A Comprehensive Examination of Self-Reported Obsessive-Compulsive Symptoms and Sleep Disturbances in a Global Post-Secondary Student Cohort: UNILIFE-M

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PREFACE

Chapter 1 provides an introduction to the thesis. Chapter 2 gives an overview of the UNILIFE-M (University Students' Lifestyle and Mental Health Study) data source. Chapters 3 and 4 involved secondary data analysis from UNILIFE-M study, for which ethics approval was obtained from the University of Ottawa Research Ethics Board (H-11-24-10937) as well as from the respective ethics board at each participating site. Chapter 5 presents a summary of findings and policy implications. The entire thesis was completed by me (Saguna Katyal), with supervision from Dr. Ian Colman and Dr. Marco Solmi, as part of the requirement for the MSc thesis. Dr. Colman, Dr. Solmi (co-supervisors) and Dr. Felipe Schuch (Thesis Advisory Committee Member) oversaw the thesis from initiation till completion, provided their methodological and clinical expertise and reviewed the final manuscript. Dr. Umberto Granziol provided expertise for the data analytical component of the network analysis.

ABSTRACT

Young adults present an elevated risk of developing obsessive-compulsive disorder (OCD) symptoms and sleep disturbances. However, current evidence in the literature is limited to clinical samples. The goal of this thesis was to understand OCD symptoms and sleep disturbances through network analysis, longitudinal analysis, and latent class analysis. Data was used from the University Students' Lifestyle and Mental Health Study (UNILIFE-M)- a global cohort of first-year post-secondary students. Results from network analyses noted certain central symptoms- ordering, checking, unpleasant thoughts, and nightmares. The longitudinal analysis suggested that baseline sleep disturbances may be a risk factor for developing OCD symptoms at 1-year follow-up. Latent class analysis identified five OCD classes, 1) "Checking and Ordering", 2) "Checking, Hoarding and Obsessive Thoughts" in baseline data and only 2) "Obsessive Thoughts" in follow-up data, 3) "Mild", 4) "Moderate", 5) "Severe." Findings from this thesis may serve as a guide for early intervention in students.

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List of Abbreviations

DSM-5	Diagnostic and Statistical Manual of Mental Disorders-5
OCD	Obsessive-Compulsive Disorder
UNILIFE-M	University Students' Lifestyle and Mental Health Study
REDCap	Research Electronic Data Capture
CCSM	Cross-Cutting Symptom Measure

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1. Introduction

1.1. Mental health and lifestyle patterns

Globally, mental health problems have become highly prevalent in the recent years. In 2019, an estimated 970 million individuals experienced a mental health illness.[1] Current literature suggests that the onset of most mental health problems occurs between late adolescence to young adulthood (17-34 years old)[2], with 65-75% of initial mental health disorders being diagnosed before the age of 25.[3,4] Young adulthood is an important developmental stage, as it often coincides with the beginning of post-secondary education.[5,6] During this phase, young adults frequently leave their parental homes and take on new responsibilities.[7] As a result, they are more likely to experience lifestyle changes, such as prolonged sedentary behaviors, less physical activity, poor sleep quality, and increased use of substances - all of which are known to have a detrimental effect on mental health.[8]

1.2. Sleep patterns and mental health in young adults

As young adults transit into post-secondary education, they often struggle with maintaining regular sleep patterns.[9] Sleep is a biological process that is essential for an individual's functioning. The American Academy of Sleep Medicine and Sleep Research Society recommends adults (i.e., 18-60 years old) to sleep at least seven hours per night.[10] However, young adults often do not meet this guideline. In fact, the prevalence of poor sleep patterns among postsecondary students is 20-27%[11,12] versus 10-15%[13] in the general population. A longitudinal study of 50,000 Norwegian university students found that insomnia prevalence among female undergraduate students was 34.2% versus 22.2% in male undergraduate students.[14] Another cross-sectional study noted that 60% of students reported poor sleep quality (i.e., delayed bedtimes and inadequate sleep) and those with poor sleep quality had greater psychological problems such as stress, anger, confusion, fatigue and depression.[15]

Furthermore, young adults often sleep for fewer hours during the weekdays and longer hours during the weekend.[16] This variability in sleep duration has been associated with higher risk of

mental health problems in adolescents such as concentration difficulties, depression, aggression, and social withdrawal.[17] In fact, an U-shaped association has been observed, indicating that those who sleep less than 8 hours or greater than 9 hours have the highest risk for developing a mental illness, whereas, 8-9 hours of sleep was associated with the lowest risk of a mental illness.[16]

Previous research studies have consistently shown that disrupted sleep is associated with a variety of mental health disorders such as major depressive disorder, anxiety disorders, eating disorder and Attention Deficit Hyperactivity Disorder (ADHD).[18–23] Additionally, a meta-analysis including 65 randomized controlled trials (RCTs) found a dose-response relationship, indicating that disrupted sleep is linked to worse mental health outcomes.[24] Recent evidence in the literature has also shown support for the association between sleep disturbances and obsessive-compulsive disorder (OCD).[25] In previous meta-analyses, patients with OCD have reported a higher prevalence of a delayed-sleep onset, insomnia, poor sleep quality, and increased nighttime awakenings.[26–28] Furthermore, in non-clinical samples, young adults with delayed bedtimes have also indicated greater obsessive-compulsive symptoms.[29]

1.3. Obsessive-compulsive symptoms

OCD affects approximately 100 million individuals in their lifetime.[30] This psychiatric illness is characterized by obsessions and compulsions.[31] Obsessions are recurrent, unwanted and intrusive thoughts.[32] Compulsions are behaviors or mental acts completed in response to obsessions. Individuals with OCD become involved in a vicious cycle of obsessions and compulsions. For example, an obsessive thought might be, “did I turn the gas stove off?”, and then this is followed by a “coping mechanism” of repeatedly checking whether gas stove is off to relieve anxiety.[33] The goal of these compulsions is to alleviate the distress associated with the obsessive thought, but it paradoxically increases the distress, further feeding back in to the vicious cycle.

OCD symptoms are very heterogenous with multiple specifiers, but, five major types of compulsions have been identified by several confirmatory analyses- symmetry (i.e., ordering, arranging things), reassurance-seeking (i.e., repeatedly checking certain things), cleaning/washing (i.e., fear of contamination), hoarding (i.e., fear of throwing away objects), and neutralizing (i.e., counting).[34–37] For example, a symmetry-related obsession might be, “Pencils

on my desk are not arranged properly", then a compulsion might be to spend a considerable amount of time ensuring the symmetry of the pencils feels "just right."

It is important to note that individuals diagnosed with OCD must present both obsessions (i.e., intrusive thoughts) and compulsions (i.e., mental or behavioral acts) that are extremely time-consuming, distressing and disrupt an individual's day-to-day functioning.[38] Box 1 describes the diagnostic criteria of OCD based on the *Diagnostic and Statistical Manual for Mental Disorders-Fifth Edition* (DSM-5).[39]

Box 1. Diagnostic criteria of obsessive-compulsive disorder based on the *Diagnostic and Statistical Manual for Mental Disorders-Fifth Edition* (DSM-5)

A. Presence of obsessions, compulsions or both:

Obsessions are defined by (1) and (2):

1. Recurrent and persistent thoughts, urges or images that are experienced, at some time during the disturbance, as intrusive, unwanted, and that in most individuals cause marked anxiety or distress
2. The individual attempts to ignore or suppress such thoughts, urges, or images, or to neutralize them with some thought or action (i.e., by performing a compulsion).

Compulsions are defined by (1) and (2):

1. Repetitive behaviors (e.g., hand washing, ordering checking) or mental acts (e.g., praying, counting, repeating words silently) that the person feels driven to perform in response to an obsession, or according to the rules that must be applied rigidly.
2. The behaviors or mental acts are aimed at preventing or reducing distress or preventing some dreaded event or situation. However, these behaviors or mental acts either are not connected in a realistic way with what they are designed to neutralize or prevent or are clearly excessive.

B. The obsessions or compulsions are time consuming (e.g., take more than 1 hour per day) or cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.

C. The disturbance is not better explained by the symptoms of another mental disorder.

Specify if:

With good or fair insight: The individual recognizes that obsessive-compulsive beliefs are definitely or probably not true or that they may or may not be true.

With poor insight: The individual thinks obsessive-compulsive disorder beliefs are probably true.

With absent insight/delusional beliefs: The individual is completely convinced that obsessive-compulsive disorder beliefs are true.

Specify if:

Tic related: The individual has a current or past history of a tic disorder.

