Sleep and mental health: the association, heterogeneity and Covid

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Date final version: 9-7-2023

Abstract

Mental health problems are on the rise globally, while reported sleep duration is decreasing over time. This paper researched the association between sleep (both duration and quality) and mental health, the heterogeneity of the relationship between sleep duration and mental health by socioeconomic status and whether this relationship altered after the Covid pandemic in the Netherlands. To test this, I used an individual fixed effects model for the regression with interaction effect dummies for the heterogeneity and Covid effect. The research found a strong negative and significant correlation between bad sleep quality and mental health, but a weaker negative correlation between sleep duration and mental health. However, the interaction dummies were both not significant, meaning that no heterogeneity by socioeconomic status or a change of the relationship after Covid were found. An implication of these results could be raising awareness to the public about healthy sleeping behaviour with the aim to increase sleep quality.

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Introduction

Sleep is a primal human need and essential for the functioning of the body and the mind. It helps children and teenagers mature and a deficit of sleep for a longer period of time can cause serious chronic health problems for adults such as heart diseases, high blood pressure or obesity (Giuntella & Mazzonna, 2019; NIH, 2022). Sleep is also highly correlated with mental health: mental disorders such as anxiety, depression, autism or schizophrenia tend to have a significant relationship with sleeping problems (Baglioni et al., 2016). Recently, the Covid pandemic saw a shift in people's sleeping behaviour: for most groups of the population, sleep duration increased whilst the quality of sleep (e.g., the absence of disruptions, feeling rested afterwards etc.) decreased[1]. This paper's main aim is to find the relationship between sleep, both quality and duration, and mental health in the Netherlands. The other aims are to test the heterogeneity of the relationship between sleep duration and mental health for different socioeconomic status (SES) groups and whether the year of the Covid pandemic showed another relationship between sleep duration and mental health than the year before.

Besides the health hazards described above, lack of sleep leads to significant declines in cognitive and motor skills, increasing the likelihood of motor vehicle accidents, work-related injuries, and fatal incidents (Luyster et al., 2012). Furthermore, sleep deprivation also negatively impacts the economic performance. The study of Giuntella & Mazzona (2019) calculated that next to the 2 billion dollars of health care costs associated with sleep deprivation, it also leads to the loss of approximately 4.4 million working days in the US. Nevertheless, the average duration of sleep among individuals has declined over the years. For instance, adults in the United States typically slept an average of 7.40 hours per night in 1985, whereas by 2012, this figure had decreased to 7.18 hours per night (Ford et al., 2015). This epidemic of sleep deficit is not only prevalent in the US: a study from Kerkhof (2017) shows that in the Netherlands approximately 43.2% of the population is getting insufficient sleep and 8.2% is suffering from insomnia. Moreover, mental health problems are also on the rise globally: the WHO (2019) found a 13% increase in mental health disorders in the decade between 2007 and 2017. A worrying figure when you take into account that depression is one of the leading causes of suicide worldwide (Kang et al., 2013).

A detailed understanding of the sleep-mental health relationship has far-reaching implications for public health policies and interventions. Sleeping problems and mental health disorders apply a significant burden on healthcare systems worldwide, as discussed in the paragraph above. By clarifying the complex

[1] For health care workers the sleep duration did also decrease during the Covid pandemic (Neculicioiu et al., 2022).

relation between these variables, I could empower policymakers, healthcare professionals, and researchers to design targeted interventions that promote mental health and improve sleep quality through information campaigns on a societal scale. This could result in the lowering of the burden of the health care system and minimize the loss of working days.

In the past few decades, several papers researched the effect of sleep as a behaviour in economics. As discussed above, the relationship between sleep and mental health has already been covered by multiple papers. The same counts for the heterogeneity of the relationship by SES and the change in sleeping behaviour and mental health individually after the Covid pandemic. However, this research can add a new perspective to the existing literature by examining whether the Covid pandemic not only impacted sleep and mental health separately, but if the relationship between the two changed as well. The Netherlands has also already been a researched field when it comes to sleeping behaviour and mental health. But again, this research focussed mainly on sleep and mental health individually, rather than the relationship between them and the possible heterogeneity of this relationship by SES. Therefore, studying this for the Netherlands could be a useful insight to compare the heterogeneity between the different countries.

Firstly, I will present a literature review which starts with the beginning of sleep behaviour in economics. Then, the possible reasons for delaying sleep are discussed, specifically looking at the use of digital devices. Next, the physical, cognitive and economic consequences of sleep deficit are listed, whereafter I summarize the consensus about the relationship between sleep and mental health. Finally, the heterogeneity of this relationship by SES and the changing sleep behaviour after Covid are discussed. This provides a theoretical framework to base my main hypotheses for this research around.

