 33.33%, 3 = 66.66% and 4 = 99.99%. Percentages were added and divided by four. A higher score equaled a lower quality of sleep. This study defined participants with a global NFA-score of ≥ 75% as having poor sleep quality[43].

Since no item in the NFA-score evaluated how rested participants felt, participants were further asked to evaluate if they had felt well rested during the past four weeks. Answers ranged from 1-3: 1 = Yes, usually, 2 = Yes, but not very often, 3 = No, never (almost never). Answering 3 categorized participants into having poor sleep quality regardless of the NFA-score.

Sleep quantity

Sleep quantity was defined as either short (< 5h) or long (> 9h). Participants were asked if they, based on self-reported sleep duration, 1: slept less than five hours or 2: slept longer than 9 hours a night during the last four weeks.

Answers were assessed on a 1-4 scale (1 = Not during the past four weeks, 2 = Less than once a week, 3 = One or two times a week, 4 = Three or more times a week. Participants answering four were dichotomized into either short or long sleepers.

Socioeconomic status

Four different measures of SES were used: marital status, employment status, education length and income. Data were drawn from registers in Statistics Denmark in 2010.

Marital status:

Data on marital status was obtained from The Danish Income Statistics Register[37]. Marital status was dichotomized into single or cohabiting with a partner. For missing 2010 values information was drawn from *North Denmark Health Profile 2013* where marital status were converted into single or cohabiting.

Employment status:

For the purpose of categorizing participants according to employment status, DREAM was used[39]. Data were derived from week 1 to 52 in 2010. Participants were divided into being either student, employed, unemployed or retiree. A student was defined as a person receiving The Danish Students' Grants. An employed participant was defined as a person receiving no social security benefits or receiving social security benefits compatible with any sort of job activation exemplified with a person having a flex job who was then been categorized as em-

ployed. Participants were categorized according to the employment status they had for most weeks during 2010. If participants had belonged to two different categories of employment status for 26 weeks, the participant was categorized according to the latest employment category in 2010.

Education

Information regarding education was drawn from The Population's Education Register [38]. Education was classified according to The International Standard Classification of Education 2011 (ISCED)[45]. Education was measured as the highest achieved level in 2010, divided into following categories: basic school, high school, vocational education, short/medium education and long/high education. For missing 2010 values information was drawn from *North Denmark Health Profile 2013* where the education length was converted to the ISCED classification.

Income

Data on income were obtained from The Danish Income Statistics Register in 2010 [37]. Yearly income was measured by three parameters: personal income, household income and OECD-modified equivalised household income. Each parameter was categorized into six income groups: poor, low, work, middle, high, and upper (Appendix B).

Additional covariates

Self-reported covariates were drawn from *North Denmark Health Profile 2013*. Covariates included age, sex, BMI, smoking status and SGH. Age in years was categorized into <40, <50, <60 and 60+ years. Sex was assessed as male/female. BMI was calculated from height and weight and categorized into underweight (< 18,5), normal (18,5–24,9), overweight (25–29,9), obese (30–34,9) and morbidly obese (> 35). Smoking status was divided into: never, former, occasional and current smoker. SGH was assessed as "Excellent", "Very good", "Good", "Poor" and "Awful".

Participants

This study included participants from *North Denmark Health Profile 2013* aged 20 years old or above in 2010 in order to ensure a more stabile SES[33,46]. Exclusion criteria for the study were chronic diseases and conditions known to cause poor sleep quality and quantity[2,8,12,11,17–19,23,25,27]. The Danish National Prescription Registry was used to identify subjects receiving anti-diabetic drugs and antidepressants before May 1st 2010. They were then excluded from

the study population under the assumption that when receiving these drugs the participants suffered from diabetes, depression or anxiety. Only participants who had received antidepressants the past year were excluded. The Danish National Patient Register was used to identify participants suffering from certain respiratory diseases, severe obesity, heart attack, stroke and participants who had gone through coronary artery surgery before May 1st 2010. They were excluded from the population (Appendix B). Participants who had missing data on dependent or independent variables were excluded. This resulted in a study population of 14,212 participants (Fig.1).

[INSERT FIGURE 1: "Exclusion procedure"]

Cases of poor sleep quality were defined as participants having a NFA-score of 75 or above or never having felt well-rested during the past four weeks. Cases of abnormal sleep duration were defined as participants sleeping less than 5 hours or longer than 9 hours three times or more a week. Controls were all participants included.

Statistical methods

Demographic characteristics were described by frequencies and percentages for groups defined by good and poor quality sleepers. For sleep quantity participants were divided into normal, short and long sleep duration. For the calculation of p-values the chi-square test was used. The second part investigated unadjusted and adjusted estimates. Estimates were adjusted for sex, age, BMI and smoking habits. The initial unadjusted analysis revealed SGH to affect sleep parameters extensively. SGH status was adjusted for in the final model. SES parameters were included in a regression model as the dependent variables. For sleep quality multiple logistic regression was used and for sleep quantity multinominal regression was used to analyze possible associations between SES and sleep. Additionally, to detect for interaction multiple logistic and multinominal regression models with the inclusion of interaction were used. No interaction was found (for additional information, see Appendix C).
Results were expressed as odds ratios (OR) and 95% confidence interval (CI) where reference was the category variable consisting of most participants. Stratified analysis was conducted according to the 11 municipalities participants were selected from. Since this procedure only worked for multiple logistic regression, sleep quantity could not be stratified. However, au-

thors found that the stratification for sleep quality had only little (differences to the third decimal) to no difference on outcomes. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc. Cary, North Carolina, USA).

Ethics

No ethical approval was required for this study. Approval by the Danish Data Protection Agency was obtained prior to the beginning of the study (approval number GEH-2014-014). All information on participants was anonymized according to a surrogate Civil Registration Number.

Results

Population characteristics

In table 1 characteristics of the population by sleep quality and quantity were shown. For sleep quality the groups differed on all variables except age. For sleep quantity the groups differed on all variables except sex.

[INSERT Table 1: "Characteristics of 14,212 participants from North Denmark Region aged ≥ 20 according to sleep parameters"]

13.93% of participants reported poor sleep quality. For sleep quantity 6.45% had short sleep and 5.56% had long sleep duration. Regarding SES parameters (table 1) more cohabiting participants reported good sleep quality and had more frequent normal sleep duration. For employment status more employed participants had good sleep quality and more normal sleep duration. As educational level increased, more participants reported good sleep quality. The same applied to normal sleep duration. For all income parameters a pattern that the highest income groups had lower frequencies of poor sleep quality was observed. The same pattern existed for short and long sleep duration.

In table 2, table 3 and table 4 odds ratios (95% confidence intervals) for the association between SES parameters and sleep measures before and after adjustment for the possible confounding effects of sex, age, BMI, smoking status and SGH were shown.