1.4. Sleep disturbances

Sleep is an essential biological process for optimal metabolic and cognitive functioning.[40] The suprachiasmatic nucleus (SCN) in the hypothalamus is responsible for regulating sleep/wake patterns by releasing a hormone, known as melatonin.[41] Sleep disturbances refer to difficulties with initiating and maintaining asleep such as higher sleep latency (i.e., not sleeping within 30 minutes), increased nighttime awakenings (i.e., waking up in the middle of the night), environment-related discomfort (i.e., feel cold or hot at night), having breathing difficulties or pain during sleep.[42,43] Disruptions in sleep can change activity in certain brain regions, which has been linked to increased risk of mental health problems.[44] For example, sleep deprivation has

been noted to negatively impact working memory and inhibitory control, specifically influencing the frontal and thalamic regions of the brain.[45,46]

1.5. Obsessive-compulsive symptoms and sleep disturbances

Current evidence in the literature remains inconsistent regarding the relationship between obsessive-compulsive symptoms and sleep difficulties.[47] A few studies have noted that individuals with OCD are more likely to report a delayed sleep onset [48,49], reduced total sleep time[50], greater daytime dysfunction[51], lower sleep efficiency[28], and increased sleep latency.[52] Some have even indicated that individuals diagnosed with OCD are seven times more likely to receive a diagnosis of insomnia than those without OCD.[47] Adolescents with OCD also report a greater prevalence of Disorders of Initiating and Maintaining Sleep (DIMS).[53] However, other findings have suggested that only severe OCD symptoms are associated with later bedtimes[54] and reduced sleep duration.[53]

Previous studies have also suggested that individual differences in sleep-wake cycles (i.e., chronotypes) may be influencing the correlation between OCD symptoms and sleep.[55–57] Two main chronotypes exist- morningness (i.e., prefer to sleep and wake up early) and eveningness (i.e., prefer delayed sleep and wake times).[58] Individuals with OCD with an "eveningness" preference tend to report greater negative affect and disrupted sleep quality, compared to those with a "morningness" preference.[55,56]

Prior literature has shown mixed results regarding the OCD features correlated with sleep disturbances. Some studies have indicated that sleep disturbances may only be associated with obsessions, but not with compulsions.[59] While, others have suggested that sleep disturbances may only be linked to certain subtypes of OCD such as unacceptable thoughts [60,61] and symmetry/hoarding.[53] Furthermore, a few studies have noted that sleep related-problems may be comorbid with internalizing problems.[62,63] Whereas, mediation analyses have revealed that repetitive negative thinking [64], anxiety symptoms and depressive symptoms [65] might be potential mediators between the association of OCD and disrupted sleep.

In fact, a few studies have also shown support for a bidirectional relationship between OCD symptoms and disrupted sleep (see Figure 1).[66–68] Reynolds and colleagues have proposed a model suggesting a cyclical relationship between sleep problems and OCD among children and adolescents.[69] That is, individuals who experience frequent unwanted thoughts may spend more time engaging in nighttime routines- often after their partners, children or parents have gone to sleep.[29] These nighttime compulsions can increase pre-sleep arousal or delay bedtimes, leading to a reduction in sleep time. This decrease in sleep duration results in a lack of inhibition of intrusive thoughts. This is due to the disrupted connectivity between the prefrontal cortex and amygdala affecting the cognitive ability to inhibit intrusive thoughts.[70,71] Therefore, the reduced ability to inhibit intrusive thoughts further feeds back into the loop and perpetuates the cycle (see Figure 2).[72] Hence, it is unclear whether sleep disturbances are an outcome or a risk factor of OCD, instead there may be an intertwined association between OCD and disrupted sleep that has not been extensively studied in the literature yet.

Figure 1. Bidirectional association between obsessive-compulsive disorder and sleep disturbances

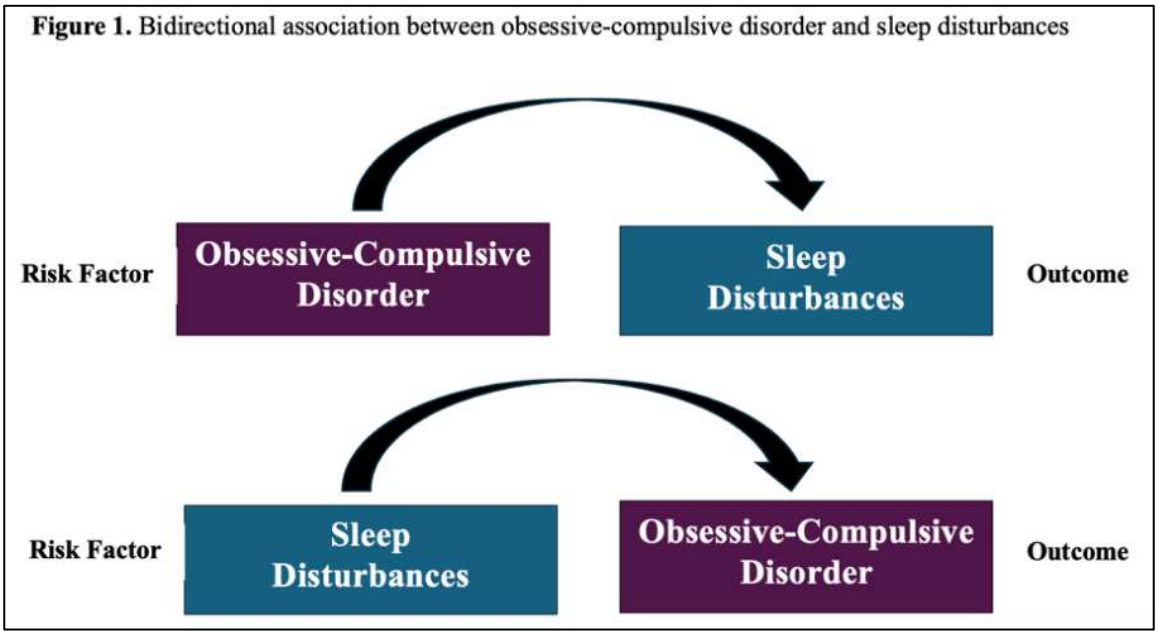
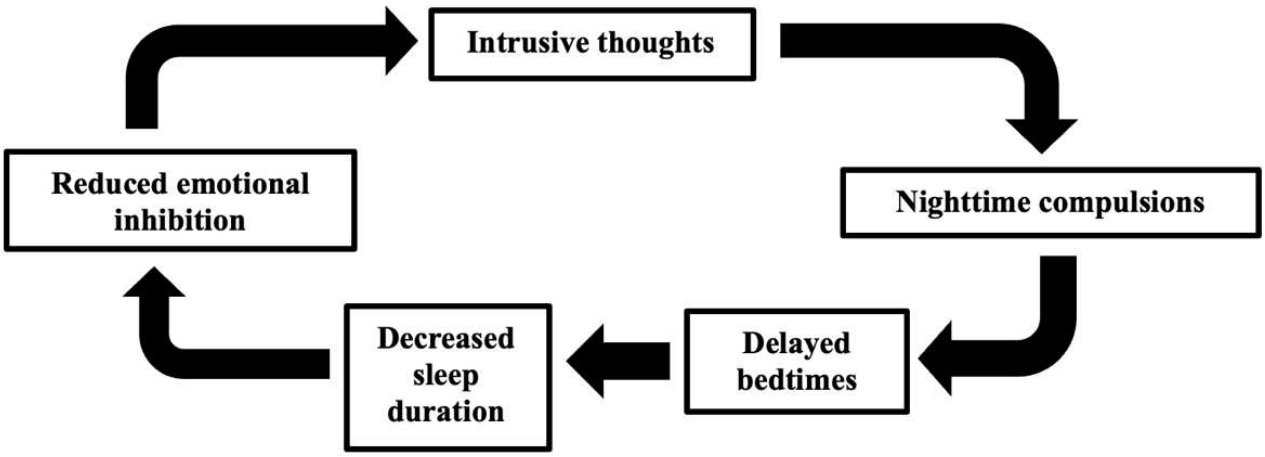


Figure 2. Feedback loop between obsessive-compulsive symptoms and disrupted sleep



1.6. Sleep disturbances as an outcome of OCD symptoms

As previously mentioned, sleep disturbances may be a consequence of OCD symptoms. For example, a meta-analysis, involving 111 patients with OCD and 141 controls, found that those with OCD had higher sleep latency than controls, even after controlling for depression.[73] Evidence from studies using all-night sleep electroencephalogram (EEG) recordings has also suggested that those with OCD have more nighttime awakenings, decreased rapid-eye movement efficiency and overall less sleep time than healthy controls.[74]

Previous research evidence has also indicated that those with OCD have a much higher prevalence of Delayed Sleep Phase Disorder (DSPD)- approximately 20-40% compared to the general population- 0.2-0.5%.[65] DPSD is a sleep disorder described by difficulty in falling asleep at a desired time and associated with daytime dysfunction as well as disruption in day-to-day functioning.[75] Similarly, in a meta-analysis of matched case control studies [48] and a prospective study,[76] 42% of patients with OCD had a comorbidity with Delayed Phase Sleep Disorder (DPSD). Patients with a comorbidity were more likely to be male, younger, and have severe OCD symptoms. Furthermore, individuals diagnosed with both DSPD and OCD have noted to be more resistant to treatment such as exposure-ritual prevention treatment [77] and transcranial stimulation.[78] Even in non-clinical samples, OCD symptoms have been associated with greater

difficulties falling asleep at night and waking up in the morning.[66] Overall, there exists considerable evidence suggesting that disrupted sleep may be an outcome for OCD.

