Erasmus School of Economics

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Bachelor Thesis

Exploring the association between bedtime procrastination and future depression development

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Abstract

Getting sufficient sleep is essential for the mental health of individuals, however, the new phenomenon of *bedtime procrastination* might inhibit this process. Bedtime procrastination (BP) is defined as the act of going to bed later than planned, without external reasons that caused the delay. BP has been linked to depression. However, the prior research only consisted of simple regression models. This research supplements this analysis with a multiple-period regression model, where the relationship between previous bedtime procrastination and future depressive symptoms is computed. The data used in the analysis was gathered from multiple surveys administered by Centerdata on the LISS (Longitudinal Internet Studies for the Social Sciences) panel, a representative sample of the Dutch population. The one-period multiple regression model, with controls, confirmed that bedtime procrastination is significantly associated with more depression in the same period. The ultimate multiple-period analysis with past BP and future depressive symptoms two, three, and five years later, found that high bedtime procrastination was significantly associated with more depression symptoms three years later. The models computed for the other two periods did not find a significant relationship between BP and subsequent depressive symptoms.

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List of abbreviations

Abbreviation	Definition
BP	Bedtime Procrastination
BPS	Bedtime Procrastination Scale
CBT	Cognitive Behavioral Therapy
CI	Confidence Interval
CIA	Conditional Independence Assumption
LISS	Longitudinal Internet Studies for the Social Sciences
MHI-5	Mental Health Index-5
OR	Odds Ratio
RCT	Randomized Controlled Trial
WHO	World Health Organization

Introduction

Sleep

Objectively, sleep is highly beneficial for a variety of reasons, however, people still choose to sleep for insufficient amounts of time and put far too little urgency on the importance of a good night of rest. The exact mechanics of sleep are still a mystery to some degree (Vyazovskiy, 2015), however, it is known that sufficient sleep greatly improves health outcomes and decreases the risk of obesity, cardiovascular disease, neurodegenerative disease, and mental health problems (Hale et al., 2020). This means sleep can be an important factor in improving the overall health of a population and that it is essential to maintain good sleep quality, especially for people that struggle with health issues.

So, it is clear that quality sleep is strongly associated with many positive health outcomes, however as (Kroese, De Ridder et al., 2014; Kroese, Evers et al., 2014) explored, bedtime procrastination (also known as sleep procrastination) is a very prominent and harmful procrastinating behavior in which people regularly delay their bedtime, without external factors causing them to do so. This behavior seems to be irrational, since these people do not have a good reason to procrastinate, and sleep is beneficial for good physical and mental health outcomes. Recently more and more research has emerged on the topic, many building on the foundation laid by Kroese, De Ridder et al. (2014) and Kroese, Evers et al. (2014). The field is becoming a distinct health and behavioral topic and seems to have implications for many different outcomes, one of which is depression.

Bedtime procrastination and depression

Recently mental health and depression symptoms are worsening, especially among young people (CBS, 2022). Additionally, according to a report from the World Health Organization (WHO), the first year of COVID-19 resulted in an estimated increase of 25% in anxiety and depressive disorders (Kestel et al., 2022). Depression is becoming more prevalent and thus it is even more important to research all the different aspects and risk factors of depression.

Strikingly, Chung et al. (2020) and Guo et al. (2020) both found that bedtime procrastination is far more prevalent among depressed young adults and that bedtime procrastination was even correlated with more depressive symptoms in the non-depressed group. This is especially harmful since adequate sleep health is very important in depressed people and can even be predictive of the severity of their symptoms and the effectiveness of their treatment (McGlinchey et al., 2017). This specific relationship of harmful behavior among an especially vulnerable demographic is a very necessary field of research and must be better understood for the betterment of national physical and mental health and well-being.

Furthermore, bedtime procrastination is correlated with fewer hours of sleep (Kroese, Evers et al., 2014; Kadzikowska-Wrzosek, 2018), and as the results of the Randomized Controlled Trial (RCT) conducted by Freeman et al. (2017) showed, insomnia can worsen psychological disorders and

symptoms, like hallucinations and paranoia, but also depression. Similarly, McGlinchey et al. (2017), found sleep disturbance to be a clear predictive factor for the severity of depressive symptoms. These findings suggest that the lower amount of sleep that is associated with bedtime procrastination might result in worsened mental health and specifically depression symptoms.

The previous literature seems to clearly illustrate a relationship between insomnia and depression and some association between bedtime procrastination and depression. Additionally, bedtime procrastination is associated with fewer sleeping hours (Kroese, De Ridder et al., 2014; Magalhães et al., 2020). The relationship between specifically bedtime procrastination and depression symptoms, however, has merely been studied using just simple one-period correlational analysis. To fill this gap, this research will not just analyze the correlation between the two in the same period but also analyze if bedtime procrastination in an earlier period is associated with more subsequent depressive symptoms. Similar to the work of Roberts and Duong (2013) and Alvaro et al. (2017) however, here instead of insomnia, previous bedtime procrastination will be used to compute the association with later depressive symptoms.

Analyzing the association between previous bedtime procrastination and later depressive symptoms will give more accurate results of the exact relationship between BP and depression and will give some indication of a possible causal relationship between the two. The results can also indicate that bedtime procrastination might be a risk-factor for subsequent depression development. If the results show that previous BP is significantly associated with subsequent depression, this implies that bedtime procrastination might increase the chance of developing depression. This will give the scientific research on bedtime procrastination more knowledge on its possible effects, but can also have important implications for the treatment and prevention of depression, by presenting evidence on a possible risk behavior.

Research question

From the previous discussion about the topic of bedtime procrastination, it becomes apparent where the research of the subject still lacks and where thus this paper shall try to improve the current knowledge of sleep procrastination and its relationship with depression. In particular, the lack of research on the directionality of the relationship and the relationship of bedtime procrastination with future depression will be examined in this paper and thus the research question is:

Research question: Is bedtime procrastination associated with more depressive symptoms two to five years later in life?

In this question, bedtime procrastination refers to the behavior of "going to bed later than intended while no external circumstances are accountable for doing so" as explained by Kroese, De Ridder, et al. (2014). Depression here is defined as a psychological disorder that causes feelings of sadness,

hopelessness, and a lack of interest in activities one once enjoyed. However, in this research depression will not be assessed by the diagnosis of clinical depression, but by the scores of a "mental health inventory" questionnaire that assesses the severity of particular depression symptoms.

Furthermore, to come closer to an answer for this broader research question, this report will try to answer several sub-questions;

Sub question 1: What is the association between bedtime procrastination and depression scores in the same period?

Sub question 2: What is the relationship between bedtime procrastination and sleep outcomes?

Sub question 3: Which other specific demographics are associated with higher depression scores?

Sub question 4: What is the association between previous bedtime procrastination and depression in later periods?

Theoretical framework

The introduction of bedtime procrastination

The foundation for the current state of the research and knowledge on the topic of bedtime procrastination was laid with the two publications by Kroese et al. in 2014 (Kroese, De Ridder et al., 2014; Kroese, Evers et al., 2014). The former of the two, the most revolutionary, introduces the topic of bedtime procrastination as a distinct procrastinating behavior that might be related to health and sleep outcomes and introduces the main measure for bedtime procrastination (BP) used in most research on the topic.

Kroese, De Ridder et al. (2014) used Amazon Mechanical Turk to gather participants for their study. The study itself consisted of an online survey with measures for BP, procrastination, self-regulation, and sleep outcomes, plus a set of questions about demographics. To measure BP, Kroese, De Ridder et al. created a novel nine-item scale (Cronbach's $\alpha = 0.92$), the same scale was later used in many different studies on BP and will also be used in this research. Participants that indicated that they are being treated for sleeping problems or that they work night shifts, were excluded from the sample. Since these factors can have severe effects on the sleep outcomes of participants without them being in their control, which would not be relevant for the study.