After the literature review, I will describe the dataset and their characteristics, review the variables of interest across the quartiles of income and look at the differences in these variables before and after Covid at first glance. Then, I will outline the method used in this paper, whereafter the results are published. Finally, the conclusion and discussion will summarize the insights of this research, recommend possible policy implications and describe the limitations of the study.

Literature Review

The study of economics would not exist without scarcity. Scarcity forces people to make choices in their life about how to allocate their time and resources, which is the foundation of economics as we know it today. Up until a couple of decades ago, sleep was viewed as a fixed activity, meaning that economists did not think of sleep as something that individuals chose to do. However, Biddle and Hamermesh (1990) disagreed with this philosophy and opted to view sleep as a behaviour rather than a fixed variable for consumers. They studied the association between the number of hours worked daily and the duration of sleep per night and found that one additional hour of work during the day, corresponds with a decrease in sleep time by approximately 10 minutes. This supported the theory of sleep being a behavioural choice for individuals and laid the foundation for including sleep as a topic of interest in economics.

A reason why people are trading their amount of sleep hours for other activities nowadays, could be the accessibility to advanced technology. Billari et al. (2018) did research into the causal effect of having access to smart digital devices on people's bedtime procrastination in Germany. Bedtime procrastination refers to the act of intentionally delaying the time of sleep, without there being any external factors that would hinder an individual from doing so at their intended bedtime (Kroese et al., 2014). Firstly, they found a strong association between the use of those electronic devices (for gaming or watching TV) and bedtime procrastination, especially for teenagers and young adults. Then, using an instrumental variable (IV), they found that access to a high-speed internet connection (the IV) decreases sleep duration and the subjective satisfaction of sleep in their sample. A similar conclusion was drawn from a systematic literature review of 67 studies between 1999 and 2014, where 90% of the reviewed literature saw a significant association between the use of digital devices and bedtime procrastination (Hale & Guan, 2015). However, Hale & Guan (2015) emphasize that the relationship is merely associative and not causal. One could indeed question whether the use of these devices is the single cause for bedtime procrastination or if this behaviour is a consequence of an underlying factor. One example for this could be the relatively new theorem in Psychology called 'revenge bedtime procrastination'. This refers to the phenomenon where individuals intentionally delay their bedtime and sacrifice sleep to reclaim a sense of leisure and personal time in their daily lives, which is otherwise limited by a busy schedule (Suni & Suni, 2023). So perhaps the use of digital devices is not the cause of the rise of bedtime procrastination, but merely a tool for individuals to enjoy some extra leisure time in the evenings. The event of bedtime procrastination is also becoming a common practice in the Netherlands. In 2016, 29.1% of a representative

Dutch sample indicated that they go to bed later than they would like to for 2-3 days a week, while 8.6% indicated that this is the case for 6-7 days a week (Kroese et al., 2016).

But the decrease in sleep duration does not come without its consequences. As previously discussed in the introduction, Giuntella and Mazzonna (2019) examined the differences in health and economic performance between people living in two closely related counties in the US with different time zones. The researchers found that individuals residing in the State that receives an extra hour of natural sunlight at the end of the day were found to sleep, on average, for a shorter duration and reported to experience insufficient sleep more often as well. Consequently, this resulted in worse health outcomes, such as obesity, breast cancer and heart diseases, and reduced the economic performance of its inhabitants. These associations of health outcomes like obesity, decreases in cognitive functions and cardiovascular diseases with insufficient sleep (or poor sleep quality) are also established in other academic literature (Waters & Bucks, 2011; Van Cauter et al., 2008; Lao et al., 2018). Moreover, Giuntella and Mazzonna (2019) calculated that the health care costs associated with these health outcomes equalled around 2 billion dollars ($6 per person in the US) and that the loss in economic performance totalled up to around 4.4 million working days. Sleep duration not only influences economic performance on societal level, but also on a personal level. Gibson and Shrader (2018) found that an average increase of sleep duration by one hour per week causes earnings to rise on a personal level with 1.1% in the short run and 5% in the long run.

Several studies examined the association between sleep and mental health in the last decade, with the consensus that there is a positive relationship between the two variables, e.g., healthier sleeping behaviour corresponds with better mental health (Milojevich & Lukowski, 2016; Furihata et al., 2012; Riemann et al., 2001). Freeman et al. (2017) studied whether curing insomnia has a causal effect on mental disorders such as paranoia and hallucinations using digital cognitive behavioural therapy to improve sleep in a Randomized Control Trial. They discovered that this treatment decreased insomnia and paranoia, while increasing mental health and they concluded that healthy sleeping behaviour is a contributing factor to the mental health of their sample. Furthermore, they also saw decreases in other mental health problems such as depression and anxiety when the treatment was administered. A similar conclusion was drawn by Giuntella et al. (2017), where they found that increases in sleep duration decreased depressive symptoms and increased cognitive abilities among Chinese employed adults above 45.