1.7. Sleep disturbances as a risk factor of OCD

Some studies have also indicated that sleep disturbances may be a risk factor for developing obsessive-compulsive symptoms. For example, a previous study recruited individuals diagnosed with a sleep disorder, specifically the DSPD, and measured their intrusive thoughts.[79] They found that those diagnosed with DSPD had greater symptoms of intrusive thoughts than those without DSPD. Similarly, a longitudinal study among individuals with OCD, showed that later bedtimes at baseline may be associated with prospective increases in obsessive-compulsive symptoms at a follow-up time.[67] A plausible hypothesis is that sleep disturbances may impair executive function and create difficulty in inhibiting intrusive thoughts, leading to a greater vulnerability to OCD.[80] Moreover, in a study involving 212 undergraduates found that those with delayed bedtimes had greater number of intrusive thoughts compared to those with non-delayed bedtimes.[81] Thus, delayed sleep has been correlated with the onset of obsessive-compulsive symptoms in both clinical and non-clinical samples.

1.8. Literature gap

Despite robust research evidence regarding the association between obsessive-compulsive symptoms and sleep disturbances, there still remain a few gaps in the literature.

First, the type of OCD dimensions that interact with certain aspects of sleep disturbance is unclear. An approach to address this gap is to conduct a network analysis.[82] In the field of psychopathology, network analyses provide a novel perspective by examining intertwined associations and identifying highly interconnected symptoms (i.e., central symptoms).[83] These central symptoms can serve as potential targets for interventions.[84] Two previous network analyses among obsessive-compulsive symptoms and sleep disturbances have shown that "resistance to obsessions and compulsions" [85] and "degree of interference associated with obsessions and compulsions" were the most central symptoms.[86] However, these studies utilized a depression instrument to assess sleep problems (Quick Inventory Depression Symptomology-

QIDS-SR), instead of using a more robust instrument to examine sleep disturbances such as the Pittsburgh Sleep Quality Index (PSQI). A more recent network analysis has noted daytime dysfunction, and compulsive behaviors to be central symptoms among OCD and insomnia networks.[87] However, all of these studies included patients with a clinical diagnosis of OCD, lacking representation from non-clinical samples (e.g., post-secondary students).

Second, current evidence in the literature lacks a consensus regarding the direction of association between OCD symptoms and disrupted sleep. Research studies have shown support for both sleep disturbances to be a risk factor and an outcome of OCD, with some even suggesting a bidirectional association.[66–68] This is likely because previous meta-analyses investigating sleep patterns and OCD have mostly included data from cross-sectional studies, and only a few included prospective studies.[50,73] So, a better approach might be to understand the bidirectional relationship between disrupted sleep and OCD in a longitudinal manner.

Third, OCD symptoms present a significant amount of heterogeneity. For example, men tend to report more checking compulsions, whereas, females are more likely to report hoarding symptoms and washing/cleaning compulsions.[88,89] A study from a large community sample noted that females presented more heterogenous symptoms (i.e., from different OCD clusters) and males present more homogenous symptoms (i.e., from similar OCD clusters).[90] Therefore, latent class analyses investigating different clusters of OCD dimensions may provide an important perspective. So far, most latent class analyses have been conducted using clinician-administered instruments (i.e., Yale-Brown Obsessive Scale) in clinical samples.[91,92] However, it might be valuable to examine OCD symptom profiles in non-clinical samples, such as post-secondary students.

1.9. Goal of this thesis

In this thesis, I present two studies: 1) Network analysis of OCD symptoms and sleep disturbances and 2) Longitudinal study examining the association between OCD symptoms and sleep disturbances and a latent class analysis of OCD symptoms.

Current literature suggests that young adults as students are at an elevated risk of developing obsessive-compulsive symptoms [93] and sleep disturbances.[94] Hence, to implement early intervention in this population, it is important to understand their presentation of symptoms. Therefore, in this thesis, I utilized data from a global cohort of first-year post-secondary students -University Students' Lifestyle and Mental Health Study (UNILIFE-M).[95] Participants completed an online survey regarding their mental health symptoms and lifestyle patterns at baseline in 2023 or 2024 (i.e., beginning of post-secondary career). Those who completed the baseline survey were contacted for follow-up after 1 year. This is an ongoing prospective study, however, in this thesis, only partial data from baseline (i.e., beginning of post-secondary career) and 1-year follow-up was included.

Several factors have been known to affect the association between OCD and sleep disturbances such as sex [96], sexual orientation [97,98], ethnicity [99], body mass index (BMI) [100], depressive symptoms [101], and employment status.[102] Hence, I controlled for these covariates in the studies. This way we can get a better understanding of the association between sleep disturbances and obsessive-compulsive symptoms, which may inform early prevention strategies in young adults.

1.10. Structure of the thesis

Based on the guidelines provided by the School of Epidemiology and Public Health (SEPH) at the University of Ottawa, this thesis is presented in an article-based format. Chapter 2 describes an overview of the UNILIFE-M (University Students' Lifestyle and Mental Health Study) survey. Chapter 3 examines the relationship between OCD symptoms and sleep disturbances through a network analysis. Chapter 4 longitudinally assesses the association between OCD symptoms and sleep disturbances and identifies different OCD symptom profiles through a latent class-analysis. Lastly, Chapter 5 discusses the overall findings of the two research studies and their contribution to the literature.

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2. University Students' Lifestyle and Mental Health Study (UNILIFE-M) Survey

2.1. Overview

The University Students' Lifestyle and Mental Health Study (UNILIFE-M) is a prospective multi-site, international study examining the relationship between mental health symptoms (i.e., depression, anxiety, substance abuse, obsessive-compulsive symptoms, sleep problems, mania, hyperactivity) and lifestyle behaviors (i.e., diet, restorative sleep, sedentary behaviour, physical activity, stress management and social support) during the university/college years.[1] This data was collected via a self-reported online survey from students in over 50 universities in 22 countries (Austria, Australia, Brazil, Chile, Colombia, Ecuador, Finland, Germany, Greece, Japan, Lebanon, Mexico, Netherlands, New Zealand, Nigeria, Peru, Spain, Suriname, Switzerland, the UK, Uruguay, and the US). Participants completed the baseline survey at the beginning of their first year in college/university in 2023 or 2024. Those who completed the baseline survey were contacted to complete the same survey at 1-year follow-up. This is an ongoing prospective study and will also involve following up with students after 2 years and 3.5 years. However, both the research papers included in this thesis used partial baseline data and the second paper on the longitudinal analysis also involved the use of partial 1-year follow-up data from 8 countries (Australia, Austria, Brazil, Chile, Colombia, Germany, Japan and Spain).

2.2. Inclusion criteria

Participants must 1) be between the ages of 16 to 35 years old, 2) be enrolled as a first-year student in the 2023 or 2024 academic year at a participating UNILIFE-M university/college and 3) provide their electronic consent before beginning the baseline survey.

2.3. Recruitment methods and consent

A convenience sampling approach was utilized to recruit students by putting up posters on university/college campuses, digitally advertising on social media and university/college websites, sending direct emails to students, and face-to-face recruitment in classrooms. These advertisements contained the QR code or the link to the study survey. The specific recruitment

methods varied slightly based on the data privacy laws and policies in the respective countries. All students self-enrolled in this study by scanning the QR code/or clicking on the survey link and were required to provide their electronic consent prior to beginning the survey. Participants were allowed to withdraw from this study at any time. Only those participants who provided consent at baseline were contacted after 1-year for completion of the follow-up survey.

2.4. Compensation

Compensation was optional: a few sites (Australia, Austria, Finland, Japan, Netherlands, Switzerland, United States) compensated participants via study credits, or gift cards.

2.5. Ethics approval and data management

Each participating site was required to obtain ethics approval from their respective research ethics board. Questionnaires that were not available in the language of the local study site were officially translated and back translated to record the data. The survey was administered via REDCap (Research Electronic Data Capture) platform and all data was pseudomized to maintain participants' privacy. The anonymized data was securely sent from the Brazil site to the Ottawa site via a password protected electronic transfer. The ethics approval to conduct secondary data analyses presented in this thesis was obtained from the University of Ottawa Research Ethics Board (H-11-24-10937) (see Appendix A).

2.6. Measures

Mental health symptoms

Mental health symptoms were examined at two levels. At the first level, all participants who took part in the study completed the Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) Cross-Cutting Symptom Measure (CCSM).[2] This is a self-reported assessment that examines 13 domains- depression, psychosis, anger, mania, anxiety, somatic symptoms, suicidal ideation, memory problems, sleep problems, repetitive thoughts and behaviors, personality function and substance abuse. The participants respond using a Likert scale with 5 points ranging from 0 (none/not at all) to 4 (severe/ nearly every day). A minimum rating of 2 (mild/ several days) for depression, mania, anxiety, sleep, obsessive and compulsive symptoms or substance abuse was

required to move on to complete the second level assessment. However, if they did not meet the set threshold at the first level then they did not complete the second level assessment.