The results showed a clear correlation between bedtime and overall procrastination ($r = 0.60$, $p < 0.001$), so a relationship is present, but this still indicated a distinction between the two. Moreover, bedtime procrastination explained more of the variance in sleep outcomes than overall procrastination. And for specifically insufficient sleep and hours of sleep, bedtime procrastination was significantly stronger correlated with those sleep outcomes than overall procrastination. A subsequent regression model using demographics, self-regulation, and bedtime procrastination, showed that BP was

significantly associated with hours of sleep (β = -0.52, $p < 0.001$), fatigue (β = 0.36, $p < 0.001$) and insufficient sleep (β = 0.56, $p < 0.001$).

The collection of participants through the Amazon Mechanical Turk platform did result in a very diverse sample, however not a very representative population, since it only includes voluntary participants of this service, who self-select the surveys they want to participate in. Furthermore, this data is cross-sectional, with possible confounding variables and the bedtime procrastination measures were all self-reported from recollection.

The second study from Kroese, Evers et al. (2014) on bedtime procrastination and self-regulation analyzed the same relationship as before, however with some improvements to the data collection and the sample. In this study, the sample was gathered from the Longitudinal Internet Studies for the Social Sciences (LISS) panel (Centerdata, 2023). This panel is a consistent and representative sample of Dutch individuals and households managed by Centerdata, which participates in monthly surveys, like the one for Kroese, Evers et al. (2014). In this survey, similar measures were used as in the first study, with the addition of a sleep diary and external reasons for sleep delay. The sleep diary required participants to monitor their sleep, to more accurately measure sleep hours. Similar to the previous study, participants that indicated that they are being treated for sleeping problems or that they work night shifts were excluded from the sample.

The results of the regression, with controls for external factors and self-control, again show that bedtime procrastination is significantly correlated with hours of sleep ($\beta = -.18$ $p < 0.001$). Furthermore, Kroese, Evers et al. propose that bedtime procrastination acts as a mediator between self-control characteristics and insufficient sleep, as shown in the diagram below (***Figure 1***). However, there can be many different explanations and confounding variables that would cause this relationship. It is still apparent, however, that there is a strong relationship between bedtime procrastination and less/insufficient hours of sleep. The possible mediation of bedtime procrastination between self-control and insufficient sleep is an interesting concept but with the evidence provided it cannot be proven. However, for this research, this specific pathway is not important, the only relevant information is that there is a significant correlational relationship between bedtime procrastination and insufficient sleep that can be better understood.

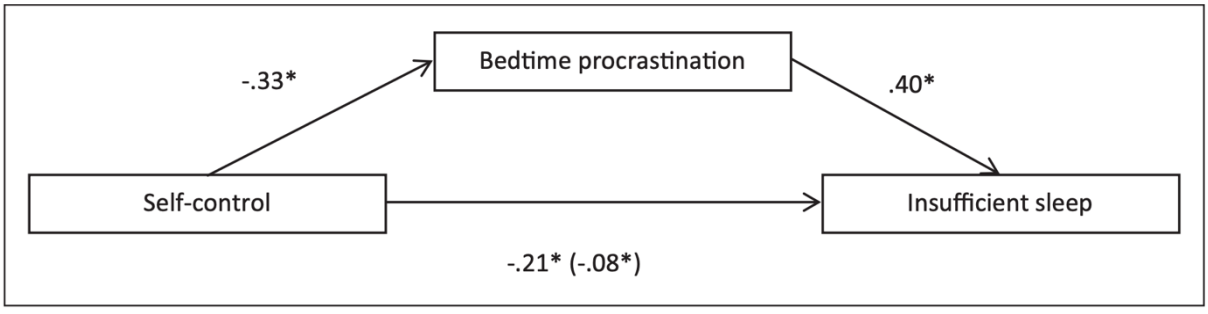

***Figure 1*:** Standardized regression coefficients of the relationship between self-control, bedtime procrastination, and experiencing insufficient sleep, controlling for demographics and external reasons. (Kroese, Evers et al., 2014)

Insufficient sleep and mental health

The aforementioned literature introduced the topic of bedtime procrastination and showed its relationship to sleep outcomes, however, it did not go much deeper into the possible implications of this relationship. The deterioration of sleep quality and quantity however has many important implications. One of the implications is that insufficient sleep might be related to worse mental health and specifically depression. This relationship was briefly discussed in the introduction, however, there is a large amount of interesting literature on this relationship.

A randomized controlled trial (RCT) by Freeman et al. (2017), mentioned earlier, investigated this relationship. The RCT was designed to research if the treatment of insomnia would have effects on the paranoia and hallucination symptoms of the patients, but also secondary measures among which was a depression measure. The 3755 participants with insomnia were recruited from 26 UK universities. Afterwards, the participants were randomly assigned to either cognitive behavioral therapy (CBT) as a treatment for their insomnia (treatment group), or treatment as usual (control group).

The results show that the CBT treatment was significantly more effective in reducing insomnia for all periods (all $p < 0.0001$), which was then used to analyze if this decrease in insomnia also improved the mental health measures. This is indeed the case and for all the measures, including those for paranoia, hallucinations, and depression, there was a significantly greater improvement in the treatment group, compared to the control (all $p < 0.0001$). These results show that the treatment of insomnia can also improve depression symptoms and thus there seems to be an association between a decrease in insomnia and a decrease in depression. This does not prove that insufficient sleep causes depression, however, it does imply at the very least, that a reduction in insomnia can also lead to a reduction in depression. However, it could also be the case that the insomnia treatment itself aided in the reduction in depression symptoms, but the treatment was specifically designed to treat insomnia.

Nonetheless, McGlinchey et al. (2017) found sleep disturbance was associated with more depression, during all periods of an RCT where participants received one of two depression treatments. The RCT consisted of 63 depressed adolescents that were randomly assigned to either the treatment group with Interpersonal psychotherapy for depressed adolescents (Mufson et al., 2004) or to the control group with treatment as usual (Mufson et al., 2004). The participants were assessed at baseline and during weeks 4, 8, and 12, by a professional that was unaware of the treatment of the participant. During assessment two measures were used to assess depression; the Hamilton Rating Scale for Depression (HRSD; Hamilton, 1967; Cronbach's $\alpha = 0.74$) and the Beck Depression Inventory (BDI-II; Beck et al., 1988; Cronbach's $\alpha = 0.88$), along with measures for sleep disturbance and social adjustment.

The results of the RCT by McGlinchey et al. (2017) showed that the treatment seemed to be significantly more effective ($\beta = -0.76$; $p < 0.05$) for only the HRSD. However, sleep disturbance was correlated with significantly higher depression scores for both the HRSD ($\beta = 1.04$; $p < 0.001$) and the BDI-II ($\beta = 1.63$; $p < 0.001$). Additionally, differences in treatment for depression did not lead to significant differences in sleep disturbance and sleep disturbance overall did not change significantly over the course of the RCT. However, the difference in the effectiveness of treatments was also only significant for one of the measures ($p < 0.05$) and not significant anymore in the model with sleep disturbance added in. The lack of significance is likely due to the small sample.

Due to the lack of significance and sample size, it is not possible to conclude much about the possible effect of (treatment of) depression on sleep disturbance, however, the results of McGlinchey et al. (2017) do indicate that sleep disturbance, if it is present, is related to more severe depression and worsened effectiveness of depression treatments, similar to Freeman et al. (2017).

Additionally, Baglioni et al. (2011) performed a meta-analysis, of the longitudinal epidemiological studies that focussed on both insomnia and depression, during the period of 1980 until 2010. The meta-analysis was aimed at analyzing the predictive value of insomnia on the development of subsequent depression. After carefully examining the papers, if they met the inclusion criteria and after removing outliers, Baglioni et al. (2011) found that overall, for people without depression, those with insomnia at baseline have a twofold risk of developing depression compared to those without insomnia (Odds Ratio (OR) = 2.10; 95-CI = 1.86–2.38).