[INSERT Table 2: "Multiple logistic regression models and the association between SES and poor sleep quality before and after adjustment"]

Marital status

In table 2 single participants appeared to have higher odds of poor sleep quality compared to their cohabiting counterparts when unadjusted (OR = 1.33, 95% CI 1.19-1.49). Sex, age, BMI and smoking status did not seem to confound the association. After adjustment for SGH the odds of poor sleep quality was attenuated (OR = 1.16, 95% CI 1.03-1.31).

In table 3 single participants appeared to have the highest odds of short sleep duration compared to cohabiting participants when unadjusted (OR = 1.29, 95% CI 1.10-1.52). The same pattern was seen in model 2 and 3. After adjustment for SGH, single marital status lost its significance (OR = 1.12, 95% CI 0.95-1.33).

In table 4 single participants were more prone to have long sleep duration compared to those cohabiting when unadjusted. However, the OR was not significant in model 4 (OR = 1.16, 95% CI 0.98-1.38).

[INSERT Table 3: "Multiple logistic regression models and the association between SES and short sleep duration before and after adjustment"]

[INSERT Table 4: "Multiple logistic regression models and the association between SES and long sleep duration before and after adjustment"]

Employment status

In table 2, model 1 unemployed had the highest odds of poor sleep quality (OR = 2.00, 95% CI 1.63-2.45). This pattern persisted in model 2 and 3. In model 4 OR decreased (OR = 1.29, 95% CI 1.03-1.61). Being retired also increased the odds of poor sleep quality and the odds were enhanced in model 2 and 3 (OR = 1.49, 95% CI 1.28-1.82 and OR = 1.42, 95% CI 1.17-1.72, respectively). After adjustment for SGH status no association between retiree and poor sleep quality remained (OR = 0.97, 95% CI 0.82-1.16).

Table 3 showed that unemployed had higher odds of short sleep duration. This pattern was true for all models, even though the odds were attenuated in model 4 (OR = 1.61, 95% CI 1.22-2.12). Retired participants also had higher odds of short sleep duration though enhanced in model 2 and 3. In model 4 no association between being retired and having short

sleep duration was found (OR = 1.15, 95% CI 0.92-1.45).

In table 4, model 1-3 both unemployed participants, students and retired participants had higher odds of long sleep duration. In model 4 only students had significantly higher odds of having long sleep duration (OR =1.61, 95% CI 1.09-2.38).

Education length

Table 2, model 1 showed that participants with basic school education had the highest odds of poor sleep quality (OR = 1.41, 95% CI 1.26-1.58). This pattern persisted in model 2 and 3. In model 4 no association between basic school education and poor sleep quality remained (OR = 1.13, 95% CI 1.00-1.28). A pattern that short/medium length education decreased the odds of poor sleep quality existed though it only was significant in model 2 and 3. The same pattern was observed for long length education.

Table 3 showed that participants having basic school education, had higher odds of short sleep duration compared to participants having a vocational education. The pattern persisted in model 2 and 3 but in model 4 the odds were attenuated (OR = 1.33, 95% CI 1.13-1.57). Short/medium and long length educated participants had lower odds of short sleep duration but in model 4 long education length lost its significance (OR = 0.68, 95% CI 0.45-1.03).

In table 4 the same pattern was seen for long sleep duration and education length.

Income parameters

Table 2 showed a pattern that poor to low income participants had increased odds of poor sleep quality. Middle to upper income participants had decreased odds of poor sleep quality. For personal income no significance was found in model 4.

Table 3 showed a pattern that people of middle to upper income levels had lower odds of short sleep duration. Except for personal income a pattern was seen that participants of low income levels had higher odds of short sleep duration compared to participants belonging to the work level income.

In table 4 the income parameters showed a pattern that poor to low income levels increased the odds of long sleep duration, while middle to upper income levels decreased the odds of long sleep duration.

Discussion

Key results

Authors found that people having poor or low household and equivalised income were significantly more likely to have poor sleep quality and abnormal sleep duration. The same was true concerning single marital status, short education length, unemployment and retirement. After adjustment for SGH, the odds were attenuated but remained significant for marital status, education length, employment status and income parameters for both poor sleep quality and abnormal sleep duration, though personal income was not a strong predictor of sleep measurements.

Sleep quality

This study found that 14% participants had poor sleep quality. The prevalence of poor sleepers found in previous studies ranges from 9%-55% indicating large differences[8,18,21,24–26]. One possible explanation to this difference was the measure used to measure sleep quality. Most studies using PSQI plus the standardized > 5 point as a cut off for poor sleep quality found high prevalences of poor sleepers ranging from 26-55%[8,21,24–26]. Patel et al. instead used a 1-5 point scale to evaluate overall restlessness found a prevalence of 9% poor sleepers [18]. In this study, the NFA-score was used and participants diagnosed with diseases known to decrease sleep quality were excluded. This might have contributed to the explanation of the low percentage of poor sleepers found in this study.

Sleep quantity

Authors found that 6% of participants had a short sleep duration, while previous studies reported prevalences of 15%-37%[2,15,17,19,24]. In this study, short sleep was defined as sleep duration below five hours, while most other previous studies used sleep duration below six hours. This might explain the low percentage of short sleepers found in this study. 6% had a sleep duration above 9 hours which is comparable to the 4-10% found in previous literature[15,17,19].

Marital status and sleep

This study found that single participants had 16% higher odds of having poor sleep quality than their cohabiting counterparts. In line with this, previous studies found that being single increased the odds of poor sleep quality[15,17,19,25,26,46]. For sleep quantity this study found that single participants had more short and long sleep duration though not significant after adjusting for SGH. When comparing to existing literature, results regarding sleep quantity have been

diverging. Hale et al. found a pattern similar to the one observed in this study[46]. Ryu et al. found that married had higher odds of short sleep while Park et al. found widowed, divorced and separated had the highest odds[17,19]. Ryu et al. found that married had lower odds of long sleep duration than their unmarried counterparts, though not significant[19]. Park et al. found no pattern for long sleep duration and marital status[17].

As suggested by Hale et al., increased sleep schedule flexibility might result in the higher odds of abnormal sleep duration found among single people[46]. Furthermore, single people may also have less social support which have also been suggested to have negative impact on sleep quantity[46]. Authors of this study suggested that this might also influence sleep quality.

Employment status and sleep

In line with Mezick et al., this study found that unemployed people were more prone to report poor sleep quality compared to their employed counterparts with an increased odds of 29%[14]. This was corroborated by Soltani et al. and Stringhini et al[21,26]. Further studies have shown that also sleep duration is influenced by employment status. Present study found that unemployed had 61% higher odds of short sleep duration, which was in accordance with results found by Park et al[17]. Krueger et al. found the same pattern though the results were attenuated after adjustment[15]. Regarding long sleep duration literature have shown that unemployed tend to have more long sleep duration than employed[17,19,32,46]. This result could not be reproduced in this study. One possible explanation to this diverging result could be that unemployment status might be confounded by SGH, which might partly explain the attenuated odds seen after the final adjustment.