Obsessive-compulsive disorder (OCD) symptoms

If the respondents met the first level threshold for OCD, in other words, scored at least 2 (mild/several days) to the question "How much (or how often) you been bothered in the past two weeks by unpleasant thoughts, urges, or images that repeatedly enter your mind or feeling driven to perform certain behaviours or mental acts over and over again?" then they moved to complete the Obsessive-Compulsive Inventory-Revised (OCI-R) (see Appendix B). This is a self-reported questionnaire with 18 items assessing the severity of obsessive-compulsive symptoms. Each item was self-rated by the participant as 0 (not at all), 1 (a little), 2 (moderately), 3 (a lot) or 4 (extremely). OCI-R total scores were determined by adding all the individual scores together- ranging from 0 to 72, with a clinical threshold above 21. The OCI-R scores were classified as mild (0 to 15), moderate (16 to 27) and severe (≥ 28).[3]

Sleep disturbances

If the respondents met the first level threshold for sleep problems, in other words, scored at least 2 (mild/several days) to the question "How much (or how often) you been bothered in the past two weeks by problems with sleep that affected your overall sleep quality?" then they moved to complete the Pittsburgh Sleep Quality Index (PSQI) Component 5 Score (see Appendix C). PSQI contains 19 items assessing seven domains: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication and daytime dysfunction.[4] However, to make the UNILIFE-M survey more concise, only the sleep disturbances domain (9 items- 5b-5j) and 1 sleep latency item (5a) were included in the survey. Since item 5j was a qualitative assessment, it was not used in our analyses in this thesis. Each item (5a-5i) was self-rated by the participant as 0 (not during the past month), 1 (less than once a week), 2 (once or twice a week), or 3 (three or more times a week). To determine the overall PSQI score, I calculated the sum of the sleep disturbances' items only (5b-5i), excluding the 1 sleep latency item. The total PSQI Sleep Disturbances domain ranged from 0 to 27. This domain sub-score was then re-classified into no difficulty (0), mild difficulty (1-9), moderate difficulty (10-18) or severe difficulty (19-27).[5,6]

Sociodemographic characteristics

UNILIFE-M collected a variety of sociodemographic variables. Table 1 shows the operationalization of participant characteristics that were included in this thesis.

Table 1. Operationalization of participant characteristics

Participant Characteristics	*Operationalization*	
	Survey Questions	**Survey Responses**
Sex[*]	"What is your biological gender?"	Male or Female
Age	"What is your age?"	Exact age was provided in a text box
Sexual Orientation[*]	"Regarding your sexual orientation, are you?"	Heterosexual, Homosexual, Bisexual, Pansexual, or Other
Gender Identity[*]	"What's your gender identity?"	Cisgender (identifies with the biological sex), Transgender (does not identify with the biological sex) or Non-Binary (identifies with both genders or none)
Ethnicity[**]	"What is your ethnic group?"	Asian, Black, Brown, White, Indigenous or Other
Work Status	"Are you currently working?"	Yes or No
Marital Status	"What's your marital status?"	Married, Single, Widowed, Divorced or Defacto Relationship
Pregnancy Status[^]	"Are you pregnant?"	Yes or No
Body Mass Index (BMI)	"What is your height, in m, approximately?" and "What is your weight, in kg, approximately?"	Exact height and weight were provided in a text box, from which BMI was calculated
Clinical Diagnosis of OCD	"Do you have a mental health problem or developmental disorder that has been diagnosed by a psychiatrist?"	If they chose the radio button option, "Obsessive-compulsive disorder"

*Sex was not reported from New Zealand. Sexual orientation was not reported from Lebanon and New Zealand. Gender identity was not reported from Lebanon.

**For purposes of the Table 1, grouped together Asian (i.e., East Asian) and Brown (i.e., South Asian/ Middle Eastern/Hispanic). This variable was not reported from Netherlands, Germany, Austria, Switzerland, Lebanon, Mexico (Puebla) and Finland.

^This variable was only asked if participants answered "Female" for sex.

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3. Network Analyses of Self-Reported Suprathreshold Obsessive-Compulsive Symptoms and Sleep Disturbances in a Selected Global Post-Secondary Student Cohort: UNILIFE-M

PREFACE

Goal addressed: To conduct network analyses to identify the specific OCD symptoms that are highly associated with disrupted sleep.

Author contributions: Saguna Katyal developed the research protocol, cleaned and merged the data by site, carried out the network analyses, and finished the manuscript. Dr. Umberto Graniziol provided methodological expertise in conducting the network analyses. Dr. Marco Solmi and Dr. Ian Colman provided their clinical and methodological feedback on the research protocol, guided me through all parts of this research paper, and reviewed the final writing of the manuscript. Dr. Felipe Schuch provided their clinical expertise on the research protocol and the final writing of the manuscript. All those who provided the UNILIFE-M data are part of the co-author list and have reviewed the final manuscript.

Publication: In progress to submitting to *Psychiatry Research* journal

Ethics Approval: Ethics approval was received to conduct secondary data analysis using UNILIFE-M data from the University of Ottawa Research Ethics Board (H-11-24-10937), as of November 14, 2024. Each site received approval from their respective research ethics board.

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Abstract

Background: Obsessive-compulsive disorder (OCD) symptoms have been consistently associated with greater sleep disruption. However, it is unclear which OCD symptoms and types of sleep disturbances are most important and strongly interconnected.

Methods: We used baseline data from the University Students' Lifestyle and Mental Health Study (UNILIFE-M) with a global sample of 18,434 first-year post-secondary students from 22 countries, aged 16-35. Of whom, 4,477 met the DSM-5 Cross Cutting Symptom Measure threshold for OCD symptoms and sleep disturbances. Network analyses were considered separately for OCD symptoms, OCD domains, sleep disturbances, a composite network of OCD symptoms and sleep disturbances and a Network Comparison Test (NCT) by sex, sexual orientation, and gender identity.

Results: In the OCD network, three most central symptoms were arranging things in a particular way (Strength Centrality (SC)=1.56), getting upset by unpleasant thoughts (SC=1.37) and repeatedly checking doors or windows (SC=0.91, Expected Influence= 1.34). Three OCD domains were more central than others: neutralizing (SC=0.80), checking (SC=0.77) and ordering (SC=0.77). In the sleep disturbances network, two most central symptoms were pain during sleep (SC=1.54) and not able to breathe comfortably (SC=1.21). In the composite network, the OCD node of unpleasant thoughts was weakly correlated with sleep disturbances' node of bad dreams (r=0.30, partial correlation=0.07). Networks were stable with a correlation-stability coefficient of 0.75. The NCT in the composite network of OCD symptoms and sleep disturbances found no difference in network invariance but the average strength of all nodes was greater among females (global strength=11.68) than males (global strength=10.91), with a global strength difference statistic- S=0.78, p-value= 0.01. No difference was found in global strength nor network invariance by sexual orientation and gender identity.

Conclusion: Future research can explore potential mediators, and test whether targeting these central symptoms (i.e., ordering, checking, unpleasant thoughts and nightmares) can affect the overall network structure.

Keywords: obsessive-compulsive disorder, sleep, network analysis, post-secondary students

3.1. Introduction

Obsessive-compulsive disorder (OCD) affects approximately 100 million people across the globe.[1] OCD is defined by obsessions and compulsions.[2] Obsessions are intrusive, distressing, and recurring thoughts, and compulsions are repetitive mental acts or behaviors in an attempt to counteract obsessive thoughts.[3] This is a debilitating disease that severely impacts a person's physical, social, emotional functioning and their overall quality of life.[4] An important lifestyle factor that has been associated with OCD symptoms is poor sleep patterns.[5,6]

Previous research studies have noted mixed results in the association between poor sleep patterns and OCD symptoms.[7] Some studies have emphasized that sleep disturbances, sleep latency[8] and daytime dysfunction are higher among individuals with OCD;[9] on the other hand, others have suggested that sleep difficulties are only correlated with obsessions but not with compulsions.[10] A few studies have shown that those who are diagnosed with OCD are more likely to have a delayed sleep onset,[11] reduced total sleep time, and lower sleep efficiency[12] than those without OCD. The U.S National Comorbidity Survey Replication (NCS-R) data from 2,073 patients found that obsessive-compulsive symptoms (OCS) were linked with greater sleep difficulties, even after controlling for depression.[13] A previous network analysis in an U.S. national clinical sample showed that the OCD symptom that connects most strongly to sleep disturbances was having a greater degree of control over obsessions and compulsions.[14] However, current literature is lacking network analyses of sleep disturbances and OCD symptoms in non-clinical samples.

It is important to note that young adulthood (i.e.,17-34 years old) is the period when the onset of most mental health problems occurs.[15] Emerging adulthood is associated with transition to university environment which is accompanied by significant changes in social, academic and financial demands, contributing to the adoption of unhealthy lifestyle behaviors such as irregular sleep patterns.[16,17] Furthermore, young adults are more likely to experience OCD[1] and sleep problems[18] compared to older adults; thus, to inform early interventions, it would be beneficial to understand the interaction between OCD symptoms and sleep disturbances among post-secondary students. Therefore, to identify central symptoms among this population, we used baseline data from the University Students' Lifestyle and Mental Health Study (UNILIFE-M), a

multi-site, global study in first-year post-secondary students. We conducted four types of network analyses: 1) OCD symptoms only, 2) OCD domains, 3) sleep disturbances only and 4) OCD and sleep disturbances.