Moreover, in the final meta-analysis, for those without depression, the incidence of subsequent depression in the group with insomnia at baseline was 13.1 percent, which was significantly higher than the incidence of 4.0 percent in the group without insomnia at baseline. Additionally, Baglioni et al. found that the effectiveness of insomnia in predicting subsequent depression was similar for individuals from a wide array of different ages, ranging from children to elderly individuals.

Reciprocal relationship

Until now, the possible effects of insufficient sleep on depression have been discussed, as is also the main theoretical basis for this research. However, there is also likely a relationship in the other direction. Evidence for such a reciprocal relationship between insomnia and depression has been found in prior research, as discussed by De Zambotti et al. (2017). Insomnia and depression seem to be intertwined, especially in earlier stages of life.

Roberts and Duong (2013) studied more than 3000 adolescents (between ages 11–17), using measurements of both depression and insomnia in two waves, one year apart, to study if baseline insomnia is predictive of depression in the second wave, and vice versa. The results showed that baseline insomnia roughly doubled the risk of developing major depressive disorder (OR = 2.18; 95-CI = 1.07–4.41) when adjusted for age, gender, family income, and depression at wave 1. Similarly, baseline depression doubled the chance of having insomnia and daytime fatigue in the second wave

(OR = 2.31; 95-CI = 1.01–5.28), when adjusted for age, gender, family income, and insomnia at wave 1.

A similar relationship was measured by Alvaro et al. (2017), who studied Australian high-school students for depression and insomnia in two periods six months apart. In the final regression analysis that included age, gender, chronotype, and depression at baseline, depression was significantly predictive of future insomnia (β = 0.22; 95-CI = 0.09–0.35). The same was the case in the other direction, where insomnia was significantly predictive of future depression (β = 0.21; 95-CI = 0.07–0.35). Again, showing that there seems to be a reciprocal relationship between depression and insomnia.

The evidence for a reciprocal relationship might also make the correlational relationship between bedtime procrastination and depression more unclear. Since even if there would be a causal relationship, it is unclear if the relationship might be because bedtime procrastination results in less sleep, which can result in depression, or if the depression might result in people delaying their sleep. This is partly what the multiple-period analysis of this research aims to clear up, if BP is releted to future depressive symptoms, that would indicate that there seems to be at least a relationship in that direction.

Bedtime procrastination and depression

As discussed, bedtime procrastination is associated with less sleep, and insufficient sleep is closely related to mental health outcomes, especially depression. However, does the evidence suggest that this also creates a relationship between bedtime procrastination and depression? Research on the topic does exist, but is still quite elementary, not giving concrete results on the exact dynamics of the relationship.

For instance, in Guo et al. (2020), a study was performed with roughly 400 Chinese medical students, to research the impact that bedtime procrastination might have on depression among this population that experiences increased rates of both depression and insufficient sleep. However, the analysis was done by simply performing correlational and linear regression analyses. Even though, this still does provide further results on a possible relationship. In the study, the Bedtime Procrastination Scale (BPS) introduced by Kroese, De Ridder et al. (2014) was used to measure bedtime procrastination, along with the Beck Depression Inventory-II (BDI-II) to measure depression.

The results of the study show that there is indeed a significant difference in BP between depressed and non-depressed students, where the mean BPS was significantly higher in the depressed group ($p < 0.001$). The binary logistic analysis also confirmed that individuals with higher BPS scores showed significantly more depression symptoms (β = 0.812; $p < 0.001$). Furthermore, within the group of non-depressed students, the BPS scores were significantly correlated with depression symptoms ($r = 0.233$; $p < 0.001$). Showing that, even among the students that did not have BDI-II scores associated with depression, those who exhibited more bedtime procrastination, also showed more depression symptoms.

Chung et al. (2020) similarly investigated bedtime procrastination and its relationship with sleep outcomes and psychological factors, however with the addition of a time-use survey. The study surveyed more than 100 participants in early adulthood (ages 18–31), gathering data on demographics, time use, sleep, and depression symptoms. The BPS by Kroese, De Ridder et al. (2014) was used to measure BP (Cronbach's $\alpha = 0.85$) and the Center for Epidemiologic Studies Depression Scale (CES-D; Cronbach's $\alpha = 0.77$) was used to measure depression. The participants that were being treated for sleeping disorders and/or worked night shifts were excluded from the sample, as precedented by Kroese, De Ridder et al. (2014) and Kroese, Evers et al. (2014).

When dividing the sample into high and low BP groups, with the cut-off being the median value of the BPS, the high BP group showed significantly higher depression levels ($p < 0.05$). The high BP group also exhibited significantly higher levels of insomnia severity ($p < 0.001$) and higher rates of clinical insomnia symptoms ($p < 0.001$). Providing further evidence that bedtime procrastination seems to affect the prevalence and severity of insomnia and insufficient sleep, which is linked to increased rates of depression, which again is present among bedtime procrastinators in this sample.

The time use aspect of the study by Chung et al. (2020) provides some insight into what bedtime procrastinators might engage in instead of going to sleep. The results of the survey show that within the three hours just before going to sleep, the high BP group engages in significantly more leisure activities than the other group. Specifically, smartphone usage is significantly higher for this high BP group, compared to the low BP group. On average, the time that the high BP group spent on their smartphone in the three hours before bedtime was 451% or 61 minutes higher than the low BP group.

Hypotheses

Summarizing the earlier literature, bedtime procrastination is correlated with less sleep and insufficient sleep (Kroese, Evers et al., 2014), additionally, it is correlated with depression (Chung et al., 2020; Guo et al., 2020). This relationship is likely because depression and insufficient sleep are very closely linked, with insomnia being significantly predictive for subsequent depression development (Baglioni et al., 2011) and as found by Freeman et al. (2017), the treatment of insomnia also improves depression, suggestion a causal relationship. However, the relationship is likely also reciprocal (Roberts and Duong, 2013; Alvaro et al., 2017) which is why it is important to not just analyze the correlation between BP and depression, but also if previous bedtime procrastination is related to future depressive symptoms in people without a history of depression. These findings provide the theoretical basis that allows for the definition of some hypotheses to accompany the earlier stated research questions:

Hypothesis 1: More bedtime procrastination will be correlated with more depressive symptoms in the same period.

Hypothesis 2: Bedtime procrastination scores will be negatively correlated with sleeping hours measured in the same period.

Hypothesis 3: Age and general health will be negatively correlated with depression symptoms.

Hypothesis 4: High bedtime procrastination will be associated with more subsequent depressive symptoms two to five years later in life.

Additionally, the reciprocal relationship between sleep and depression that was discussed earlier, will likely cause the estimated coefficient for the simple regression analysis to be biased and bigger than the actual effect of bedtime procrastination on depression. The possible effect of depression on bedtime procrastination will also be included in this calculation, along with many confounding variables. For this reason, the multiple-period analysis is used, to come closer to an accurate estimate of the possible effect of previous bedtime procrastination on the subsequent depression symptoms of individuals without a history of depression, which will likely be smaller than the general correlation.

Methods

Datasets and variables

The datasets that will be used are part of the LISS panel (Centerdata, 2023). The LISS panel is a longitudinal internet survey study, with a collection of roughly 5,000 Dutch households with 7,500 individuals. Two LISS panel datasets will be used in this analysis, the first one to gather data on bedtime procrastination, with the "Bedtime Procrastination: An Exploration of the 'Who', 'What' and 'Why'" dataset from 2013. In this survey the bedtime procrastination levels are measured using the Bedtime Procrastination Scale (BPS; Cronbach's alpha = 0.87) from Kroese, De Ridder et al. (2014), this scale is a nine-item Likert scale that assesses the level of bedtime procrastination (Appendix 1). The dataset only provides BPS scores for the year 2013, so it is not possible to analyze correlations with past and future bedtime procrastination or changes in bedtime procrastination.