Education and sleep

For sleep quality this study initially found a pattern that a low educational level increased the odds of poor sleep quality, while a higher educational level decreased the odds of poor sleep quality, but after the final adjustments no difference between education length and sleep quality was observed. SGH was the greatest confounder. Existing literature proposed that a low educational level significantly increased the odds of poor sleep quality, while a higher educational level decreased the odds[12,10,18,26,47]. The diverging results found in this study compared to previous literature could be due to the confounding effect of SGH, which this study adjusted for.

For sleep quantity authors found that basic school educated had approximately 30% higher odds of both short and long sleep duration. Short/medium education decreased the odds of abnormal sleep duration with approximately 25-30%. This pattern is in line with existing literature[12,17,19,46].

In general, it has been suggested in previous literature that higher educated people have more knowledge, a healthier lifestyle and fewer chronic stressors than their lower educated counterparts, thereby explaining the differences found in all sleep parameters[21,46,47].

Income parameters and sleep

Generally, authors found a pattern that participants in the lowest income groups had higher odds of poor sleep quality and abnormal sleep duration. This is in line with existing literature where the same pattern was found[2,10,18,19]. The opposite was found among the highest income levels, indicating a protective effect of prosperity on sleep quality and quantity which was in accordance with existing literature[11,15,16]. Throughout literature different measures of income have been used. This study investigated three income parameters and found that personal income did not affect sleep quality. Neither did the lowest personal income levels increase the odds of short sleep. It might reflect that a low personal income was not a risk factor of poor sleep quality and short sleep duration. This indicated that mainly the total resources in a household influenced sleep parameters. On the other hand, a high personal income still seemed to provide protection against abnormal sleep duration.

SGH, SES and sleep

An attenuation of the odds of poor sleep quality and abnormal sleep duration was observed after including SGH in the regression model. This was in agreement with Friedman et al. who suggested a model where SGH partly explained the association between SES and sleep parameters[1]. On the other hand, Moore et al. suggested sleep quality as a mediator in translating SES into SGH, thereby not considering SGH to be a confounder[12]. The same suggestion was made by Sekine et al[3].

One possible suggestion for future studies would be to exclude participants evaluating their SGH to be poor instead of including SGH as a confounder.

Strengths and limitations

A strength of this study was its case-control design which had a higher evidence level and a higher ability to detect causal interference compared to existing cross-sectional literature, by

temporally separating exposure from outcome[48,49]. Furthermore, register data were used for the process of exclusion and SES parameters which diminished the susceptibility to selection and information bias[49]. Authors also intended to increase the reliability and reproducibility by including a large sample size. Another strength was the exclusion of participants with diseases known to influence sleep parameters. Additionally, this study included several measures of SES and investigated their relation to both sleep quality and quantity, which provided an increased insight into possible associations between SES and sleep.

There were several limitations to this study that should be considered. First, it should be taken into consideration that the evaluation of sleep quality and quantity relied on subjective self-reports. This raised the possibility of recall bias and over or underestimation of sleep parameters. By the use of sleep diaries this might have been prevented. A further limitation regarding the measures of sleep was the questionnaire used in *North Denmark Health Profile 2013*, which was a questionnaire never used before. Authors therefore choose to involve only the four already validated questions derived from KSQ. Additionally, for the measure of sleep duration participants were only asked how often in a week they slept less than five hours and more than nine hours and abnormal sleep duration was classified as abnormal sleep duration three or more times a week. A questionnaire covering the exact sleep duration during e.g. all weekdays in a week would have been preferred in order to minimize the risk of over and underestimation of sleep duration. Further, no objective measure of sleep such as polysomnography or actigraphy, was available. It would have been preferable especially for measuring sleep quantity. However, it would have been costly to use on a population of more than 20,000 participants. Furthermore, it has been shown that subjective evaluations were good at predicting morbidity and mortality[11].

Another limitation to the present study was the low participation rate in *North Denmark Health Profile 2013*. It has been shown that response rates are increasing with increasing SES and thereby the prevalence of poor sleep quality and abnormal sleep duration might be underreported in this study[50]. This increased the risk of selection bias, which potentially decreased the rates of poor sleepers on both sleep parameters, thereby underestimating the extend of sleep problems in the general population. The population was further reduced because of missing values for sleep parameters and other covariates, where list-wise deletion was used. This could also cause selection bias and might affect the external validity of the re-

sults found in this study. By using multiple imputation, selection bias could have been eliminated, but this feature was not used due to a limited time frame.

What this study adds

This study contributed to the understanding of the influence of SES on sleep quality and quantity. This association was investigated after the exclusion of diseases known to cause poor sleep and after adjustment for confounders known to influence sleep. To our knowledge, it was the first longitudinal study, in a field where existing literature consisted mainly of cross-sectional studies.

This study identified single, unemployed, low educated and poor financial positioned people as possible targets for health promoting strategies in order to prevent the multiple negative health consequences of poor sleep quality and abnormal sleep duration.

Further, authors found that personal income did not affect neither sleep quality nor short sleep duration, indicating that it was the total resources in a household that affected sleep. For future research authors therefore recommend using other measures of income.

This study increased the understanding of a possible population at risk, where clinicians, politicians and society might intervene by providing information about appropriate sleep hygiene, thereby promoting health and preventing disease.

Conclusion

This case-control study hypothesized and found that people of low SES were more prone to have poor sleep and found that single marital status and low SES parameters were associated with poor sleep quality and abnormal sleep duration. However, if SGH was considered a confounder, it partly explained the association.

This knowledge identified groups at risk where interventions towards better sleep hygiene could be beneficial in order to promote health and prevent disease caused by poor sleep quality and abnormal sleep duration.

Tabels and figures

Table 1: Characteristics of 14,212 participants from North Denmark Region aged ≥ 20 according to sleep parameters