A few sex differences have also been noted in the literature, such as higher OCD incidence among females in adolescence/adulthood,[19] earlier onset of OCD among males, and more washing and cleaning rituals among females than males.[20] However, sex differences in the association between OCD and poor sleep have not yet been investigated through a network analysis. Thus, we also carried out a Network Comparison Test (NCT) to determine if there is a difference by sex, sexual orientation, or gender identity. We also used the community detection method to identify different clusters of OCD and sleep symptoms. In line with evidence from previous studies,[7–14] we hypothesized that greater severity of sleep disturbances would be associated with higher levels of OCD symptoms and stronger associations between certain OCD symptoms and sleep patterns. To the authors' knowledge, this is the first study to conduct a network analysis examining obsessive-compulsive symptoms and sleep disturbances among post-secondary students.

3.2. Methods

3.2.1. Study design and inclusion criteria

We used partial baseline data from the University Students' Lifestyle and Mental Health Study (UNILIFE-M study).[21] UNILIFE-M is a multicenter cohort study in which first-year post-secondary students were surveyed regarding their lifestyle and mental health patterns. The survey was administered online through REDCap (Research Electronic Data Capture) platform. Students were recruited using a convenience sampling approach that involved social media campaigns, posters on campus, face-to-face recruitment, e-mail invitations, and a study website. The inclusion criteria were as follows: between the ages of 16-35 years old, enrolled in a first-year university/college program in 2023 or 2024, and willing to provide their consent to participate in the survey. Students were surveyed in the first term after their enrollment in their post-secondary career. This was a multi-site study involving students from 22 countries (Austria, Australia, Brazil, Chile, Colombia, Ecuador, Finland, Germany, Greece, Japan, Lebanon, Mexico, Netherlands, New Zealand, Nigeria, Peru, Spain, Suriname, Switzerland, the UK,

Uruguay, and the US). Data presented in this cross-sectional study is based on the baseline assessment following recruitment. However, this is an ongoing study; therefore, we used partial baseline data.

3.2.2. Ethics

Participants provided informed consent before starting the survey. The current study, involving secondary data analyses, received ethical approval from the University of Ottawa Health Sciences Research Ethics Board (H-11-24-10937) in November 2024. In addition, approval to conduct the UNILIFE-M study was obtained from the Ethics Committee of the Federal University of Santa Maria (CAE: 63025822.8.1001.5346). All participating study sites also obtained ethical approval from their respective review boards.

3.2.3. Measures

OCD symptoms

The Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) Cross-Cutting Symptom Measure (CCSM) was used to determine the initial threshold for OCD symptoms. This tool has been shown to be internally consistent and a valid measure of self-reported psychopathology.[22,23] Participants were asked, "During the past two weeks, how much (or how often) have you been bothered by the following problems?" If individuals answered "2-mild/several days" or greater to any of these 2 questions: "Unpleasant thoughts, urges, or images that repeatedly enter your mind" or "Feeling driven to perform certain behaviors or mental acts over and over again" then individuals moved on to complete the Obsessive-Compulsive Inventory-Revised (OCI-R) scale. OCI-R asked the question "How much that experience has distressed or bothered you during the past month?" - with 18 items on the scale. Response options for each item ranged on a Likert scale (0=Not at all, 1= A little, 2= Moderately, 3= A lot, and 4= Extremely). The OCI-R has demonstrated strong psychometric properties, including high internal consistency (Cronbach's α= 0.84-0.88) and good test-retest reliability, as reported in previous validation studies.[24–26] Some OCI-R items included: "I have saved up so many things that they get in the way", "I check things more often than necessary" and "I get upset if objects are not arranged properly." The total score from all items was summed up, ranging from 0 to 72, with higher scores indicating greater severity of OCD symptoms.[27] The OCI-R scores were classified as mild (0 to 15), moderate (16

to 27), and severe (≥ 28).[28] For purposes of descriptive characteristics of the sample, those who did not meet the DSM-5 Self-Rated Cross-Cutting Symptom Measure (CCSM) for OCD symptoms were assigned a score of 0, however, in the network analyses, these individuals were excluded.

Sleep disturbances

Similarly, the DSM-5 Self-Rated Cross-Cutting Symptom Measure (CCSM) was utilized to determine the threshold for sleep disturbances.[22] Participants were asked, "During the past two weeks, how much (or how often) have you been bothered by the following problems?" If individuals rated themselves at least "2- mild/ several days" or greater to the question: "Problems with sleep that affected your sleep quality overall" then they moved on to complete the Pittsburgh Sleep Quality Index (PSQI). This ordinal scale consists of 19 self-reported questions assessing 7 domains (sleep quality, sleep latency, average sleep duration, habitual sleep efficiency, sleep disturbances, sleeping medication use and daytime dysfunction). Although initially planned to use the entire PSQI scale, our survey only included 9 items - 1 item from 'Sleep Latency' domain and 8 items from 'Sleep Disturbances' domain of the PSQI scale.[29] The PSQI survey asked "5). During the past month, how often have you had trouble sleeping because you: a). cannot sleep within 30 minutes, b). wake up in the middle of the night or early morning, c). have to get up to use the bathroom, d). cannot breathe comfortably, e). cough or snore loudly, f). feel too cold, g). feel too hot, h). have bad dreams, and i). have pain." Response options for each item ranged from 0 (not during the past month), 1 (less than once a week), 2 (once or twice a week), or 3 (three or more times a week). To determine the PSQI Sleep Disturbances score, we calculated the sum of the sleep disturbances' domain only (5b-5i) for a total score ranging from 0 to 27- no difficulty (0), mild difficulty (1-9), moderate difficulty (10-18) or severe difficulty (19-27). For purposes of descriptive characteristics of the sample, those who did not meet the DSM-5 Self-Rated Cross-Cutting Symptom Measure (CCSM) for sleep problems were assigned a score of 0, however, in the network analyses, these individuals were excluded.

3.2.4. Data analytic plan

For the network analysis, the Markov Random Field (PMRF) method, specifically, the Gaussian Graphical Model (GGM) with polychoric correlations, was implemented for ordinal data.[30]

These networks were visually made using the *qgraph* statistical package in R Studio.[31] A network consists of nodes that are connected to each other via edges, without implying any directionality- positively correlated edges were in blue, negatively correlated edges were in red, and stronger correlations were represented by thicker lines. Partial correlation method was implemented- this is when the edges between two nodes are often adjusted for all other variables in the model, known as the conditional independent association. Partial correlation networks depicted the association between the two variables; but, if the independent and dependent variables were not correlated, no edge (i.e. connecting line) was drawn between the nodes. Regularized partial correlation accounted for all relations among other symptoms in the model, while shrinking relations among spurious symptoms- this has been noted to optimize node detection and increase the overall sensitivity.

The Extended Bayesian Information Criterion (EBIC) model selection was used to assess model fit.[32] This algorithm applied a penalty, known as LASSO (Least Absolute Shrinkage and Selection Operator), to the matrix. LASSO is considered to be very sensitive in detecting edges and pulls the weak edges to zero. This is a regularization technique that penalizes the sum of regression weights, and if an edge is insignificant, then it shrinks to zero. The EBIC tuning parameter was set to 0.5. The EBIC glasso function was used as it performs better in reducing the chance of spurious correlations (i.e., false positives). The layout "spring" was used to obtain the network. The correlation method was set to "*cor_auto"* which used polychoric and polyserial correlations- appropriate for ordinal data. The cutoff was set to 0.15, which suggests that absolute weights above this value would have the greatest width and color intensity, whereas edges below this value would have smaller width and weaker color intensity. The minimum edge weight was set to zero, and maximum edge weight was set to 1.

Centrality was estimated using node strength. Symptoms that are highly central in the network have a more influential effect on other nodes in the network. Network stability was tested using the *bootnet* package in R. The Correlation-Stability (CS) coefficient was calculated, which indicates the maximum proportion of the sample that can be dropped to still endure a correlation of 0.7 in at least 95% of the sample. Previous literature has suggested a reasonable CS coefficient to be above 0.5.[33] Bootstrapped difference test of node strength centrality was also conducted,

where the strength centrality values are plotted diagonally. Gray boxes depicted a non-significant difference between two nodes and black boxes indicated a significant difference between two nodes. To estimate edge-weight accuracy, 95% confidence intervals were obtained by non-parametric bootstrapping (boots =1000).

Four types of analyses were conducted: 1) nodes were OCI-R individual items on the scale (i.e. 18 items of OCI-R), 2) OCI-R composite sub-scales were used as nodes (i.e. six domains in OCI-R), 3) nodes were PSQI Component 5 items (i.e. 9 items of PSQI Component 5), and 4) all OCI-R and PSQI items were plotted together in a network. Participants who met the cut-off for OCD symptoms were included in the first and second analyses, those who met the threshold for sleep disturbances were included in the third analysis and those who met the cut-off for both OCD and sleep disturbances were included in the fourth analysis (i.e., composite network). Statistical significance was defined at alpha 0.05. All analyses were conducted in R Studio.

We examined community networks among OCD symptoms and sleep disturbances. A community is a cluster of nodes that are highly associated with each other. Communities were detected using the *spinglass* algorithm and the *igraph* package in R, which penalizes the edges between communities and rewards edges within a community.[34] This algorithm allowed a node to be part of only one community. We then employed the Clique Percolation Method (CPM), using the *CliquePercolation* package in R.[35] We optimized *I* and *k*, where *I* represents the strength of relationship among nodes in a community and *k* represents the minimum size of the community. Clique Percolation needs *k* to be at least 3 and we optimized *I* so that an average partial correlation of 0.20 would seem large- resulted in an optimal value of *I* to be 0.08. This method helped detect overlapping communities (i.e. one node can be part of more than one community, if a circle was split in half, then that node was assigned to 2 communities).