The scale has been used in previous research on the topic of bedtime procrastination (Chung et al., 2020; Guo et al., 2020; Kadzikowska-Wrzosek, 2018; Kroese, Evers et al., 2014; Kroese, De Ridder et al., 2014) and seems to be an effective measurement of bedtime procrastination. Additionally, the questions of the scale focus on traits of an individual over a longer period, not just the last week for instance. This means that the scale is less of a single-period measurement of current bedtime procrastination and more of a measurement of general bedtime procrastination of that person. The total score for this scale is calculated by adding the answers for all questions, with the answers for questions 2, 3, 7, and 9 being reversed. A high score indicates high levels of bedtime procrastination and vice versa.

This dataset also offers data on the levels of insufficient sleep that participants perceive, rated on a scale from 0 to 7. Furthermore, this survey, as discussed earlier, also included a follow-up survey for which participants were asked to keep a sleep diary that was used to more accurately measure sleeping hours. Not all the participants for the first part of the survey participated in tracking their sleep, however, more than half of them did. For those who did, the average hours of sleep per night is computed, which will be used to assess the relationship of bedtime procrastination with sleeping hours. These sleep outcome measures were thus assessed in the same period as the bedtime procrastination scale, in 2013.

The second dataset that will be used is the general "Health" longitudinal study. This survey is conducted every year and measures many different aspects of health, among which is also the Mental Health Inventory-5 (MHI-5; Berwick et al., 1991), which will be used to assess depression. This MHI-5 (Appendix 2) is a brief five-item scale that can be effective in screening for depression and anxiety (Rumpf et al., 2001). The scale had a Cronbach's alpha of 0.84 for 2013, 0.87 for 2015, 0.86 for 2016, and 0.87 for 2018. Additionally, as found by Cuijpers et al. (2009), the MHI-d, which only uses the three questions specifically aimed at depression, was nearly as effective as the full MHI-5 in screening for depression in a Dutch sample, with no significant difference.

Nonetheless, in the statistical analysis for this research, the full MHI-5 will be used, since it is far more prevalent in scientific research and thus can offer more knowledge on which values are typical or atypical. The total MHI-5 score is the combination of the five questions, with 1, 2, and 4 reversed, after which the total is linearly transformed to a scale ranging from 0-100. The higher the score, the healthier the person is mentally, with fewer signs of depression or other affective disorders.

Other than the MHI-5, both datasets offer demographics and other variables that will be used as controls, and to analyze which demographics are associated with more depression and or bedtime procrastination. The control variables used in the analysis are age, gender, having a paying job, general health, having a partner, and external circumstances (for going to bed later). For the external circumstance, the participants had to rate on a scale of 1 (never) to 5 (always), "To what extent is your bedtime generally affected by external circumstances that are outside of your control".

Eliminations

To eliminate some bias and to improve validity, some participants are eliminated from the sample. Firstly, people with a history of sleeping disorders are taken out of the sample. This is similar to the study by Kroese, De Ridder et al. (2014), and Chung et al. (2020), where the focus of the research is just on the behavior of bedtime procrastination, where people have no actual reason for going to bed later. People with insomnia or other sleeping problems, do have problems getting sleep and this can result in them going to bed later than preferred, without it being bedtime procrastination. Furthermore, these individuals are likely to have insufficient amounts of sleep, which would be out of their control, but still would affect the results. Furthermore, just controlling for this would be insufficient, since the impact on actual sleep outcomes can differ across individuals with sleeping disorders. But mostly since

these sleeping disorders might be related to other characteristics of the individuals that are likely correlated with the likelihood of them developing depression or exhibiting bedtime procrastination.

For this reason, individuals that indicated that they had been treated for sleeping problems, or that had a history of taking medication for sleeping problems, were eliminated from the sample. This removed 237 participants.

For the same reason, people that work night shifts are also taken out of the sample, since these people have severely different sleeping schedules and behaviors that can have different results, but are not the result of bedtime procrastination and thus, not the focus of this research. Furthermore, the sleeping schedules and behaviors of these people are likely to be substantially different and it would not be easily controlled for in a regression analysis. And this research is just focused on the specific effects of bedtime procrastination in typical individuals, not the other factors that impact sleep. This resulted in the removal of 86 participants, afterwards, 1536 participants were left in the sample.

Additionally, for the second part of the analysis where the association with future depressive symptoms is analyzed, individuals with a history of depression will also be taken out of the sample. The main reason for doing this is that this analysis aims to estimate if previous bedtime procrastination is associated with more subsequent development of depression symptoms, with the ultimate goal of providing a basis of evidence for further research to assess if this relationship might also be causal. People that have a history of depression, are much more likely to relapse or to end up in another episode of depression, even if they had improved and had healthy scores during the timeframe that bedtime procrastination was assessed.

For this reason, the participants that had used medication for depression in the past were eliminated from the sample. Additionally, participants that had a prior MHI-5 score that strongly indicates depression, were also eliminated from the sample. However, there is no universal cut-off point for the MHI-5, beyond which we can assume the participant has depression. Fortunately, many researchers have tried to estimate the ideal cut-off point, to best categorize MHI-5 scores into depressive or non-depressive, without creating too many false positives or negatives.

Still, there is quite some discrepancy in the optimal cut-off point suggested by different researchers. The main reason for this is the difference in the prioritization in the trade-off between specificity and sensitivity. Both are very important but give opposing optimums. The range of cut-off values to distinguish between depressed and non-depressed individuals ranges from 76 and 68 by Kelly et al. (2008), 74 by Cuijpers et al. (2009), 70 by Van den Beukel et al. (2012), and 60 by both Rumpf et al. (2001) and Friedman et al. (2005). For this research, we do not want to wrongly diagnose and remove many participants from the study but do want to remove participants with depression to avoid bias. To achieve both goals, the MHI-5 value of 70 is chosen, meaning that participants with a past MHI-5 score equal to or below 70, will be removed from the sample for the analysis with previous BPS scores and future depressive symptoms. In total, this resulted in the removal of 852 participants from the sample.

Analysis

Multiple linear regression

Multiple linear regression will be used to estimate the relationship between sleep outcomes and bedtime procrastination and the first estimate of the relationship between bedtime procrastination and depression in the same period. This will be done with and without control variables and the coefficients for the control variables will also be analyzed to assess if certain demographics are associated with significantly more bedtime procrastination, worse sleep outcomes, or more depression. To perform the first analysis with sleep outcomes, the following regression formulas will be used:

$$\widehat{Hrs} = \beta_0 + \beta_{BPS}BPS + \beta_z Z + \varepsilon \quad and \quad \widehat{InsufSlp} = \beta_0 + \beta_{BPS}BPS + \beta_z Z + \varepsilon$$

In the equations, Hrs stands for the average hours of sleep, BPS stands for the bedtime procrastination scale scores (measured in 2013), InsufSlp stands for the severity of which an individual experiences insufficient sleep and Z represents the control variables. The control variables that will be used, are: age, gender, living with a partner, if they have a paying job, and external circumstances for going to bed later.

For the subsequent regression analysis to estimate the relationship between bedtime procrastination and depression in the same period, the following regression equation is used:

$$\widehat{BPS} = \beta_0 + \beta_{MHI}MHI + \beta_z Z + \varepsilon$$

In this equation BPS stands for the bedtime procrastination scale scores (measured in 2013), MHI stands for the MHI-5 scores from 2013 and Z represents the control variables. The control variables that will be used, are: age, gender, living with a partner, general health, if they have a paying job, and external circumstances.

Association between bedtime procrastination and future depressive symptoms

In the second section of the methodology, the bedtime procrastination scores (from 2013) will be used in a regression analysis, with specific controls for previous periods, to see if high bedtime procrastination scores are associated with more (severe) depression symptoms later in life. In this analysis, the MHI-5 scores will be used as a measure for depression symptoms and since it has several periods, the regression analysis can control for previous depressive symptoms of an individual. The outcome variable will be the MHI-5 scores for two, three, and five years after the measurement of bedtime procrastination. The addition of a control for previous MHI-5 scores creates a similar design to an individual fixed effects analysis since the model controls for the previous depression symptoms. Thus, it analyzes the difference between periods and if individuals with high bedtime procrastination

are significantly more likely to subsequently develop more depressive symptoms than those with lower bedtime procrastination.