	Sleep quality		P-value	Sleep quantity			P-value
Total	**Good (%)** 12,232 (86.07)	**Poor (%)** 1,980 (13.93)		**Normal (%)** 12,506 (87.99)	**Short < 5h** 916 (6.45)	**Long > 9h** 790 (5.56)	
Sex							
– **Male**	6037 (88.62)	775 (11.38)		6044 (88.73)	398 (5.84)	370 (5.43)	
– **Female**	6195 (83.72)	1205 (16.28)	< .0001*	6462 (87.32)	518 (7.00)	420 (5.68)	0.0140
Age (years)							
– **< 40**	2955 (86.58)	458 (13.42)		2979 (87.28)	207 (6.07)	227 (6.65)	
– **< 50**	2673 (84.70)	483 (15.30)		2794 (88.53)	238 (7.54)	124 (3.93)	
– **< 60**	2744 (85.70)	458 (14.30)		2853 (89.10)	206 (6.43)	143 (4.47)	
– **60 +**	3860 (86.92)	581 (13.08)	0.0329	3880 (87.37)	265 (5.97)	296 (6.67)	< .0001*
Body mass index							
– **Underweight**	155 (79.08)	41 (20.92)		162 (82.65)	16 (8.16)	18 (9.18)	
– **Normalweight**	5447 (87.61)	770 (12.39)		5565 (89.51)	349 (5.61)	303 (4.87)	
– **Overweight**	4724 (86.46)	740 (13.54)		4806 (87.96)	354 (6.48)	304 (5.56)	
– **Obese**	1490 (82.41)	318 (17.59)		1541 (85.32)	142 (7.85)	125 (6.91)	
– **Morbidly obese**	416 (78.94)	111 (21.06)	< .0001*	432 (81.97)	55 (10.44)	40 (7.59)	< .0001*
Smoking status							
– **Yes**	1873 (83.69)	365 (16.31)		1905 (85.12)	200 (8.94)	133 (5.94)	
– **Occasionally**	350 (87.06)	52 (12.94)		350 (87.06)	26 (6.47)	26 (6.47)	
– **Former**	4007 (85.51)	679 (14.49)		4106 (87.62)	301 (6.42)	279 (5.95)	
– **Never**	6002 (87.16)	884 (12.84)		6145 (89.24)	389 (5.65)	352 (5.11)	
– **Total**	12,232	1980	0.0003*	12,506	916	790	< .0001*
Self-reported general health							
– **Excellent**	1432 (95.40)	69 (4.60)		1356 (90.34)	75 (5.00)	70 (4.66)	
– **Very good**	5218 (92.68)	412 (7.32)		5212 (92.58)	198 (3.52)	220 (3.91)	
– **Good**	4262 (84.56)	833 (15.44)		4731 (87.69)	356 (6.60)	308 (5.71)	
– **Poor**	924 (63.94)	521 (36.06)		1078 (74.60)	221 (15.29)	146 (10.10)	
– **Awful**	96 (39.83)	145 (60.17)	< .0001*	129 (53.53)	66 (27.39)	46 (19.09)	< .0001*
Marital status							
– **Cohabiting**	9968 (86.76)	1521 (13.24)		10179 (88.60)	707 (6.15)	603 (5.25)	
– **Single**	2264 (83.14)	459 (16.86)	< .0001*	2327 (85.46)	209 (7.68)	187 (6.87)	< .0001*
Employment status							
– **Employed**	8374 (86.90)	1262 (13.10)		8605 (89.30)	571 (5.93)	460 (4.77)	
– **Unemployed**	429 (76.88)	129 (23.12)		448 (80.29)	71 (12.72)	39 (6.99)	
– **Student**	318 (85.95)	52 (14.05)		316 (85.41)	21 (5.68)	33 (8.92)	
– **Retiree**	3111 (85.28)	537 (14.72)	< .0001*	3137 (85.99)	253 (6.94)	258 (7.07)	< .0001*
Education length							
– **Basic school**	3033 (82.44)	646 (17.56)		3066 (83.34)	332 (9.02)	281 (7.64)	
– **High school**	583 (85.61)	98 (14.39)		597 (87.67)	41 (6.02)	43 (6.31)	
– **Vocational**	5284 (86.85)	800 (13.15)		5383 (88.48)	378 (6.21)	323 (5.31)	
– **Short/medium**	2687 (88.27)	357 (11.73)		2789 (91.62)	139 (4.57)	116 (3.81)	
– **Long**	645 (89.09)	79 (10.91)	< .0001*	671 (92.68)	26 (3.59)	27 (3.73)	< .0001*
Personal income annually							
– **Poor**	1053 (83.90)	202 (16.10)		1050 (83.67)	790 (7.73)	108 (8.61)	
– **Low**	2174 (83.71)	423 (16.29)		2202 (84.79)	193 (7.43)	202 (7.78)	
– **Work**	3021 (84.20)	567 (15.80)		3098 (86.34)	291 (8.11)	199 (5.55)	
– **Middle**	3312 (87.50)	473 (12.50)		3433 (90.70)	188 (4.97)	164 (4.33)	
– **Higher**	1500 (88.34)	198 (11.66)		1545 (90.99)	77 (4.53)	76 (4.48)	

– **Upper**	1172 (90.92)	117 (9.08)	< .0001*	1178 (91.39)	70 (5.43)	41 (3.18)	< .0001*
Household income annually							
– **Poor**	980 (82.08)	214 (17.92)		1000 (83.75)	84 (7.04)	110 (9.21)	
– **Low**	2507 (83.71)	488 (16.29)		2541 (84.84)	250 (8.35)	204 (6.81)	
– **Work**	2760 (86.28)	439 (13.72)		2782 (86.96)	215 (6.72)	202 (6.31)	
– **Middle**	3248 (86.34)	514 (13.66)		3374 (89.69)	223 (5.93)	165 (4.39)	
– **Higher**	1740 (89.00)	215 (11.00)		1802 (92.17)	80 (4.09)	73 (3.73)	
– **Upper**	997 (90.06)	110 (9.94)	< .0001*	1007 (90.97)	64 (5.78)	36 (3.25)	< .0001*
Equivalised income							
– **Poor**	414 (82.80)	86 (17.20)		425 (85.00)	30 (6.00)	45 (9.00)	
– **Low**	2336 (83.25)	470 (16.75)		2352 (83.82)	236 (8.41)	218 (7.77)	
– **Work**	3109 (85.13)	543 (14.87)		3163 (86.61)	263 (7.20)	226 (6.19)	
– **Middle**	3553 (86.57)	548 (13.43)		3656 (89.59)	238 (5.83)	187 (4.58)	
– **Higher**	1807 (89.23)	218 (10.77)		1866 (92.15)	83 (4.10)	76 (3.75)	
– **Upper**	1033 (89.98)	115 (10.02)	< .0001*	1044 (90.94)	66 (5.75)	38 (3.31)	< .0001*
* **p-value < 0.001 %**							

Table 2: Multiple logistic regression models and the association between SES and poor sleep quality before and after adjustment