Although the association between sleep duration and mental health is positive, this relationship could differ for different groups. Individuals with a lower SES are more likely to experience sleeping inefficiencies

than people with a higher SES, indicating a discrepancy in sleep quality between the two groups (Patel et al., 2010). This was also found by Friedman et al. (2007) among elderly women and they concluded that SES is highly correlated with sleep efficiency, meaning that high SES individuals are more efficient than low SES individuals. Bessone et al. (2021) conducted research in an impoverished part of India to see whether increasing the duration of sleep would have positive economic consequences. What they found, however, was that increasing the sleep duration at night by 27 minutes did not improve their productivity at work, cognition or overall wellbeing. This could again be evidence for the heterogeneity of the relationship between sleep duration and mental health by SES, since the sleep quality of those groups in India was very poor, which then in turn causes an increase in sleep duration to be ineffective for mental health.

As for the relationship between sleep and mental health during the Covid lockdown, research showed that the sleep duration increased, while quality of sleep and mental health generally worsened (Neculicioiu et al., 2022; Facer-Childs et al., 2021). These trends might be evidence for sleep quality being a better predictor for mental health than duration of sleep. However, it could also mean that sleep duration is not monotonically related to mental health, but that both insufficient and excessive sleeping durations are associated with worse mental health than the recommended duration of sleep. Moreover, the sleep timing of individuals changed during the Covid pandemic, meaning that people tended to go to sleep later and woke up later in the morning. On top of this, Neculicioiu et al. (2022) also found a negative correlation between long-Covid patients and sleep duration, indicating that catching the virus itself might influence your sleeping behaviour.

The existing literature on this topic gives me enough foundation to expect a significant positive correlation between sleep and mental health in my sample. Specifically, I believe I will find a strong positive correlation between mental health and sleep quality, but a weaker positive relationship between mental health and sleep duration. Secondly, I hypothesize that this relationship varies across different income levels of individuals, where the correlation between sleep duration and mental health will be even weaker for low SES individuals. Since literature pointed out that because of a worsened sleeping quality of low SES individuals, the duration of sleep is less linked to their mental health, I expect to see a larger positive association between sleep duration and mental health for people with a higher income than people with a lower income (e.g., more sleep is associated with better mental health). My final hypothesis is that the Covid pandemic diminished the association between the duration of sleep and mental health even more, since people had the chance to sleep more but their mental health declined.

Thus, for the first hypothesis, I will look at both sleep duration and sleep quality to gain insight of the overall association of the two variables with mental health separately, while keeping the other variable constant. Then, for the second and third hypotheses, I will only look at sleep duration, since sleep quality is most likely one of the factors that make these relationships heterogeneous. I want to emphasize that this paper will merely focus on finding the most unbiased association between the two factors, not a causal relationship, since this is tricky to establish due to the bi-directional nature of the relationship.

Data

To test the hypotheses, I used data from the LISS (Longitudinal Internet studies for the Social Sciences) panel. It consists of multiple longitudinal datasets from 5.000 Dutch households with roughly 7.500 individuals. The respondents fill in surveys each month and the data is stored in the archive. The variables used for this research are extracted from two different surveys: one survey is based on health-related questions and the other on the time-use of the individuals. The focus of this study will be on the years 2019 and 2020, to compare the results of one year prior to the Covid outbreak and the year of the outbreak. The surveys from both years are from the month of October. To clean up the data, I eliminated all individuals that only appeared in one of the two years, who reported unlikely weekly self-reported sleep duration numbers (below 14 hours and above 100 hours), that had missing values and who were under 18. I chose a cutoff point at 100 hours of sleep per week to drop some outliers from the dataset and the minimum of 14 hours because humans need at least two hours of sleep to function (although this is not sustainable). After cleaning up the data, there were 2,544 respondents left with data in both years, yielding 5,088 datapoints in total.

To construct the outcome variable of mental health, I used the results of five different statements the respondents answered. Those statements are 'I felt very anxious ', 'I felt so down that nothing could cheer me up', 'I felt calm and peaceful', 'I felt depressed and gloomy' and 'I felt happy'. The respondents could give six different answers, ranging from 'never' to 'continuously'. I inverted the answers of 'I felt happy' and 'I felt calm and peaceful' to ensure that every statement was directed in the same way. With the outcome of these statements, I created a 'Mental Health Index' (MHI), averaging all the statements combined, with 1 being the worst mental health state possible and 6 being the best.