To avoid bias from recurring depression in bedtime procrastinators, as stated earlier, individuals with a history of depression, will be deleted from the dataset. Since these individuals might already have depression and even if they improved for the period in which bedtime procrastination was measured, it might return and, in these people, the bedtime procrastination might have been a result of the depression. The subsequent formula that will be used to analyze the relationship of bedtime procrastination with future depression is:

$$\widehat{MHI}_{future} = \beta_0 + \beta_{BPS} MHI_{2013} + \beta_{MHI} MHI_{2013} + \beta_z Z + \varepsilon$$

In this equation MHI stands for the MHI-5 scores, for 2013, the period of the BPS measurement and future MHI, for the periods after the bedtime procrastination assessment. BPS stands for the bedtime procrastination scale scores. And Z represents the control variables. The control variables that will be used, are: age, gender, general health, living with a partner, if they have a paying job, and external circumstances.

Assumptions and limitations

For the multiple regression analysis, the main assumption, that likely does not hold, is the Conditional Independence Assumption (CIA). The CIA assumes that all the difference in the outcome variable, depression symptoms, that is not explained by the model, is not correlated with the explanatory variable, bedtime procrastination. If this assumption does hold, there should be no confounding variables not included in the model, and thus the estimated coefficient of the independent variable can be interpreted as the effect on the dependent variable.

However, in reality, it is virtually impossible to control for all confounding variables and to be sure that the CIA does hold. This is also the main limitation of the multiple regression analysis in this case, the estimated effect almost certainly contains some bias from, among other things, confounding variables that are correlated with bedtime procrastination and have some effect on depression. This does mean that the results of this analysis can in no way be interpreted as a causal effect, however, the results can indicate a possible relationship between the two variables. These results can then be used as evidence of the possible relationship and a theoretical framework for later research, which can provide a deeper analysis and further evidence of the relationship.

The analysis with future depression scores is aimed to remove some of the possible bias of confounding variables and the unobservable differences between individuals. Since this multiple-period model also controls for previous MHI-5 scores, the model estimates if bedtime procrastination is associated with more subsequent depression development, compared to those with less bedtime procrastination. This results in a more valid estimation of the effect since all unobserved differences

between individuals that have a constant effect on depression over time are now controlled for. The only assumption that is now relevant is that the change in depression, between periods, is not caused by a variable that correlates with bedtime procrastination.

This is a less strong assumption than the CIA, since all the factors that have a time-invariant effect on depression are now controlled for, however, this assumption is still a big limitation. Because there is still a significant likelihood that there are some unobserved variables that might be correlated with BP that can have an effect on depression that can change over time. The ultimate model, with past BP and future depression, does include several control variables to eliminate some of the bias, however, bedtime procrastination is very likely to still be correlated with certain (behavioral) characteristics that are also associated with higher rates of depression. Examples of this could be social media use (De Choudhury et al., 2021), neuroticism (Clark et al., 1994), or self-discipline (Bienvenu et al., 2001). Nonetheless, the results of this analysis will give more valid evidence than previous regression models for bedtime procrastination as a possible risk factor for the future development of depression.

Results

Descriptive statistics

Out of the sample of 1,536 participants, consisting of 52.41% women and 47.59% men, 70.90% lived together with a partner, while 29.10% did not live with a partner. Furthermore, 58.27% had a paying job and 41.73% do not have a paying job. The other non-binary characteristics of the sample are presented in ***Table.1***. As is visible below, the mean age of the participants was roughly 52 years, this is older than other studies on this relationship by Chung et al., 2020 and Guo et al., 2020. Additionally, it is shown that there are fewer observations for the average sleep variable, this is because this variable was measured with the sleep diary, which was not completed by all participants of the survey. The MHI-5 scales for later periods also consist of fewer observations since some of the participants of the LISS panel did not participate in the surveys of these following years, due to attrition.

There are some extreme values mainly for MHI-5 scores and average sleep. However, no observations were removed as outliers, since these values are still reasonable for extremely depressed individuals and/or individuals that sleep very little due to various reasons, which is especially relevant since those extreme values could be associated with high levels of bedtime procrastination.

Table 1: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
BPS (2013)	1,536	24.043	7.167	9	45
MHI-5 (2013)	1,536	76.534	15.915	0	100
Age (2013)	1,536	52.213	17.415	16	90
Insufficient sleep (2013)	1,536	1.947	1.932	0	7
Average sleep (2013)	978	7.577	0.902	3.929	17.357
External circumstances (2013)	1,536	1.730	0.973	1	5
MHI-5 (2015)	1,340	77.275	15.053	16	100
MHI-5 (2016)	1,244	77.077	15.338	20	100
MHI-5 (2018)	1,054	77.784	15.322	12	100

To give an initial visualization of the distribution of depression scores, among higher and lower bedtime procrastinators, ***Figure 2*** shows the distributions of MHI-5 scores for those who have below and above average BPS scores. The graph shows that the group with below average BP is more left-skewed and has a greater number of individuals with very high and healthy MHI-5 scores. The group with high BP on the other hand, is more evenly distributed across the spectrum, with less individuals having extremely high mental health scores and a large portion of the group having lower scores, indicating depression.

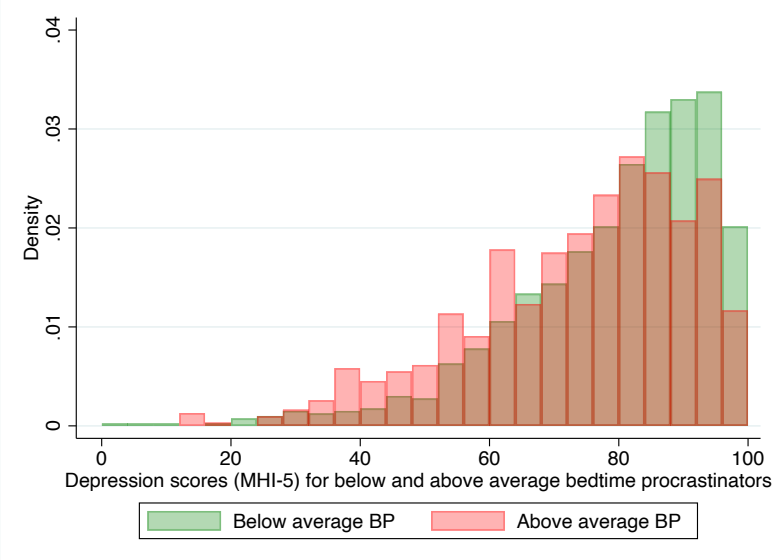

Figure 2: Histogram showing the distribution of depression scores, for below and above-average bedtime procrastinators.

Bedtime procrastination and sleep

Before going deeper into the relationship between bedtime procrastination and depression, we analyze if BP is related to lower amounts of sleep, which could be the main reason for the possible effect on depression. ***Figure 3*** gives a visualization of this relationship, plotting average hours of sleep against BPS scores from the same period, with the addition of a regression slope (model presented in column **(1)** ***Table 2***). The graph and the slope of the regression line, without controls, show that there is a negative correlation in the sample between BP and hours of sleep. This gives some indication that BP is associated with less sleep, however, this is just a correlational analysis and does not include any control variables, to remove any bias.