Model	**1**	**2**	**3**	**4**
Adjusting variables	Unadjusted	+ Sex and age	+ Body mass index and smoking status	+ Self-reported general health status
Marital status				
– **Cohabiting***	1.00	1.00	1.00	1.00
– **Single**	1.329 (1.186-1.489)	1.353 (1.206-1.518)	1.318 (1.173-1.480)	1.162(1.028-1.313)
Employment status				
– **Employed***	1.00	1.00	1.00	1.00
– **Unemployed**	1.995 (1.625-2.451)	1.970 (1.601-2.422)	1.834 (1.488-2.262)	1.291 (1.033-1.613)
– **Student**	1.085(0.804-1.463)	1.088 (0.798-1.484)	1.114 (0.815-1.523)	1.221 (0.881-1.691)
– **Retiree**	1.145 (1.027-1.277)	1.493 (1.277-1.816)	1.422 (1.172-1.724)	0.973 (0.818-1.157)
Education length				
– **Basic school**	1.407 (1.257-1.575)	1.431 (1.272-1.610)	1.385 (1.231-1.558)	1.130 (0.997-1.281)
– **High school**	1.110 (0.885-1.393)	1.025 (0.812-1.295)	1.065 (0.942-1.346)	1.151 (0.906-1.461)
– **Vocational***	1.00	1.00	1.00	1.00
– **Short/medium**	0.878 (0.768-1.003)	0.815 (0.712-0.932)	0.845 (0.738-0.967)	0.928 (0.806-1.069)
– **Long**	0.809 (0.633-1.034)	0.819 (0.640-1.048)	0.882 (0.688-1.131)	1.060 (0.823-1.365)
Personal income annually				
– **Poor**	1.022 (0.858-1.218)	1.144 (0.955-1.371)	1.177 (0.981-1.412)	1.090 (0.896-1.324)
– **Low**	1.037 (0.903-1.190)	1.221 (1.050-1.416)	1.217 (1.048-1.413)	1.055 (0.900-1.236)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.761 (0.667-0.868)	0.746 (0.653-0.853)	0.768 (0.672-0.879)	0.940 (0.817.1.081)
– **Higher**	0.703 (0.591-0.836)	0.709 (0.594-0.846)	0.752 (0.629-0.899)	1.045 (0.869-1.257)
– **Upper**	0.532 (0.431-0.656)	0.566 (0.456-0.704)	0.610 (0.490-0.759)	0.873 (0.697-1.094)
Household income annually				
– **Poor**	1.373 (1.148-1.642)	1.479 (1.231-1.778)	1.478 (1.228-1.779)	1.290 (1.058-1.572)
– **Low**	1.224 (1.064-1.407)	1.308 (1.133-1.510)	1.301 (1.127-1.503)	1.171 (1.006-1.362)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.995 (0.867-1.141)	0.931 (0.808-1.071)	0.949 (0.825-1.093)	1.064 (0.919-1.232)
– **Higher**	0.777 (0.653-0.924)	0.703 (0.588-0.840)	0.735 (0.615-0.879)	0.946 (0.785-1.140)

– **Upper**	0.694 (0.556-0.865)	0.625 (0.499.0.783)	0.678 (0.540-0.850)	0.864 (0.684-1.092)
Equivalized income				
– **Poor**	1.152 (1.007-1.318)	1.224 (0.948-1.582)	1.289 (0.997-1.666)	1.334 (1.011-1.759)
– **Low**	1.189 (0.927-1.526)	1.317 (1.141-1.520)	1.306 (1.130-1.508)	1.124 (0.964-1.312)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.888 (0.781-1.010)	0.821 (0.719-0.937)	0.844 (0.739-0.963)	0.984 (0.857-1.129)
– **Higher**	0.691 (0.584-0.817)	0.619 (0.521-0.735)	0.652 (0.548-0.776)	0.873 (0.729-1.046)
– **Upper**	0.637 (0.515-0.789)	0.571 (0.459-0.710)	0.622 (0.499-0.774)	0.817 (0.652-1.024)

Model 1: OR (95% CI) unadjusted; Model 2: OR (95% CI) adjusted for sex and age; Model 3: OR (95% CI) adjusted for sex, age, BMI and smoking status; Model 4: OR (95% CI) adjusted for sex, age, BMI, smoking status and general health.
***Reference variable for calculated OR and 95% CI.**

Table 3 Multiple logistic regression models and the association between SES and short sleep duration before and after adjustment

Model	**1**	**2**	**3**	**4**
Adjusting variables	Unadjusted	+ Sex and age	+ Body mass index and smoking status	+ Self-reported general health
Marital status				
– **Cohabiting***	1.00	1.00	1.00	1.00
– **Single**	1.293 (1.101-1.519)	1.316 (1.119-1.547)	1.257 (1.067-1.479)	1.122 (0.950-1.326)
Employment status				
– **Employed***	1.00	1.00	1.00	1.00
– **Unemployed**	2.389 (1.834-3.112)	2.351 (1.803-3.065)	2.127 (1.627-2.782)	1.606 (1.215-2.124)
– **Student**	1.001 (0.639-1.570)	1.011 (0.636-1.606)	1.036 (0.651-1.648)	1.077 (0.673-1.721)
– **Retiree**	1.215 (1.042-1.417)	1.700 (1.334-2.165)	1.586 (1.248-2.016)	1.152 (0.918-1.446)
Education length				
– **Basic school**	1.542 (1.322-1.799)	1.620 (1.383-1.898)	1.555 (1.327-1.823)	1.331 (1.131-1.566)
– **High school**	0.978 (0.701-1.365)	0.908 (0.646-1.277)	0.948 (0.674-1.335)	0.977 (0.691-1.382)
– **Vocational***	1.00	1.00	1.00	1.00
– **Short/medium**	0.710 (0.581-0.867)	0.680 (0.556-0.832)	0.714 (0.583-0.874)	0.765 (0.623-0.939)
– **Long**	0.552 (0.368-0.828)	0.547 (0.365-0.822)	0.607 (0.404-0.913)	0.683 (0.453-1.030)
Personal income annually				
– **Poor**	0.983 (0.773-1.251)	1.123 (0.877-1.438)	1.164 (0.908-1.492)	1.099 (0.853-1.416)
– **Low**	0.933 (0.772-1.128)	1.107 (0.903-1.357)	1.091 (0.890-1.339)	0.969 (0.787-1.193)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.583 (0.482-0.705)	0.555 (0.458-0.672)	0.576 (0.475-0.698)	0.669 (0.550-0.814)
– **Higher**	0.531 (0.410-0.687)	0.506 (0.389-0.657)	0.549 (0.422-0.714)	0.697 (0.533-0.911)
– **Upper**	0.633 (0.483-0.828)	0.612 (0.464-0.807)	0.679 (0.514-0.897)	0.878 (0.661-1.166)
Household income annually				
– **Poor**	1.087 (0.836-1.413)	1.183 (0.906-1.545)	1.170 (0.895-1.530)	1.034 (0.787-1.359)
– **Low**	1.273 (1.053-1.540)	1.388 (1.142-1.686)	1.371 (1.127-1.666)	1.252 (1.026-1.528)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.855 (0.704-1.038)	0.786 (0.645-0.957)	0.811 (0.666-0.989)	0.883 (0.722-1.079)
– **Higher**	0.574 (0.441-0.748)	0.510 (0.390-0.666)	0.547 (0.419-0.716)	0.658 (0.502-0.864)
– **Upper**	0.822 (0.616-1.097)	0.732 (0.547-0.980)	0.822 (0.613-1.102)	0.980 (0.727-1.321)
Equivalized income				