For the independent variable of interest (sleep), I used two different measurements. The first one is the sleep duration of the respondents, reported as the total hours of sleep they had in the last seven days. The second variable is a dummy variable that indicated whether the respondents were experiencing sleeping problems, with 0 being 'no' and '1' being 'yes', which will be used as an indicator for sleep quality (e.g., having sleeping problems indicates a poor sleep quality). For the control variables I only added factors that could change over time and could influence both the independent and dependent variable, since this research will use an individual fixed effect model (which will be further explained in the methodology). These variables are the number of children living at home, civil status, income and a year dummy (which has the value 1 for the year 2020). Income is a continuous variable, defined as net household income and divided by 500 to simplify the interpretation of the regression outcome. Since the sample is relatively old, which you can find in Table 1, the level of education is unlikely to differ across the years and is thus not a relevant control variable for this study.

Table 1 shows the descriptive statistics of the sample. The most notable statistic is the average age of the sample, 57.4, which is relatively old. Another statistic that stands out is that 71% of the respondents do not have children living at home but is not surprising when you take the average age of the sample into account. Moreover, the average sleep duration in the last seven days was 61.2 hours and approximately 22% of the sample is experiencing difficulties with sleeping. The average MHI of this sample is 4.8 and has a minimum value of 1 and maximum value 6.

Table 1: Descriptive statistics of the sample

	N	Percentage / mean (SD)	Minimum	Maximum
Gender	**5,088**			
Female	2,590	50.9%	-	-
Male	2,498	49.10%	-	-
Age	**5,088**	57.4 (16.7)	18	103
Civil status	**5,088**			
Married	2,923	57.5%	-	-
Divorced	611	12.0	-	-
Widowed	343	6.7%	-	-
Never been married	1,211	23.8%	-	-
Number of children living home	**5,088**			
None	3,654	71.8%	-	-
1-2	1154	22.7%	-	-
3-6	280	5.5%	-	-
Net income per month	**5,088**	3320.3 (1800.4)	0	17,000
Education*	**5,088**			
Lower level	1,043	20.5%	-	-
Middle level	1,533	30.1%	-	-
Higher level	2,466	48.5%	-	-
Other	46	0.9%	-	-
Sleeping problems	**5,088**			
Yes	1,132	22,3%		
No	3,956	77.8%		
Hours of sleep last 7 days	**5,088**	61.2 (13.2)	14	100
Mental Health Index	**5,088**	4.8 (0.8)	1	6

*Lower education consists of primary school and VMBO, middle education consists of havo/vwo and MBO, higher education consists of HBO and WO, other consists of no education.

Table 2 below shows the variables of interest for the quartiles of household income. The average sleep duration shows a decreasing trend as income increases, where the highest quartile, on average, sleeps over an hour shorter per week than the lowest quartile. Nevertheless, the share of individuals reporting difficulties with sleeping is more than double for the lowest quartile than it is for the highest quartile. This could be an indication that indeed high SES individuals show a higher efficiency in sleep in this sample since their sleep duration is lower than low SES individuals, but they are also less likely to report sleeping problems. Additionally, higher income individuals also reported a better mental health on average. This could support the idea of a heterogeneous relationship between sleep duration and mental health, because one additional hour of sleep could be more effective for high income individuals due to their improved quality of sleep.

Table 2: Means of sleep duration, sleeping problems and MHI divided over the quartiles of income