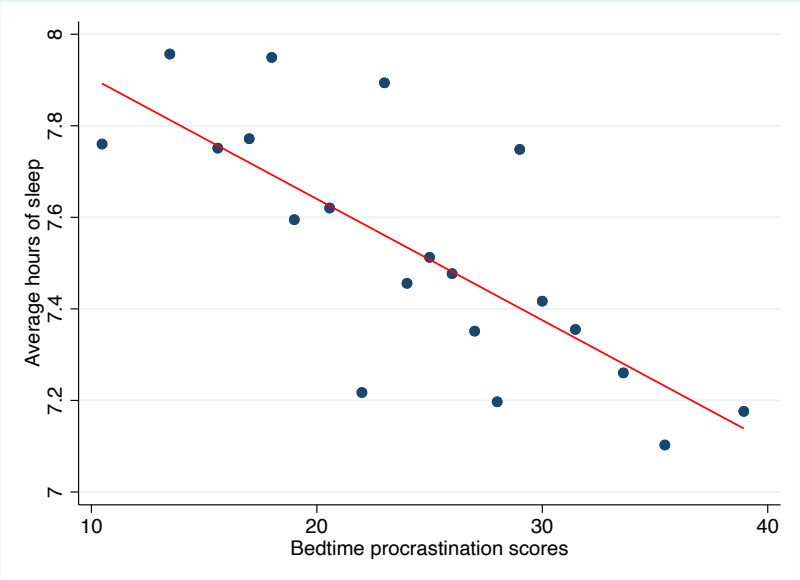

Figure 3: Binned scatter plot of average hours of sleep against bedtime procrastination scores, with best-fit regression line (β_{BPS}= -0.025***, column **(1)** ***Table 2***)

To give a better indication of the relationship between bedtime procrastination and sleep outcomes, a linear regression is performed with the BPS as the dependent variable and two sleep outcomes as independent variables (average sleep and insufficient sleep, both measured in the same period as the BPS scores). For each of the outcomes, the model is estimated with and without relevant control variables, to remove part of the bias from the estimate. The results for the relationship between bedtime procrastination and hours of sleep or insufficient sleep are presented in ***Table 2***. The results show that bedtime procrastination is indeed associated with fewer hours of sleep and more feelings of insufficient sleep. Even when controlling for external circumstances that could lead to less sleep.

Table 2: Regression results for sleep outcomes (average sleep and insufficient sleep) on bedtime procrastination scores (BPS)

	Average sleep		**Insufficient sleep**	
	(1)	**(2)**	**(3)**	**(4)**
BPS	-0.025***	-0.024***	0.127***	0.107***
(Bedtime procrastination)	(0.004)	(0.004)	(0.006)	(0.006)
Age		-0.010***		-0.011***
		(0.002)		(0.003)
Gender		-0.110*		0.206*
		(0.055)		(0.084)
Paying job		-0.410***		0.238**
		(0.060)		(0.091)
Partner		0.058		0.171
		(0.070)		(0.102)
External circumstances		-0.079*		0.375***
		(0.037)		(0.051)
Cons.	8.158***	9.295***	-1.107***	-0.934**
	(0.097)	(0.247)	(0.141)	(0.357)
N	978	978	1536	1536

Notes: Robust standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *BPS* (bedtime procrastination) rated from 9-45. *Average sleep* computed from the sleep diary; Feelings of *Insufficient sleep* scored by participant from 0-7; For *gender*: 1= 'man', 2= 'woman'; For *paying job*: 0= 'has no paid job', 1= 'has paid job'; For *partner*: 0= not living with a partner, 1= living with a partner; For *external circumstances*: 1= bedtime never affected by external circumstances, 5= bedtime always affected by external circumstances.

One-period regression model for bedtime procrastination and depression

After analyzing the relationship between bedtime procrastination and sleep outcomes, the first regression analysis between bedtime procrastination and depression is performed. Where just the relationship between bedtime procrastination and depression scores in the same period is computed, with and without control variables. All variables in the model were measured in the same period, in 2013. This model is estimated to confirm results from earlier research, that found a relationship between bedtime procrastination and depression in the same period. This relationship is analyzed first, before analyzing the relationship between previous bedtime procrastination and future depression. The results of this one-period regression model are presented in ***Table 3***.

Both models show a significant negative relationship between BP and depression symptoms. In the first model (**1**) with a coefficient of -0.426 ($p < 0.001$), and in the second model (**2**) with a slightly smaller coefficient of -0.215 ($p < 0.001$). This does indicate that people who participate in more bedtime procrastination, on average, do have more depression symptoms and are more likely to be depressed.

Looking at the other coefficients of the second regression model (**2**) gives an idea of the other factors that are associated with more depression, other than bedtime procrastination. However, these coefficients cannot be interpreted the same way since these are controls and are likely to still be biased estimates. Age, General health, Partner, and External circumstances all have significant coefficients. Age and general health are both positively related to depression in the model, which means that irrespective of BPS scores, older participants and participants with better general health seem to have less (severe) depression symptoms and better mental health.

The results also show that ceteris paribus, those who live together with a partner, have higher MHI-5 scores on average and thus less (severe) depression symptoms. Lastly, the external circumstances variable has a significant negative coefficient in the model. This shows that ceteris paribus, participants that experienced many external circumstances that prevented them from going to bed on time, experienced more depression symptoms than those that did not have the same external circumstances.

Table 3: Regression results for depression scores (MHI-5) on bedtime procrastination in the same period

	MHI-5 2013	
	(1)	**(2)**
BPS (Bedtime procrastination; 2013)	-0.426***	-0.215***
	(0.057)	(0.053)
Age		0.143***
		(0.027)
Gender		-1.418
		(0.729)
Paying job		1.259
		(0.811)
General health		7.879***
		(0.541)
Partner		4.634***
		(0.901)
External circumstances		-2.011***
		(0.459)
Cons.	86.767***	60.30***
	(1.382)	(3.987)
N	1536	1536

Notes: Robust standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. MHI-5 (mental health/depression symptoms) rated from 0-100, 100 being perfectly healthy. BPS (bedtime procrastination) rated from 9-45. For *gender*: 1= 'man', 2= 'woman'; For *paying job*: 0= 'has no paid job', 1= 'has paid job'; For *general health*: 1= poor, 5= excellent; For *partner*: 0= not living with a partner, 1= living with a partner; For *external circumstances*: 1= bedtime never affected by external circumstances, 5= bedtime always affected by external circumstances.

To give a visual representation of this relationship between bedtime procrastination and depression symptoms, the two are plotted against each other in ***Figure 4***, with the addition of a regression line with the same coefficients as column (1) from ***Table 3***. The graph shows even more clearly that there is a distinct correlation between BPS and depression scores, just like the regression results showed. Furthermore, there is an interesting outlier in the group with the highest BPS scores, who exhibited extremely low MHI-5 scores on average. So, in this sample, the group with the highest BPS scores was even more severely depressed than the trend would predict.

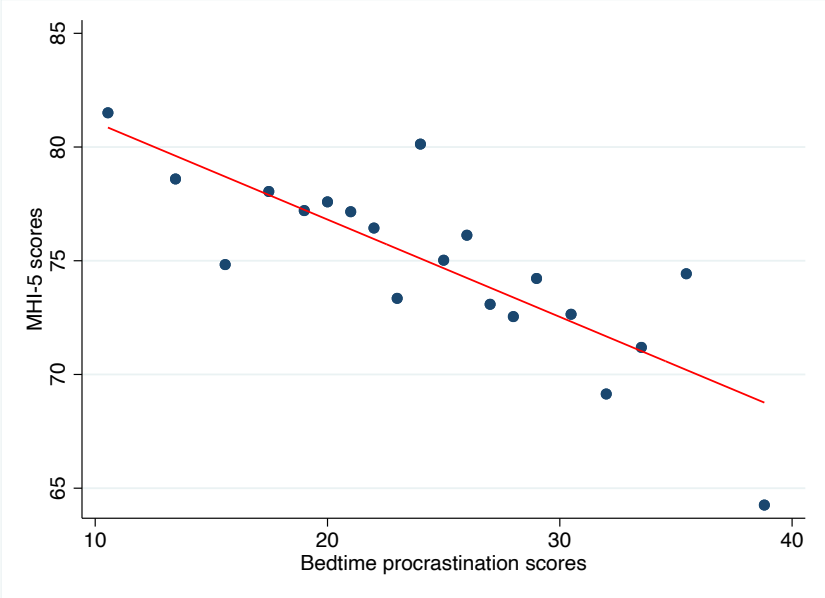

Figure 4: Binned scatter plot of MHI-5 scores against bedtime procrastination scores, with regression line (column **(1)** from ***Table 3***)

Bedtime procrastination's association with future depression

After removing participants with a history of antidepressant use and/or MHI-5 scores associated with depression, the multiple-period analysis is performed to estimate the association between previous bedtime procrastination and subsequent depression symptoms. The results of this analysis, for depression scores two, three, and five years after the BPS measurement, are presented in ***Table 4***.