– **Poor**	0.849 (0.574-1.255)	0.852 (0.573-1.268)	0.907 (0.609-1.351)	0.908 (0.607-1.358)
– **Low**	1.207 (1.004-1.450)	1.446 (1.188-1.760)	1.424 (1.170-1.735)	1.264 (1.033-1.546)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.783 (0.653-0.939)	0.703 (0.584-0.846)	0.733 (0.608-0.883)	0.824 (0.681-0.995)
– **Higher**	0.535 (0.415-0.689)	0.464 (0.359-0.600)	0.503(0.388-0.651)	0.624 (0.480-0.811)
– **Upper**	0.760 (0.575-1.005)	0.664 (0.501-0.881)	0.749 (0.563-0.996)	0.916 (0.696-1.225)

Model 1: OR (95% CI) unadjusted; Model 2: OR (95% CI) adjusted for sex and age; Model 3: OR (95% CI) adjusted for sex, age, BMI and smoking status; Model 4: OR (95% CI) adjusted for sex, age, BMI, smoking status and general health.
***Reference variable for calculated OR and 95% CI.**

Table 4 Multiple logistic regression models and the association between SES and long sleep duration before and after adjustment

Model	**1**	**2**	**3**	**4**
Adjusting variables	Unadjusted	+ Sex and age	+ Body mass index and smoking status	+ Self-reported general health
Marital status				
– **Cohabiting***	1.00	1.00	1.00	1.00
– **Single**	1.357 (1.145-1.608)	1.287 (1.085-1.528)	1.261 (1.061-1.498)	1.162 (0.976-1.384)
Employment status				
– **Employed***	1.00	1.00	1.00	1.00
– **Unemployed**	1.628 (1.159-2.289)	1.584 (1.125-2.230)	1.489 (1.055-2.101)	1.217 (0.856-1.728)
– **Student**	1.954 (1.349-2.830)	1.539 (1.047-2.262)	1.571 (1.067-2.313)	1.614 (1.093-2.383)
– **Retiree**	1.539 (1.314-1.802)	1.478 (1.154-1.894)	1.428 (1.116-1.828)	1.194 (0.942-1.513)
Education length				
– **Basic school**	1.527 (1.294-1.803)	1.479 (1.246-1.754)	1.442 (1.215-1.712)	1.292 (1.086-1.538)
– **High school**	1.200 (0.864-1.668)	1.036 (0.738-1.454)	1.065 (0.759-1.496)	1.084 (0.770-1.527)
– **Vocational***	1.00	1.00	1.00	1.00
– **Short/medium**	0.693 (0.558-0.861)	0.672 (0.540-0.837)	0.687 (0.551-0.856)	0.717 (0.575-0.894)
– **Long**	0.671 (0.449-1.001)	0.651 (0.436-0.974)	0.686 (0.458-1.027)	0.736 (0.491-1.104)
Personal income annually				
– **Poor**	1.601 (1.254-2.045)	1.536 (1.196-1.974)	1.578 (1.227-2.030)	1.521 (1.180-1.961)
– **Low**	1.428 (1.165-1.750)	1.403 (1.131-1.741)	1.404 (1.131-1.742)	1.298 (1.044-1.615)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.744 (0.601-0.920)	0.750 (0.605-0.930)	0.767 (0.619-0.951)	0.845 (0.680-1.050)
– **Higher**	0.766 (0.584-1.004)	0.785 (0.596-1.033)	0.821 (0.623-1.082)	0.953 (0.721-1.260)
– **Upper**	0.542 (0.385-0.763)	0.562 (0.397-0.797)	0.595 (0.419-0.845)	0.695 (0.488-0.989)
Household income annually				
– **Poor**	1.515 (1.188-1.932)	1.404 (1.097-1.798)	1.407 (1.098-1.803)	1.287 (1.002-1.654)
– **Low**	1.106 (0.904-1.353)	1.066 (0.868-1.310)	1.066 (0.867-1.310)	1.000 (0.812-1.232)
– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.674 (0.545-0.832)	0.686 (0.553-0.852)	0.694 (0.559-0.861)	0.729 (0.587-0.907)
– **Higher**	0.558 (0.424-0.834)	0.583 (0.441-0.770)	0.601 (0.454-0.795)	0.670 (0.505-0.887)
– **Upper**	0.492 (0.343-0.707)	0.522 (0.362-0.751)	0.556 (0.385-0.802)	0.616 (0.426-0.890)
Equivalized income				
– **Poor**	1.482 (1.059-2.073)	1.331 (0.946-1.875)	1.391 (0.987-1.961)	1.391 (0.985-1.965)
– **Low**	1.297 (1.069-1.574)	1.258 (1.026-1.542)	1.255 (1.023-1.539)	1.155 (0.939-1.420)

– **Work***	1.00	1.00	1.00	1.00
– **Middle**	0.716 (0.586-0.874)	0.726 (0.592-0.891)	0.739 (0.602-0.908)	0.796 (0.648-0.979)
– **Higher**	0.570 (0.437-0.744)	0.592 (0.451-0.778)	0.615 (0.468-0.808)	0.702 (0.533-0.924)
– **Upper**	0.509 (0.359-0.723)	0.538 (0.378-0.767)	0.575 (0.403-0.821)	0.648 (0.453-0.927)

Model 1: OR (95% CI) unadjusted; Model 2: OR (95% CI) adjusted for sex and age; Model 3: OR (95% CI) adjusted for sex, age, BMI and smoking status; Model 4: OR (95% CI) adjusted for sex, age, BMI, smoking status and general health.
***Reference variable for calculated OR and 95% CI.**