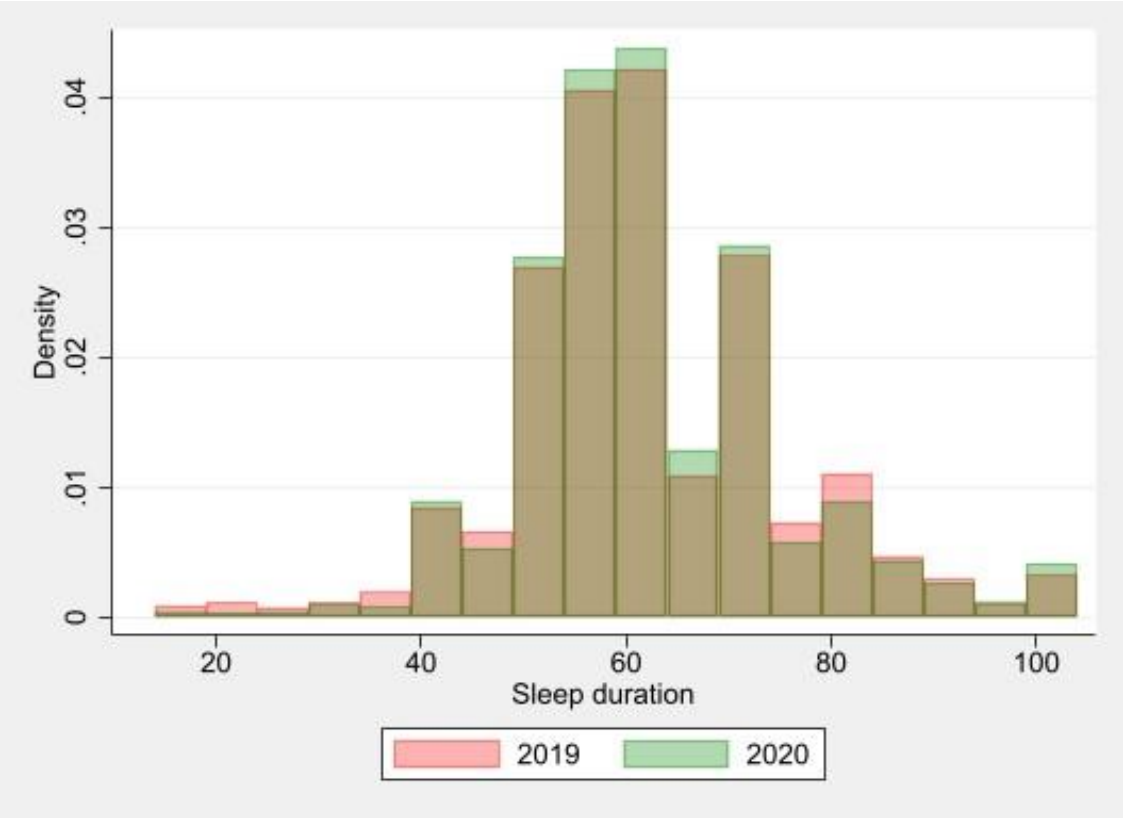
Quartiles of income	Hours of sleep	Sleeping problems	MHI
0-25%	61.53	32.02%	4.61
25-50%	61.59	22.18%	4.86
50-75%	61.09	19.41%	4.88
75-100%	60.44	15.48%	4.91

If we then fixate on the same variables but look at the differences of the means over time (Table 3), the weekly sleep duration increased by approximately 20 minutes in 2020. The distribution of the amount of sleep also changed by a small margin, which is visible in Figure 1. In 2019 the extremes are more represented, but 2020 shows more representation around the recommended amount of 8 hours of sleep per night (which is 56 hours per week). However, the share of respondents experiencing sleeping problems and the average MHI both show no real evidence of changing over the years. This could be proof for a possible shift in the relationship between sleep duration and mental health after the Covid pandemic, since the sleep duration increased but the mental health of people did not seem to improve. Also, this could mean that the sleep quality worsened over this period, because the sleep duration increased but the share of sleeping problems did not decrease.

Table 3: Means of sleep duration, sleeping problems and mental health across the years

Variable	2019	2020
Hours of sleep	60.99	61.33
Sleeping problems	22.29%	22.21%
Mental Health Index	4.80	4.84

Figure 1: Distribution of the amount of sleep across the years



Note: the bin width is 5 hours of weekly sleep.

Methodology

To find the most unbiased association as possible, I ran three different regressions with an individual fixed effects model. This model looks at the within individual variation across the two years and thus rules out all the time-invariant factors that could contribute to the Omitted Variable Bias (OVB). For this reason, it is not necessary to control for any variables that stay fixed over time such as gender, age or country of heritage for example. There is, however, still a possibility of the presence of time-varying variables that are correlated with sleep and mental health. This means that there is still a chance of OVB, but with this model, the risk of biased results is somewhat mitigated. Additionally, I want to emphasize again that no causal interpretation can be derived from the outcome of the results, because of the bi-directional nature of this relationship.

Firstly, for the most unbiased correlation between sleep and mental health, the regression looks as follows:

$$Y_{it} = \alpha_i + \rho_1 T_{it}^p + \rho_2 T_{it}^d + \beta_x X_{it} + \gamma D_t + \epsilon_{it} \quad \textbf{(1)}$$

Where Y_{it} is the mental health problems index, α_i indicates the time-unvarying individual fixed effects, T_{it}^p is the dummy variable indicating whether the person Is experiencing sleeping problems, T_{it}^d indicates the amount of weekly sleeping hours, X_{it} is a vector of control variables (income, civil status and number of children living at home), D_t is the year-dummy and ϵ_{it} is the time-varying error term. The i and t stand for each individual and the year, respectively. To analyze whether sleeping quality has a stronger correlation with mental health than sleep duration, I can look at the signs, significance and magnitude of ρ_1 and ρ_2. Because both sleep duration and sleep quality are added to the regression, the partial correlation is measured, keeping the other variable constant. For example, for sleep duration this means that the outcome shows the correlation between sleep duration and mental health, whilst keeping the sleeping problems constant.