The models for MHI-5 scores for each of the three periods after the BP measurement include the MHI-5 scores of 2013 as a control, to analyze if the BPS score is significantly associated with more subsequent depression symptoms in individuals that were previously not (as) depressed. All the coefficients for the 2013 MHI-5 scores are highly significant in all three models. This shows that the mental health of participants is somewhat consistent and those with previously good mental health are likely to also have good mental health in the 2-5 years afterward.

The coefficient for the BPS scores, however, is only significant in the model for the 2016 MHI-5 scores. In the models for the years 2015 and 2018, the results do not show a significant relationship between previous BPS scores and future depression symptoms, after controlling for previous MHI-5 scores. Nonetheless, in the model for the year 2016, the previous BPS scores do indeed show a significant association with the MHI-5 scores and thus the depression symptoms ($\beta = -0.175$; $p < 0.001$). The coefficient is negative, showing that, ceteris paribus, those who exhibited more bedtime procrastination three years prior, on average had worse mental health and more depressive symptoms.

Table 4: Regression results for multiple-period regression model with past bedtime procrastination and future depressive symptoms.

	MHI-5		
	2015	**2016**	**2018**
BPS 2013	-0.056	-0.175**	-0.081
(Bedtime procrastination)	(0.061)	(0.066)	(0.066)
MHI-5 2013	0.560***	0.503***	0.565***
	(0.055)	(0.057)	(0.067)
Age	0.034	0.063	0.079
	(0.029)	(0.035)	(0.051)
Gender	0.577	-0.816	1.040
	(0.787)	(0.846)	(0.908)
Paying job	1.240	1.851*	2.519*
	(0.824)	(0.942)	(1.219)
General health	0.545	1.655**	1.121
	(0.618)	(0.569)	(0.717)
Partner	-0.325	-0.143	0.580
	(0.876)	(0.964)	(1.068)
External circumstances	-0.245	-0.998	-1.248*
	(0.439)	(0.582)	(0.506)
Cons.	32.386***	37.379***	29.346***
	(6.547)	(6.300)	(7.846)
N	600	562	475

Notes: Robust standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. MHI-5 (mental health/depression symptoms) rated from 0-100, 100 being perfectly healthy. BPS (bedtime procrastination) rated from 9-45. For *gender*: 1= 'man', 2= 'woman'; For *paying job*: 0= 'has no paid job', 1= 'has paid job'; For *general health*: 1= poor, 5= excellent; For *partner*: 0= not living with a partner, 1= living with a partner; For *external circumstances*: 1= bedtime never affected by external circumstances, 5= bedtime always affected by external circumstances.

Conclusion

The main research question of this thesis was "*Is bedtime procrastination associated with more depressive symptoms two to five years later in life?*" To answer this main question, we first review the results' implications for the sub-questions and then formulate the best possible answer to the main research question.

The first sub-question was in regard to the general correlational relationship between bedtime procrastination and depression symptoms in the same period. The results of the multiple regression analysis clearly showed that even with sufficient controls, more bedtime procrastination was strongly related to more depressive symptoms. Meaning that bedtime procrastination and depression are significantly correlated, even with the full regression model. And that in this sample, ceteris paribus, individuals who exhibit more bedtime procrastination also have more depressive symptoms in that period. This is in line with the expectations set by prior literature and the hypothesis that was formulated.

The second sub-question concerned the relationship between bedtime procrastination and sleep outcomes. Similar to the earlier findings of Kroese, Evers et al. (2014), and others, the results of this analysis also showed that bedtime procrastination was significantly related to fewer hours of sleep and more frequent feelings of insufficient sleep for participants. This is, again, in line with prior expectations and is likely to be a mechanism through which a possible effect of BP on depression would follow.

The aim of the third sub-question was to locate other (demographic) factors that could be associated with depression, other than bedtime procrastination. As discussed with the results, the coefficients of the control variables in the regression models give some indication of demographics that might be associated with more depression. In line with the expectations encompassed in the hypothesis, both age and general health were negatively associated with depression in the sample. Meaning that for individuals with similar BPS scores, having worse general health or being younger was associated with more depression on average. Furthermore, for living with a partner, ceteris paribus, those who were living with a partner generally had better mental health than those that did not live with a partner.

Lastly, the final sub-question was in regard to the association of bedtime procrastination with depressive symptoms in future periods. If BP was significantly associated with more severe depression for future periods, that would give an indication of a possible causal effect, which would be very interesting for future research. The results of the analysis, however, did not reveal BP to be significantly associated with subsequent depression symptoms for two of the three future periods computed. Nonetheless, for the period of 2016, three years after the BPS measurement, the analysis revealed that the BPS score of participants in 2013 had a significant regression coefficient. This does show that the BPS score of participants was significantly related to the depression symptoms three years later, and that, on average, more bedtime procrastination was associated with more depression three years later.

Nonetheless, these results do not necessarily imply that bedtime procrastination causes, or has a concrete effect on, depression, it could also be the case that there are other time-variant characteristics

that cause both depression and bedtime procrastination, where the bedtime procrastination presents itself earlier than the depression in a significant portion of the cases. Such as social media use, neuroticism, or self-discipline, as mentioned earlier. However, this does show that in this sample, bedtime procrastination is, in some cases, associated with future depression and can possibly be used as a risk factor that is associated with a higher chance of developing subsequent depression. However, more research is needed to provide further evidence of this relationship.

For the main research question, the results do show a strong relationship between bedtime procrastination and depression in the same period, however, the evidence for the association between bedtime procrastination and future depression development is not as strong. Higher BPS scores were significantly related to more depression for one of the three future periods, three years after measurement. For the other two periods, BPS was not significantly associated with subsequent depression. These results do give some indication that more bedtime procrastination is likely associated with more depression later in life, however since the relationship was only significant for one of the periods, further research is necessary to give more concrete answers to the research question.

Discussion

Validity

The LISS panel is a highly representative sample of the Dutch population, this ensures a good external validity for the results to be generalized for the whole Dutch population and similar populations. The eliminations that were done as part of the methodology did decrease the external validity, since this did exclude certain individuals from the analysis, meaning that the results are not necessarily applicable to this subsection of the population. Furthermore, participants from all age groups were included in the analysis, this did decrease the internal validity and the causal inference of the results, however, it does result in better external validity.

For reliability and internal validity, a possible concern is the fact that the data was gathered using a survey, which does rely on the participants answering the questions truthfully and correctly. However, the scales that were used in the surveys did all have a sufficient Cronbach's alpha, which does imply that scales are likely to be reliable and the participants did not fill in the survey at random. However, the biggest limitation of the internal validity is the method of analysis.

Due to the intricacy of bedtime procrastination as a behavior and its connections to other characteristics, it is very difficult to analyze this relationship in a way that provides extremely high internal validity, like a natural experiment or even an RCT. The method used in this research does provide better validity than earlier research, which simply used linear regression models of the two variables in the same period. However, the use of previous bedtime procrastination with future

depression still does not allow for actual causal inference, it can only give some implication that there might be such a relationship that needs to be analyzed further in subsequent research.

Interpreting results

The initial analysis of bedtime procrastination's relationship with sleep outcomes provides results, in line with the earlier expectations, indicating that BP is associated with worse sleep outcomes. As the literature on the topic showed, this association with worse sleep outcomes among high bedtime procrastinators is likely to result in worse health outcomes, particularly for instance for depression symptoms. Additionally, the results of the one-period regression model analysis show the same strong association between BP and depression, which was seen in earlier research. However, the multiple-period analysis results are less concrete, they do give some implications of the relationship that was anticipated in the theoretical framework, but the results are not significant for two of the three periods.