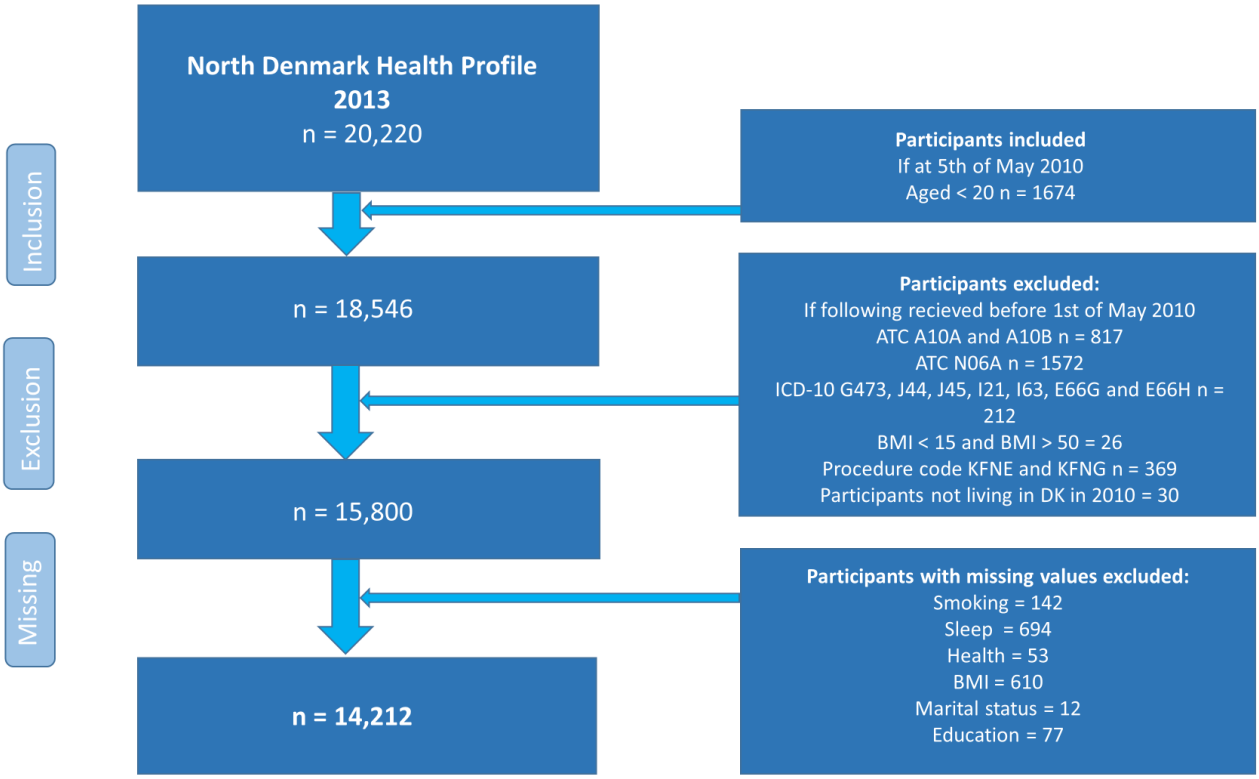

Figure 1: The exclusion procedure. A flowchart illustrating the process of exclusion and handling missing data.

References

1. Ferrie JE, Kumari M, Salo P, Singh-Manoux A, Kivimäki M. Sleep epidemiology-A rapidly growing field. *Int J Epidemiol*. 2011;40(6):1431-1437. doi:10.1093/ije/dyr203.
2. Stamatakis KA, Kaplan GA, Roberts RE. Short Sleep Duration Across Income, Education, and Race/Ethnic Groups: Population Prevalence and Growing Disparities During 34 Years of Follow-Up. *Ann Epidemiol*. 2007;17(12):948-955. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L350101233.
3. Sekine M, Chandola T, Martikainen P, McGeoghegan D, Marmot M, Kagamimori S. Explaining social inequalities in health by sleep: The Japanese civil servants study. *J Public Health (Bangkok)*. 2006;28(1):63-70. doi:10.1093/pubmed/fdi067.
4. Watson NF, Badr MS, Belenky G, et al. Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society on the Recommended Amount of Sleep for a Healthy Adult: Methodology and Discussion. *J Clin Sleep Med*. 2015;11(8):931-952. doi:10.5664/jcsm.4950.
5. Hvass LR, Manghezi A, Folker AP, Sandø N. *Social Ulighed I Sundhed – Hvad Kan Kommunen Gøre?* Copenhagen: Sundhedsstyrelsen; 2012. http://www.sst.dk/~/media/DC5BEF198B6B4E6B8CE19131A9B25B7C.ashx.
6. Ding D, Rogers K, Macniven R, et al. Revisiting lifestyle risk index assessment in a large Australian sample: should sedentary behavior and sleep be included as additional risk factors? *Prev Med (Baltim)*. 2014;60:102-106. doi:10.1016/j.ypmed.2013.12.021.
7. Eriksen, L. Davidsen, M. Jensen, HAR. Ryd, JT. Strøbæk, L. White, ED. Sørensen, J. Juel K. *Sygdomsbyrden I Danmark - Risikofaktorer*. Copenhagen; 2016.
8. Anders MP, Breckenkamp J, Blettner M, Schlehofer B, Berg-Beckhoff G. Association between socioeconomic factors and sleep quality in an urban population-based sample in Germany. *Eur J Public Health*. 2014;24(6):968-973. doi:10.1093/eurpub/ckt175.
9. El-Sheikh M, Keiley M, Bagley EJ, Chen E. Socioeconomic Adversity and Women's Sleep: Stress and Chaos as Mediators. *Behav Sleep Med*. 2015;13(6):506-523. doi:10.1080/15402002.2014.940110.
10. Grandner MA, Patel NP, Gehrman PR, et al. Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Med*. 2010;11(5):470-478. doi:10.1016/j.sleep.2009.10.006.
11. Friedman EM, Love GD, Rosenkranz MA, et al. Socioeconomic status predicts objective and subjective sleep quality in aging women. *Psychosom Med*. 2007;69(7):682-691. doi:10.1097/PSY.0b013e31814ceada.
12. Moore PJ, Adler NE, Williams DR, Jackson JS. Socioeconomic status and health: the role of sleep. *Psychosom Med*. 2002;64(2):337-344.
13. Sickel AE, Moore PJ, Adler NE, Williams DR, Jackson JS. The differential effects of sleep quality and quantity on the relationship between SES and health. *Ann N Y Acad Sci*. 1999;896:431-434.
14. Mezick EJ, Matthews KA, Hall M, et al. Influence of race and socioeconomic status on sleep: Pittsburgh SleepSCORE project. *Psychosom Med*. 2008;70(4):410-416. doi:10.1097/PSY.0b013e31816fdf21.
15. Krueger PM, Friedman EM. Sleep duration in the united states: A cross-sectional population-based study. *Am J Epidemiol*. 2009;169(9):1052-1063. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L354516053.