Then, to check the heterogeneity of this relationship regarding the SES status of the individuals, a similar regression is used, including an interaction term for SES status as well:

$$Y_{it} = \alpha_i + \rho T_{it}^d + \beta_x X_{it} + \gamma D_t + \theta T_{it}^d \times X_{it1} + \epsilon_{it} \quad \textbf{(2)}$$

With the same terms as described above, with the only difference that $T_{it}^d \times X_{it1}$ indicates the interaction term between the duration of sleep and the continuous variable of income (divided by 500). The dummy for sleeping problems is removed from this regression, since this is most likely one of the factors that results the relationship between sleep duration and mental health to differ between different SES groups.

Finally, for assessing whether the Covid pandemic influenced the relationship between sleep and mental health, the regression looks as follows:

$$Y_{it} = \alpha_i + \rho T_{it}^d + \beta_x X_{it} + \gamma D_t + \varphi T_{it}^d \times D_t + \epsilon_{it} \quad \textbf{(3)}$$

With the same terms as before, with the only difference that $T_{it}^d \times D_t$ represents the interaction term between sleep duration and the year-dummy. The sleeping problem dummy is again removed from this equation because of the same reason described above.

Results

The results of the first regression are visible in Table 4 below. As described in the data section, the MHI is on a scale of 1 to 6, with 6 being the best mental health state possible and 1 the worst, thus a positive relation means a positive association with mental health. The second column contains the fixed effects regression, and the first column contains a regular OLS regression for comparison. In the individual fixed effects model sleep duration has a significant negative association with mental health. One additional hour of sleep per night (so seven hours on a weekly basis) is associated with a 0.0091 (7*0.0013) lower MHI score, on average. If the sleeping problems dummy is left out of the fixed effects regression, the magnitude of the sleep duration coefficient remains negative (-0.0014 instead of -0.0013). So even when sleep quality is not being controlled for, higher sleep duration is still associated with worse mental health in this sample. However, when you put this in perspective, this is not a very strong correlation, considering that the standard deviation of the MHI in this sample is 0.8. To test the sensitivity of the constructed outcome variable, I performed a simple regression of gender on MHI, since women are more likely to report worse mental health (Johnston et al., 2020). This result is visible in column 3 and as you can see the female dummy shows a negative significant relationship with mental health and its magnitude is quite substantial, making the MHI sensitive enough to find significant differences.

In contrast to sleep duration, the sleeping problem dummy does have a more considerable magnitude. On average, experiencing sleeping problems is associated with a lower MHI score of 0.3151. The most notable detail is the difference in magnitude of this coefficient between the OLS and fixed effects regression. In the OLS regression, the magnitude is almost twice the size of the fixed effects coefficient, possibly caused by OVB of confounding variables that the fixed effects model accounts for, but the OLS does not (such as upbringing or genetics).

Surprisingly, the year 2020 has a positive significant relationship with mental health in comparison with 2019. On average, 2020 is associated with a 0.0406 higher MHI score than 2019. But again, this magnitude is not substantial enough for it to be a strong correlation. The coefficients of income, the civil status and the number of children living at home are not significant in the fixed effects model and can thus not be interpreted. They are, however, significant in the OLS regression, this difference is probably caused by too little variation of these variables within individuals over the years, resulting the fixed effects model to be unable to find a relationship. The OLS regression shows a significant positive relationship between income and mental health, the magnitude, however, is again not that strong. On average, an increase of income

with 500 euros a month is associated with an increase of the mental health index of 0.0220, while keeping other factors constant. This is also in line with the descriptives in Table 2, where the MHI had an increasing trend over the quartiles of income. The number of children living at home seems to be negatively correlated with mental health, which could be explained by the added mental strain for parents that comes with raising a child (or children). The constant cannot be interpreted, since there are no individuals with a sleep duration of 0 hours in this sample.

Summarizing, the duration of sleep is significantly and negatively related to mental health, but not as strong as experiencing sleeping problems and 2020 is correlated with a better mental health than 2019. The difference in the magnitude between sleep duration and sleeping problems provides strong evidence for sleep quality being more associative with mental health than sleep duration. As for a possible explanation of why the duration of sleep could be negatively related to mental health, one could argue that maybe depressed or anxious people struggle to get out of bed and thus report a higher sleep duration. Another possible explanation could be a heterogeneous relationship between sleep and mental health, which will be assessed in the next paragraph.