However, the result that bedtime procrastination was associated with future depressive symptoms in 2016, but not in 2015 and 2018, can be partly explained by two factors. The lack of a significant relation for 2015 could be because the time frame is too small, which does not allow for the groups to "grow" apart enough in their depression development, to show a significant difference. Furthermore, the lack of a significant relation for 2018 might be related to the attrition of the dataset. Since the participants with high BPS scores that developed depressive symptoms in 2016 might have dropped out of the panel due to their depression. For instance, because they were severely depressed and/or being treated, and thus had no time to participate in a rather trivial survey, or a more morbid explanation could be that some of these severely depressed participants could have ended their own lives.

This attrition of particularly depressed participants is actually also visible in the data, when comparing the mean MHI-5 scores for 2016 of participants that did or did not drop out, the mean for the group that dropped out was 81.75 compared to an 85.27 mean for the group that did not drop out. Furthermore, performing a one-way ANOVA test reveals that these means are actually significantly different with a p-value of 0.003. This does show that the group of participants that dropped out of the panel for 2018, did differ significantly from the mean depression scores, with the mean MHI-5 score of those that dropped out being lower. The lower mean MHI-5 score implies that the group that dropped out of the panel is more depressed on average. This could have been one of the reasons for the insignificant results for 2018 when 2016 did provide significant results.

Limitations

The use of all age groups, in the analysis, decreases the argument for causal inference from the results, which was already weak since there could be unobserved time-invariant confounding variables. Using just young adolescents would be more valid, since the chance is very small that they had developed depression before that point, while with the current analysis, there are possibly still participants that had

depression in the past, without it showing in the data that was available. Furthermore, even if all people with a history of depression were taken out, that would create some kind of selection bias, since the sample would only include people that didn't develop depression, probably meaning that these people are genetically less likely to develop depression. Still, even when doing the same analysis on just young adolescents, would also be limited in analyzing the causal relationship since there would still be the influence of other characteristics and genes that can lead to both bedtime procrastination and depression. However, Baglioni et al. (2011) did find that the predictive value of insomnia on depression is similar for different age groups, not just adolescents, but also adults and elderly individuals. So, the use of all age groups in this analysis is still relevant in some ways.

The elimination of people with a history of depression was very necessary for the analysis, however, there could be some problems with using an MHI-5 score of 70 or below to determine this. First of all, as discussed, there is no consensus on an exact cut-off value for the MHI-5 scale that would be best to categorize individuals with depression. Choosing 70 was based on the range of values that have been proposed in research, but perhaps a lower or higher value would have been better in eliminating depressed participants and leaving non-depressed participants.

Furthermore, the LISS panel datasets provide data on the MHI-5 scores for many years, but not for the entirety of the participant's lives. This leaves the possibility that participants had experienced depression before they were included in the LISS panel and thus did have a history of depression but were still included. However, if this were true, there could be an argument made that those depression episodes would be so far in the past that they would have a very small effect on those participants having another episode. To improve the elimination and categorization of depressed individuals both before and after the bedtime procrastination measurements, it would be more valid and reliable in subsequent research to use trained professionals. These professionals, perhaps psychologists or psychiatrists, would be better equipped to evaluate the mental state of the participants and to diagnose them with depression.

This research already improved on the validity and methods of earlier research, however for future research on the topic, the methods can be improved even further to provide more valid results that can give a better picture of the risks of bedtime procrastination. A more optimal study could use a large group of young adolescents, prior to the age of onset of depression for many individuals, and follow them for a long period of time. During this period the researchers can measure both bedtime procrastination and depression periodically and use this to later analyze if an increase in bedtime procrastination is associated with more subsequent depressive symptoms. This also allows the researchers to analyze if there is a certain timeframe after bedtime procrastination presents itself, at which point the depression symptoms arise in most individuals.

Implications

For the literature on this specific topic and in the general field of research on health and behavior, this research provides a significant addition to the knowledge base on bedtime procrastination as a whole

and specifically its relationship with depression. The scientific literature on bedtime procrastination is still limited, especially on its possible effects and associations with depression and other health outcomes. The research on the relationship between bedtime procrastination and depression was limited to a handful of analyses using multiple regression to estimate the association between the two. The results of this research firstly corroborate those findings with a similar analysis, and additionally provide a deeper analysis of the relationship, with results that indicate that bedtime procrastination could be a risk factor for the development of subsequent depression.

The analysis used in this research was not perfect, however, it can be used as an inspiration for future research. With better data and small changes to the methods, a similar analysis provides evidence of not just an association, but also a possible risk-factor for the development of future depression and with changes perhaps even causal inference. The predictive analysis was used in plenty of other research on similar topics, however until this thesis, the method had not yet been applied to the relationship between bedtime procrastination and future depression. This particular application hopefully inspires other researchers to use similar or more advanced techniques in research on this topic, to provide increasingly strong amounts of evidence for the risks and effects of bedtime procrastination.

Furthermore, these results could have very useful practical implications, since the research does show a very real relationship between bedtime procrastination and depression. More research is needed to analyze the mechanics of the relationship, but this evidence already suggests that people who exhibit bedtime procrastination are more likely to have or subsequently develop depression. This might be able to be used in practical applications, where bedtime procrastination can be used as a screening tool to detect individuals that are possibly at risk of developing or having depression. Furthermore, it will be a more discreet screening tool, since participants will be less aware of the fact that the answers to these questions might suggest that they are at risk for depression.

Government and mental health agencies could also benefit from the knowledge gained by these findings and future research on the topic. Since the implications of this research could help with understanding and combatting the current mental health crisis in The Netherlands. The results show concerning factors that are also interesting for population health purposes. Firstly, bedtime procrastination is highly prevalent in the Dutch population and is strongly related to fewer hours of sleep and more feelings of insufficient sleep. This is already concerning for many different health outcomes. Furthermore, the results show that more bedtime procrastination is significantly related to higher levels of depression. And lastly, the multiple-period analysis did give some indication that BP can be a risk factor for the subsequent development of depression. These relationships are very important for government health agencies to understand since it might be a way to keep the large demand for mental health services under control, by combatting the behavior of bedtime procrastination. Furthermore, the results of bedtime procrastination for sleep outcomes can also be detrimental for many other health outcomes, which can be a large concern for the population's health.

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Appendix A

Bedtime procrastination scale (BPS; Kroese, De Ridder et al., 2014)

To what extent do the following statements apply to you?

(Scored on a 5-point Likert scale: *1 almost never; 2 ; 3 ; 4 ; 5 almost always*)

1. It happens that I lie in bed later than I had intended.
2. If I have to get up early, I make sure I go to bed on time. (Reversed)
3. When it is time to turn off the lights, I do so immediately. (Reversed)
4. When it is time to go to bed, I often am still doing other things.
5. I easily get distracted by other things when I actually had wanted to go to bed.
6. In my opinion, I do not lie in bed on time.
7. I have a fixed bedtime to which I keep. (Reversed)
8. I want to go to bed on time, but I cannot do it.
9. In the evening, I can easily stop doing other activities to go to bed (Reversed)

Appendix B

Mental health inventory-5 (MHI-5; Berwick et al., 1991)

The following questions are about how you felt over the past month. For every question, please choose the answer that best describes how you felt during this past month. This past month ....

(Scored on a 6-point Likert scale *1 never; 2 seldom; 3 sometimes; 4 often; 5 mostly; 6 continuously, then linearly transformed to a variable ranging from 0-100, with 100 indicating perfect mental health)*

1. I felt very anxious (Reversed)
2. I felt so down that nothing could cheer me up (Reversed)
3. I felt calm and peaceful
4. I felt depressed and gloomy (Reversed)
5. I felt happy