Subgroup analyses

A Network Comparison Test (NCT) is a permutation test, which is used to compare two networks based on their strength invariance, edge invariance, and centrality measures.[36] We conducted network comparison tests to compare sub-samples by sex[37], sexual orientation[38], and gender identity.[39] Although initially planned to carry out other subgroup analyses (i.e. marital

status, age, work and pregnancy status), we found a relatively homogenous population, as this was a post-secondary cohort of students who were between a certain age group (16-35 years old) and were not married, pregnant or working.

Handling missing data

Less than 10% missing data for OCI-R and PSQI items. However, as a sensitivity analysis, multiple imputation was carried out using the *mice* package in R, with 10 iterations and 10 imputations.[40] In the scientific literature, there are many established ways of choosing an imputed dataset, [41] but our approach involved comparing the mean of the OCI-R score in the original sample to the mean of the OCI-R score in the imputed dataset and then selected the most plausible dataset. There was no difference in the overall global strength nor the network invariance test, as both tests were non-significant for the OCD and sleep disturbances' network (p-value >0.05). Hence, the analyses presented in this study were carried out using listwise deletion.

3.3. Results

3.3.1. Descriptive data

The sample consisted of 18,434 post-secondary students. Among them, 7,174 (38.9%) met the initial threshold of DSM-5 Self-Rated Cross-Cutting Symptom Measure for OCD symptoms and 7,514 (40.8%) met the initial threshold of DSM-5 Self-Rated Cross-Cutting Symptom Measure for sleep disturbances. The sub-sample that met the threshold for both OCD symptoms and sleep disturbances were 4,477 (24.3%) and 13,957 (75.7%) did not meet both the thresholds. In the sub-sample of 4,777 participants, the mean OCI-R score was 26.7, and the mean PSQI Sleep Disturbances domain score was 9.4.

To compare participant characteristics between the sample that did not meet both the thresholds for OCD symptoms and sleep disturbances (N= 13,957) and sub-sample that met both initial thresholds (N= 4,477), effect sizes and p-values were calculated. Those who met the initial threshold for both OCD symptoms and sleep disturbances were less likely to identify as heterosexual, less likely to reside in North America, more likely to reside in South America and score higher on OCI-R and PSQI Sleep Disturbances Domain. These results were statistically

significant at alpha 0.05, with effect sizes above 0.20 and p-value <0.05. No statistically significant difference (i.e., effect sizes below 0.20 and p-value >0.05) was found in terms of sex, age, gender identity, marital status, BMI, pregnancy status or work status (see Table 1).

3.3.2. OCD symptoms

OCI-R scale- 18 items as nodes

Figure 1A shows the network analysis of OCD symptoms (n=6,493). Figure 1B shows the strength centrality plot. Based on this plot, the most central symptoms were- need things to be arranged in a particular way (Strength Centrality (SC)=1.56) and get upset by unpleasant thoughts (SC=1.37). Figure 1B shows the expected influence plot. This plot takes into account both positive and negative edges. Based on this plot, the most important symptoms were: get upset by unpleasant thoughts (think_unpleasant: Expected Influence= 1.19), need things to be arranged in a particular way (stuff_be_tidy: Expected Influence= 1.67) and repeatedly check doors, windows and drawers, etc. (check_repeatedly: Expected Influence=1.34).

Figure 1C shows the stability of strength centrality measure. The Correlation-Stability (CS) coefficient was 0.75, indicating good network stability. Figure 1D shows the bootstrapped difference test of node strength centrality. The gray boxes indicate there is no significant difference between two nodes and black boxes indicate there is a significant difference. When central symptoms were compared to each other (unpleasant thoughts and arranging things), using this plot, they were not significantly different from one another. However, when “arranging things” was compared to “checking repeatedly” they were significantly different from one another. This plot suggests that arranging things and unpleasant thoughts may be more central symptoms than the “checking repeatedly” symptom. Figure 1E depicts the bootstrapped confidence intervals of the estimated edge-weights.

OCI-R scale- 6 domains as nodes

Figure 2A shows the network analysis of OCD domains (n=6,657). There were only positive edges, i.e., positive correlations among nodes. There was no obvious strong association observed between the nodes, indicated by the relatively moderate edge width between all domains. Figure 2B shows the strength centrality plot of OCD domains. Based on this plot, the most central

symptoms were checking (SC=0.77), ordering (SC=0.77), and neutralizing (SC=0.80). Figure 2B also shows the expected influence plot. This plot looks exactly the same as the strength centrality plot because there were no negative edges in this network, thus, strength and expected influence are the same. Figure 2C shows the stability of strength centrality measure. The CS-coefficient was 0.75, indicating good network stability. Figure 2D shows the bootstrapped difference test of node strength centrality. When central symptoms were compared to each other, using this plot, they were not significantly different from one another. This suggests that all three central nodes have equal importance in this network. Figure 2E shows the bootstrapped confidence intervals of the estimated edge-weights.

3.3.3. PSQI Component 5 score

Figure 3A shows the network analysis of sleep symptoms (n=7,008). Unlike OCD symptoms, there was no clustering of nodes observed. Figure 3B shows the strength centrality plot of the PSQI Component 5 Score. Based on this plot, the most central symptoms were- having pain (SC=1.54) and not being able to breathe comfortably (SC=1.21). Figure 3B also shows the expected influence plot. This plot looks exactly the same as the strength centrality plot because there were no negative edges in this network, thus, strength and expected influence are the same. Figure 3C shows the stability of strength centrality measure. The CS-coefficient was 0.75, indicating good network stability. Figure 3D shows the bootstrapped difference test of node strength centrality. When central symptoms were compared to each other, using this plot, they were not significantly different from one another. This suggests that both the central nodes have equal importance in this network. Figure 3E depicts the bootstrapped confidence intervals of the estimated edge-weights.

3.3.4. OCD symptoms and PSQI Component 5 score

Figure 4A shows the network analysis of OCD symptoms and PSQI Component 5 symptoms (n=3,991). The majority of the edges indicated a positive correlation between OCD and sleep disturbances. Among the OCD symptoms, there was a clustering of a few nodes, but not among the sleep symptoms. Figure 4B shows the bridge strength centrality plot of OCD symptoms and PSQI Component 5 Score. The OCD symptom with the highest bridge strength was- need things to be arranged in a particular way (bridge strength= 0.80). The PSQI symptom with the highest

bridge strength was- having bad dreams at night (bridge strength=0.10). Figure 4B also shows the bridge expected influence plot. In this plot, need things to be arranged in a particular way had an expected influence of 0.74 and having bad dreams had an expected influence of 0.10. This plot looked very similar to the bridge strength centrality plot because there were minimal negative edges in this network, thus, strength and expected influence were very similar. Figure 4C shows the stability of strength centrality measure. The CS-coefficient was 0.75, indicating good network stability. Figure 4D shows the bootstrapped difference test of bridge strength centrality. When central symptoms were compared to each other, using this plot, they were significantly different from one another. The OCD symptom of arranging things had a higher bridge strength than the PSQI symptom of bad dreams. Figure 4E shows the bootstrapped confidence intervals of the estimated edge-weights.

3.3.5. Community detection- OCD symptoms and PSQI Component 5 Score

Figure 5 shows the communities between OCD symptoms and PSQI Component Score 5. Based on the *spinglass* algorithm, seven communities were found: six communities were OCD symptoms and 1 community was the PSQI Component 5 Score symptoms. These six OCD communities aligned with the six OCD domains: hoarding, checking, ordering, neutralizing, washing, and obsessing.

Figure 5 also shows the Clique Percolation Method (CPM) between OCD and PSQI Component 5 Score symptoms. The 8^{th} node (having bad dreams) was split into two, which suggests that it belonged to both the PSQI sleep symptoms community and the OCD symptoms community. This was likely because the 8^{th} node (i.e., having bad dreams) was connected to two OCD symptoms- node 15 (i.e., difficult to control their thoughts) (r=0.30, partial correlation= 0.07), and node 21 (i.e., get upset by unpleasant thoughts that come into their mind against their will) (r=0.30, partial correlation=0.07).

3.3.6. Subgroup analyses

Figure 6 shows NCT by sex, the average strength of all nodes was greater among females (global strength= 11.68) than males (global strength= 10.91), with a global strength statistic of S=0.78, p-value= 0.01. No difference was found in network invariance (p-value= 0.29). This suggests

that there was a variation in the weighted absolute sum of all edges in the network. However, the difference in the individual edges was small, due to the non-significant network invariance test. The central OCD symptoms were the same for both groups, however, the central sleep symptoms differed. In females, not being able to breathe comfortably at night was a central symptom, along with having bad dreams, while for males, having bad dreams was central. Other NCT analyses conducted by sexual orientation, and gender identity showed that both the global strength test and network invariance were non-significant (p-value >0.05).