Table 4: OLS and Individual fixed effects regression results on dependent variable mental health

	OLS MHI (1)	**FE MHI (2)**	**OLS MHI (3)**
Hours of sleep	-0.0019** (0.0009)	-0.0013* (0.0008)	
Sleeping problem	-0.6067*** (0.0289)	-0.3151*** (0.0702)	
Year	0.0217 (0.0203)	0.0406*** (0.0114)	
Income (per 500 EUR)	0.0220*** (0.0029)	-0.0050 (0.0078)	
Civil Status			
Divorced	-0.1080*** (0.0356)	-0,4161 (0.3885)	
Widow	-0.0775* (0.0439)	-0.4921 (0.6206)	
Never been married	-0.0848*** (0.0302)	0.0642(0.0996)	
Number of children	-0.0335*** (0.0302)	0.0303 (0.0479)	
Female	-0.0649** (0.0210)		-0.1740*** (0.0221)
Age	0.0096*** (0.0008)		
Constant	4.5158*** (0.0878)	5.0280*** (0.1040)	5.0794*** (0.0352)
R-squared within		0.0219	
R-squared (Between)	0.1759	0.0264	0.0120
Observations	5,088	5,088	5,088

Note: *p <0.1, **p <0.05, ***p <0.01. The civil status categories are relative to the category 'Married'.

As for the second hypothesis, regarding the heterogeneity of this relationship for SES status, the results can be found in Table 5 below. Even though, on average, higher income people sleep less and their MHI is higher than lower income people (as you can see in Table 2), the interaction variable of sleep duration

and income is small and insignificant in both the OLS and fixed effects regression. Therefore, it cannot be concluded that the relationship between sleep duration and mental health is heterogeneous for SES in this sample. The decrease of the R-squared for this regression in comparison to the previous regressions is most likely to be caused by not including the sleeping problems dummy, which was quite predictive for mental health.

Table 5: OLS & Individual fixed effects regression with interaction term for SES & Sleep duration

	OLS MHI (1)	**FE MHI (2)**
Hours of sleep	-0.0002 (0.0018)	-0.0024 (0.0017)
Year	0.0219 (0.0214)	0.0406*** (0.0115)
Income (per 500 EUR)	0.0459*** (0.0153)	-0.0147 (0.0161)
Interaction income & hours of sleep	-0.0003 (0.0002)	0.0002 (0.0002)
Civil Status		
Divorced	-0.1220*** (0.0377)	-0.4177 (0.5284)
Widow	-0.0944** (0.0944)	-0.5371 (0.5914)
Never been married	-0.1152*** (0.0319)	0.0903 (0.1025)
Number of children	-0.0405*** (0.0138)	0.0265 (0.0479)
Female	-0.1285*** (0.0218)	
Age	0.0083*** (0.0009)	
Constant	4.4093*** (0.1362)	5.0226*** (0.1396)
R-squared within		0.0092
R-squared (Between)	0.0787	0.0017
Observations	5,088	5,088

Note: *p <0.1, **p <0.05, ***p <0.01.

Finally, the results for testing the influence of the Covid pandemic on the relationship between sleep and mental health are in Table 6. Adding the new interaction term of the year-dummy and the duration of sleep, causes the year-dummy to lose its significance, while the sleep duration variable stays slightly significantly negative. Moreover, the interaction term itself is also not significant. Therefore, it cannot be concluded that the year of the Covid pandemic had a different relationship between sleep duration and mental health than the year before. A possible explanation for the positive association between 2020 and mental health, for example, could be the release of workload during the lockdowns or the absence of commuting which freed up spare time for employees.

Table 6: Individual fixed effects regression with interaction term for year & Sleep duration

	OLS MHI (1)	FE MHI (2)
Hours of sleep	-0.0015 (0.0013)	-0.0017* (0.0010)
Year	0.0609 (0.1104)	0.0020 (0.0740)
Interaction year & hours of sleep	-0.0006 (0.0018)	0.0006 (0.0012)
Income (per 500 EUR)	0.0297*** (0.0031)	-0.0039 (0.0080)
Civil Status		
Divorced	-0.1212*** (0.0377)	-0.4086 (0.3893)
Widow	-0.0941** (0.0447)	-0.5305 (0.5930)
Never been married	-0.1152*** (0.0319)	0.0906 (0.1023)
Number of children	-0.0404*** (0.0138)	0.0240 (0.0479)
Female	-0.1289*** (0.0218)	
Age	0.0083*** (0.0009)	
Constant	4.4923*** (0.1081)	4.974*** (0.1071)
R-squared within		0.0091
R-squared (Between)	0.0785	0.0016
Observations	5,088	5,088

Conclusion and Discussion

This research's main aim was to find the most unbiased association between sleep (both duration and quality) and mental health. The other aims were to research whether the relationship between sleep duration and mental health differed by SES and if this relationship altered in the year of the Covid pandemic. Specifically, this study focussed on a Dutch sample between 2019 and 2020 and the results were found using an individual fixed effects model. The main reason for this research is the declining mental health of individuals worldwide and the decrease of sleep duration over the years. A better understanding of the relationship between the two could benefit society by empowering policy makers with more knowledge to increase social well-being and reduce health care costs.