16. Gu D, Sautter J, Pipkin R, Zeng Y. Sociodemographic and health correlates of sleep quality and duration among very old Chinese. *Sleep*. 2010;33(5):601-610.
17. Park S, Cho MJ, Chang SM, et al. Relationships of sleep duration with sociodemographic and health-related factors, psychiatric disorders and sleep disturbances in a community sample of Korean adults. *J Sleep Res*. 2010;19(4):567-577. doi:10.1111/j.1365-2869.2010.00841.x.
18. Patel NP, Grandner MA, Xie D, Branas CC, Gooneratne N. "Sleep disparity" in the population: poor sleep quality is strongly associated with poverty and ethnicity. *BMC Public Health*. 2010;10:475. doi:10.1186/1471-2458-10-475.
19. Ryu SY, Kim KS, Han MA. Factors associated with sleep duration in Korean adults: results of a 2008 community health survey in Gwangju metropolitan city, Korea. *J Korean Med Sci*. 2011;26(9):1124-1131. doi:10.3346/jkms.2011.26.9.1124.
20. Jarrin DC, McGrath JJ, Silverstein JE, Drake C. Objective and Subjective Socioeconomic Gradients Exist for Sleep Quality, Sleep Latency, Sleep Duration, Weekend Oversleep, and Daytime Sleepiness in Adults. *Behav Sleep Med*. 2013;11(2):144-158. doi:10.1080/15402002.2011.636112.
21. Soltani M, Haytabakhsh MR, Najman JM, et al. Sleepless nights: The effect of socioeconomic status, physical activity, and lifestyle factors on sleep quality in a large cohort of Australian women. *Arch Womens Ment Health*. 2012;15(4):237-247. doi:10.1007/s00737-012-0281-3.
22. Whinnery J, Jackson N, Rattanaumpawan P, Grandner MA. Short and long sleep duration associated with race/ethnicity, sociodemographics, and Socioeconomic position. *Sleep*. 2014;37(3):601-611. doi:10.5665/sleep.3508.
23. Gubelmann C, Guessous I, Theler J-M, Haba-Rubio J, Gaspoz J-M, Marques-Vidal P. Trends and determinants of time in bed in Geneva, Switzerland. *J Clin Sleep Med*. 2014;10(10):1129-1135C. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L600342142.
24. Sakhelashvili I, Eliozishvili M, Basishvili T, et al. Sleep-Wake patterns and sleep quality in urban Georgia. *Transl Neurosci*. 2016;7(1):62-70. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L611401035.
25. Luo J, Zhu G, Zhao Q, et al. Prevalence and risk factors of poor sleep quality among chinese elderly in an urban community: Results from the Shanghai aging study. *PLoS One*. 2013;8(11):e81261. doi:10.1371/journal.pone.0081261.
26. Stringhini S, Haba-Rubio J, Marques-Vidal P, et al. Association of socioeconomic status with sleep disturbances in the Swiss population-based CoLaus study. *Sleep Med*. 2015;16(4):469-476. doi:10.1016/j.sleep.2014.12.014.
27. Smagula SF, Stone KL, Fabio A, Cauley JA. Risk factors for sleep disturbances in older adults: Evidence from prospective studies. *Sleep Med Rev*. 2016;25:21-30. doi:10.1016/j.smrv.2015.01.003.
28. Geroldi C, Frisoni GB, Rozzini R, De Leo D, Trabucchi M. Principal lifetime occupation and sleep quality in the elderly. *Gerontology*. 1996;42(3):163-169.
29. Demakakos P, Nazroo J, Breeze E, Marmot M. Socioeconomic status and health: The role of subjective social status. *Soc Sci Med*. 2008;67(2):330-340. doi:10.1016/j.socscimed.2008.03.038.
30. Patel SR, Sotres-Alvarez D, Castañeda SF, et al. Social and health correlates of sleep

duration in a US hispanic population: Results from the hispanic community health study/study of Latinos. *Sleep*. 2015;38(10):1515-1522. doi:10.5665/sleep.5036.
31. Hall M, Bromberger J, Matthews K. Socioeconomic status as a correlate of sleep in African-American and Caucasian women. *Ann N Y Acad Sci*. 1999;896:427-430. doi:10.1111/j.1749-6632.1999.tb08161.x.
32. Lauderdale DS, Knutson KL, Yan LL, et al. Objectively measured sleep characteristics among early-middle-aged adults: the CARDIA study. *Am J Epidemiol*. 2006;164(1):5-16. doi:10.1093/aje/kwj199.
33. Adams J. Socioeconomic position and sleep quantity in UK adults. *J Epidemiol Community Health*. 2006;60(3):267-269. doi:10.1136/jech.2005.039552.
34. Hayes, VS. Christiffanini, SL. Kræmer, SRJ. Johnsen, SB. Vinding AL. *Sundhedsprofil 2013 Trivsel, Sundhed Og Sygdom I Nordjylland*. Aalborg; 2013.
35. Kildemoes HW, Sorensen HT, Hallas J. The Danish National Prescription Registry. *Scand J Public Heal*. 2011;39(7 Suppl):38-41. doi:10.1177/1403494810394717.
36. Lynge E, Sandegaard JL, Rebolj M. The Danish National Patient Register. *Scand J Public Health*. 2011;39(7 Suppl):30-33. doi:10.1177/1403494811401482.
37. Baadsgaard M, Quitzau J. Danish registers on personal income and transfer payments. *Scand J Public Health*. 2011;39(7 Suppl):103-105. doi:10.1177/1403494811405098.
38. Jensen VM, Rasmussen AW. The Danish Education Registers. *Scand J Public Health*. 2011;39(7 Suppl):91-94. doi:10.1177/1403494810394715.
39. Hjollund NH, Larsen FB, Andersen JH. Register-based follow-up of social benefits and other transfer payments: accuracy and degree of completeness in a Danish interdepartmental administrative database compared with a population-based survey. *Scand J Public Heal*. 2007;35(5):497-502. doi:10.1080/14034940701271882.
40. Åkerstedt, Thorbjörn. Hume, Ken. Minor, David. Waterhouse J. The Subjective Meaning of Good Sleep, an Intraindividual Approach Using the Karolinska Sleep Diary. 1994;291(79):287-296.
41. Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193-213. doi:10.1016/0165-1781(89)90047-4.
42. Høgh, A. Hansen, ÅM. Bloch, C. Mikkelsen, EG. Maier, CM. Persson, R. Pedersen, J. Giver, H. Olsen O. Mobning og negativ adfærd på arbejdspladsen. 2009:122.
43. Det Nationale Forskningscenter for Arbejdsmiljø. *Konstruktionen Af Skalaerne I Tre-Dækker II*.; 2005. http://www.arbejdsmiljoforskning.dk/~/media/Spoergeskemaer/copsoq/konstruktion-af-skalaerne-i-3d-ii-28-10-20052.pdf#.
44. Van Cauter E, Spiegel K. Sleep as a mediator of the relationship between socioeconomic status and health: a hypothesis. *Ann N Y Acad Sci*. 1999;896:254-261.
45. UNESCO Institue for Statistics. *The International Standard Classification of Education 2011*. Montreal,Quebec; 2012. doi:10.1108/S0195-6310(2013)0000030017.
46. Hale L. Who has time to sleep? *J Public Health (Bangkok)*. 2005;27(2):205-211. doi:10.1093/pubmed/fdi004.
47. Arber S, Bote M, Meadows R. Gender and socio-economic patterning of self-reported sleep problems in Britain. *Soc Sci Med*. 2009;68(2):281-289. doi:10.1016/j.socscimed.2008.10.016.
48. Greenhalgh T. How to read a paper: getting your bearing (deciding what the paper is about). *BMJ*. 1997;315(7102):243-246.

doi:http://dx.doi.org/10.1136/bmj.315.7102.243.
49. Juul S. *Epidemiologi Og Evidens*. 1st editio. København: Munksgaard Danmark; 2009.
50. Tjønneland A, Olsen A, Boll K, et al. Study design, exposure variables, and socioeconomic determinants of participation in Diet, Cancer and Health: a population-based prospective cohort study of 57,053 men and women in Denmark. *Scand J Public Health*. 2007;35(4):432-441. doi:10.1080/14034940601047986.