3.4. Discussion

This study was unique as it was the first to explore OCD symptoms and sleep disturbances through a network analysis in a global, post-secondary student cohort with supra-threshold OCD and sleep symptoms. In line with our hypothesis, we observed a positive correlation between OCD symptoms and sleep disturbances. In this large sample of post-secondary students from 22 countries, those who met the initial threshold (i.e., DSM-5 Self-Rated Cross Cutting Symptom Measure) for OCD symptoms and sleep disturbances scored moderately on OCI-R scores, and mildly on the PSQI Sleep Disturbances domain. In this sub-sample, we found certain OCD symptoms to be more central than others, such as ordering, checking and feeling upset by unpleasant thoughts. Similarly, a few sleep disturbances were noted to be particularly important, such as having breathing difficulties and pain during sleep. Contrary to our hypothesis, sleep disturbances were weakly correlated to OCD symptoms, as CPM showed that bad dreams were slightly associated with unpleasant thoughts.

In a network analysis, central symptoms are those that have the most connections with other nodes and activate other nodes; thus, by targeting these central symptoms (i.e., ordering, checking, bad dreams and unpleasant thoughts) with interventions, we might affect greater changes in other nodes as well.[42] Results are particularly important for the well-being of students who have OCD or poor sleep symptoms, and can inform care in this population, but might not be generalizable to the general population or other age groups.

In both the OCD network and the sleep disturbances and OCD composite network, a central OCD symptom was ordering things in a particular way. Previous research has noted that individuals with symmetry/ordering OCD symptoms have a higher likelihood of earlier age onset of OCD [43], more severe symptoms [44], greater comorbidity with other psychiatric disorders, and even suicidal thoughts.[45] Furthermore, in the *spinglass* community network, this symptom clustered together with two other OCD symptoms (i.e., getting upset if things are not arranged properly and getting upset if others change the way they have arranged things) and formed the ordering community. Furthermore, in the OCD network, another symptom that was noted to have a high expected influence was repeatedly checking doors, windows, drawers, etc. Checking is a type of reassurance-seeking behavior that has been noted to be a common compulsion for OCD.[46] Individuals engage in intensive checking as a coping mechanism to avoid harm and decrease uncertainty.[47–49] However, checking can lead to memory distrust because more they check, the less certain they feel that they have checked properly. Consequently, they become part of a vicious cycle of repeated checking, increased uncertainty and significant distress. In the spinglass network, this symptom also clustered together with 2 other OCD symptoms (i.e., check things more often than necessary and repeatedly check gas, water taps, and light switches after turning them off) to form the "checking" community. Thus, these OCD domains of checking and ordering may be valuable targets for intervention in post-secondary student populations.

In the sleep disturbances and OCD composite network, the sleep symptom with the highest bridge strength was having bad dreams. Nightmares have been linked to higher psychological distress, including in borderline personality disorders [50] and psychosis.[51] A meta-analysis found that treating nightmares may lead to a small to moderate reduction in anxiety symptoms (i.e. phobia, generalized anxiety, OCD).[52] However, other studies have noted that there was no difference in dream content among those with OCD compared to controls.[53] In terms of the CPM, we found that bad dreams was associated with two OCD symptoms- difficulty controlling thoughts and feeling upset by unpleasant thoughts. This is reasonable as individuals with OCD who suppress their unwanted, unpleasant thoughts are more likely to have vivid dreams about their fears.[54] Previous network analyses on obsessive-compulsive symptoms have also shown that negative appraisals of intrusive thoughts and distress related to obsessions were central symptoms.[55] This was similar to our finding of the OCD symptom of unpleasant thoughts to be

most strongly connected to the sleep disturbance of bad dreams, however, more research is needed to investigate the link between nightmares and obsessive-thoughts.

In terms of the *spinglass* community detection method, we found one sleep disturbances' domain and six OCD domains. There was no clustering found in the sleep disturbance symptoms, which may suggest that there was less similarity between any sleep disturbances nodes. However, among the OCD nodes, we found the same six clusters as previous confirmatory analyses of the OCI-R scale (washing, hoarding, ordering, neutralizing, obsessing, and checking).[56–58] This indicates good convergent and discriminant validity of the OCI-R scale in our sample.

The network comparison test by sex indicated a higher connectedness among nodes (i.e., greater global strength) in the female network. Female young adults have higher odds of experiencing poor sleep quality than their male counterparts.[59] This may suggest a more holistic treatment approach considering different aspects of sleep disturbance among females than males. One of the central sleep symptoms among females was breathing difficulties, but not among males. Previous studies have suggested that males are at a higher risk of developing breathing difficulties such as obstructive sleep apnea (OSA), however, females with breathing difficulties are more likely to develop mental health disorders, such as anxiety, than their male counterparts.[60,61] Thus, treatment interventions may focus on different components of sleep disturbance among females with OCD symptoms, compared to males.

Limitations

This study presented some limitations. For example, the self-reported questionnaires may have been prone to recall bias, as individuals might have miscalculated their frequency of sleep difficulties and OCD symptoms. Another limitation is the possibility of selection bias as students with mental health problems may have been overrepresented in this sample, as they have had a particular interest in the topics of the survey. Furthermore, a few regions may have been overrepresented in this sample (e.g. 47% participants from South America). The utilization of cross-sectional data was also a limitation as we cannot determine the direction of association between OCD symptoms and sleep disturbances. Furthermore, there may be ethnic variation in the sample. However, we could not account for ethnicity in our network analyses due to the

significant heterogeneity presented by including participants from different ethnic backgrounds. Another limitation was the use of partial PSQI scale; only 8 sleep disturbances items and 1 sleep latency item were included. Finally, we only analyzed data from those students with supra-threshold symptoms of OCD and sleep. Despite these limitations, this study involved the use of validated questionnaires with good psychometric properties [62,27] and collected various sociodemographic variables from a large, diverse sample of post-secondary students- therefore, potentially representing transculturally valid models.

3.5. Conclusion

Overall, our results supported previous research that OCD symptoms and sleep disturbances are positively correlated. We identified certain OCD symptoms and sleep disturbances that were more central than others, such as ordering, checking unpleasant thoughts, and nightmares. We also noted a weak association between nightmares and unpleasant thoughts. Findings from this study indicate the need of targeting these central symptoms through psychoeducational interventions among post-secondary students.

Tables/Figures

Table 1. Sociodemographic characteristics of post-secondary students

Participant Characteristics	Did not meet threshold for both OCD symptoms and sleep disturbances (n=13,957)	Met threshold for both OCD symptoms and sleep disturbances (n=4,477)	Effect size (p-value)
Sex, n (%)			
Female	11,645 (65.80%)	3,077 (70.56%)	0.10 (<0.05)
Gender Identity, n (%)[+]			
Cisgender	12,797 (97.32%)	4,054 (93.78%)	0.18 (<0.05)
Sexual Orientation, n (%)[+]			
Heterosexual	10,015 (75.91%)	2,602 (60.25%)	**0.34 (<0.05)**
Region, n (%)			
South America	6,109 (43.70%)	2,579 (57.61%)	**0.27 (<0.05)**
Europe	4,432 (31.75%)	1,240 (27.70%)	0.09 (<0.05)
North America	1,384 (9.92%)	191 (4.27%)	**0.22 (<0.05)**
Oceania	1,126 (8.07%)	341 (7.62%)	0.02 (>0.05)
Asia and Africa	906 (6.49%)	126 (2.81%)	0.18 (<0.05)
Working status, n (%)			
No	10,165 (76.29%)	3,260 (74.62%)	0.04 (>0.05)
Pregnant, n (%)			
No	8,493 (99.78%)	3,028 (99.77%)	0.01 (>0.05)
Ethnicity, n (%)*			
Caucasian	4,842 (44.79%)	1,630 (46.43%)	0.03 (>0.05)
Hispanic/East Asian/ South Asian/Middle-Eastern	2,812 (26.01%)	989 (28.17%)	0.05 (<0.05)
African American/ Northern or Sub-Saharan African	996 (9.21%)	386 (11.00%)	0.06 (<0.05)
Indigenous	297 (2.75%)	80 (2.28%)	0.03 (>0.05)
Other/Mixed	1,864 (17.24%)	426 (12.13%)	0.14 (<0.05)

Marital Status, n (%)			
Single	11,339 (85.06%)	3,762 (86.23%)	0.03 (>0.05)
Clinical Diagnosis of OCD, n (%)			
Yes	123 (0.94%)	117 (2.69%)	0.18 (<0.05)
Age, Mean [S.D]	19.86 [3.15]	20.04 [3.21]	0.06 (<0.05)
BMI, Mean [S.D]	22.89 [4.30]	23.45 [5.02]	0.12 (<0.05)
PSQI Sleep Disturbances Domain score, Mean [S.D]**	1.56 [3.54]	9.40 [4.89]	**1.82 (<0.05)**
OCI-R Score, Mean [S.D]**	1.78 [7.26]	26.72 [13.75]	**2.69 (<0.05)**