The first hypothesis stated the expectation that sleep duration would be positively correlated with mental health, while sleeping problems (e.g., having a bad sleep quality) would be negatively correlated with mental health. Additionally, I hypothesized that the correlation between sleep quality and mental health would be much stronger than the correlation between sleep duration and mental health. The latter was confirmed by the results of the first regression, where the coefficient of experiencing sleeping problems is more than three times the size of the coefficient of sleep duration (if you multiplied the sleep duration coefficient with 7). Consequently, it can be concluded that indeed, on average, sleep quality is a more important predictor of mental health than sleep duration for this Dutch sample between 2019 and 2020. This is in line with the study of Bessone et al. (2021) where they found that increasing sleep over night in India was not effective to improve mental health due to the poor sleep quality of their sample. However, the sign of the sleep duration coefficient turned out to be negative instead of positive, therefore it cannot be concluded that sleep duration positively correlated with mental health overall. An explanation for this could be that anxious or depressed individuals struggle to get out of bed some days and thus report increased amounts of sleep duration.

Secondly, I hypothesized that sleep duration would have a stronger positive association with mental health for high SES individuals than for low SES individuals, caused by a better sleep quality for high SES groups. The results of this study, however, did not support this statement. Thus, it cannot be concluded that the relationship between sleep duration and mental health differs for different SES groups in this sample between 2019 and 2020. But overall, income did show a significant positive association with mental health, meaning that for this sample a higher income is correlated with a better mental health, on average.

The final hypothesis stated that in the year of the Covid pandemic, the relationship between sleep duration and mental health changed, since the overall sleep duration increased in 2020 compared to 2019, but the mental health of the sample didn't necessarily improve. However, the insignificant interaction term for sleep duration and the year dummy provides no evidence to support this theory. Therefore, it cannot be concluded that for this Dutch sample, the relationship between sleep duration and mental health changed in 2020.

With sleep quality being a much stronger predictor for mental health than sleep duration, some policy implications can be recommended. Policies can focus on raising public awareness about the significance of sleep quality for mental health with educational campaigns. These campaigns can highlight the importance of healthy sleep habits, such as creating a favourable sleep environment, practicing relaxation techniques and managing stress, to help improve sleep quality. Also, policies can encourage general practitioners or other doctors to include assessments of sleep quality as part of routine mental health screenings. By recognizing individuals with poor sleep quality, early interventions could be implemented to address sleep-related issues and provide the right support for maintaining mental health. It is important to mention that while policy recommendations can be based on associative relationships, caution must be maintained in making causal interpretations. More research and thorough study designs are needed to establish the causal direction of the relationship between sleep quality and mental health. Nonetheless, these policy implications can serve as a starting point for addressing the potential impact of sleep quality on mental health.

A limitation of this study is the possibility of too little within variation of the variables of interest for the individuals in this sample. The use of an individual fixed effects model means that it only looks at the within variation of variables for each individual separately, meaning that if there was little to no variation for an independent variable, it is unable to find a significant relationship between the dependent and independent variable. However, there could be an overall association between the independent and dependent variable, without there being within variation for these. This could be one possible explanation of why this study was not able to find the heterogeneity of the relationship between sleep duration and mental health by SES. If the income or sleep duration of the respondents was rigid over the two years, this model is unable to find a significant coefficient for the interaction term between sleep duration and income. Another limitation could be the wide range of the reported weekly sleep duration in this sample, since the association between sleep duration and mental health could differ vastly for individuals between 2 hours and 14 hours of sleep per night. Nonetheless, the results do not change much when the interval

of sleep duration is shortened to 4 and 11 hours per night. So, this limitation is somewhat mitigated, but there is still a possibility that the extremes are distorting the overall association between sleep duration and mental health. Finally, the validity of the self-reported sleep duration variable could be questioned. The survey asked to report the total sleep duration of the respondents in the last 7 days, meaning that this outcome could be very incidental for some individuals. Some persons could have gotten less sleep than they normally would and vice versa, making this variable possibly not completely representative for a person's sleep duration in general.

Further research could examine whether the relationship between sleep duration and mental health might not be linear. As discussed in the paragraph above, I only researched the overall (linear) association between sleep duration and mental health, but possibly this relationship is not that straightforward. For example, one might argue that increasing sleep duration from 5 to 7 hours per night could be more strongly associated with a better mental health than increasing sleep duration from 12 to 14 hours a night. Additionally, future research could ask the respondents to report their sleep duration every day for an entire year, to create an average sleep duration variable that is more representative with the person's actual sleeping behaviour.

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