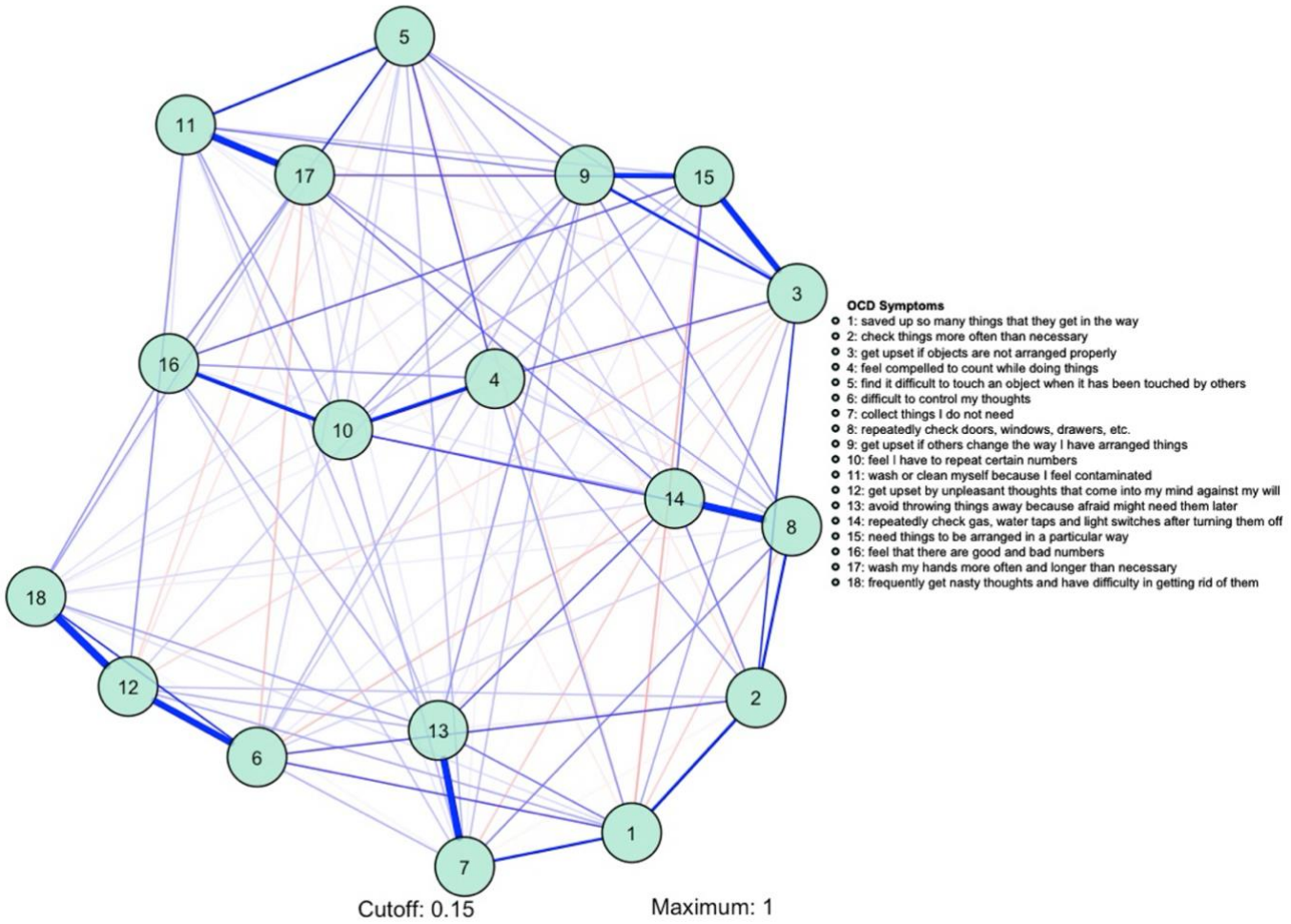
Abbreviations: Number (n), Standard Deviation (S.D), Body Mass Index (BMI), Pittsburgh Sleep Quality Index (PSQI), Obsessive-Compulsive Inventory Revised (OCI-R)

+Both sexual orientation and gender identity were not reported from Lebanon

*22% missing data for ethnicity- it was not reported from Netherlands, Germany, Austria, Switzerland, Lebanon, Mexico and Finland.<10% missing data for other covariates.

**PSQI scores were reported from those who met the DSM-5 Self-Rated Cross-Cutting Symptom Measure for sleep problems and OCI-R scores were reported from those who met the DSM-5 Self-Rated Cross-Cutting Symptom Measure for OCD symptoms. If they did not meet the threshold, they were assigned a score of 0.

Figure 1A. Network analysis of Obsessive-Compulsive Disorder symptoms (i.e., Obsessive-Compulsive Inventory Revised Scale- 18 items as nodes). EBIC tuning parameter 0.5.



Legend: Extended Bayesian Information Criterion (EBIC) and Obsessive-Compulsive Disorder (OCD)

Figure 1B. Strength centrality plot and expected influence plot of OCD symptoms

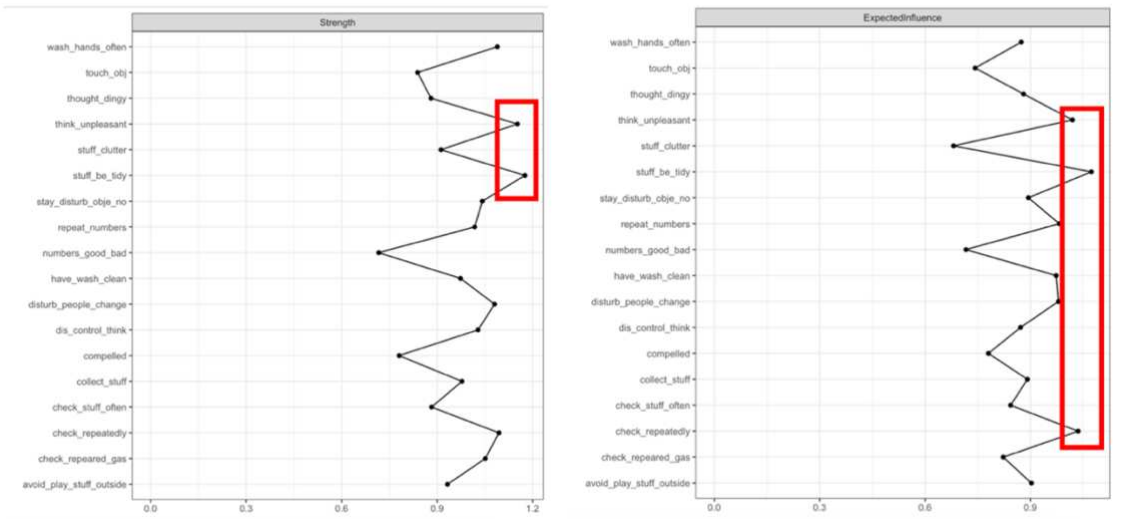


Figure 1C. Stability of strength centrality measure of OCD symptoms

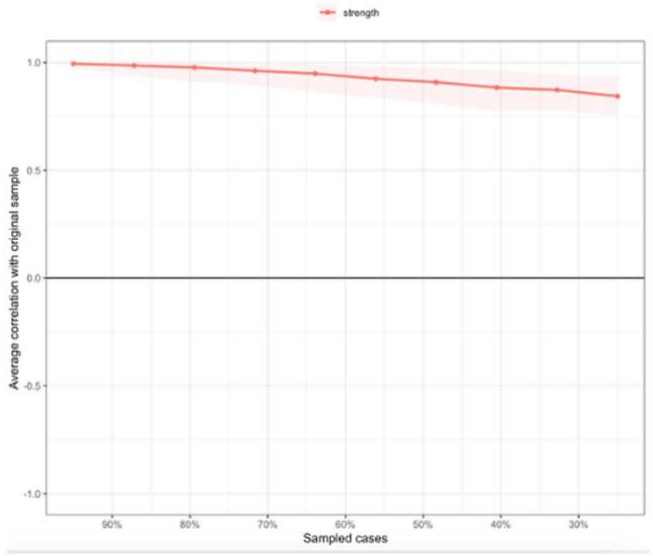


Figure 1D. Bootstrapped difference test of node strength centrality- OCD symptoms

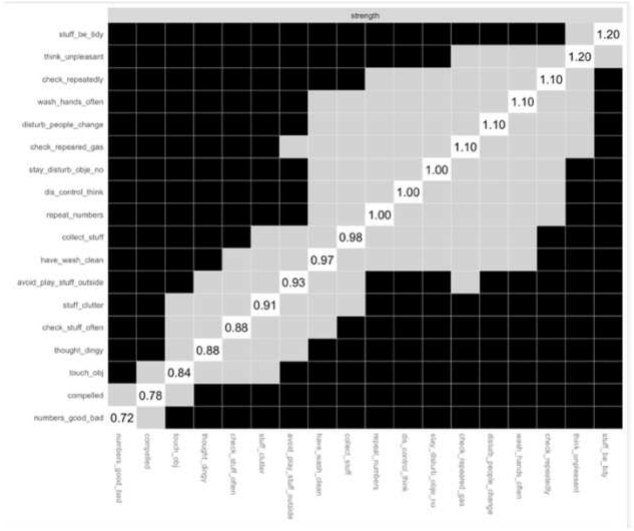


Figure 1E. Bootstrapped confidence intervals for estimated edge-weights- OCD symptoms network

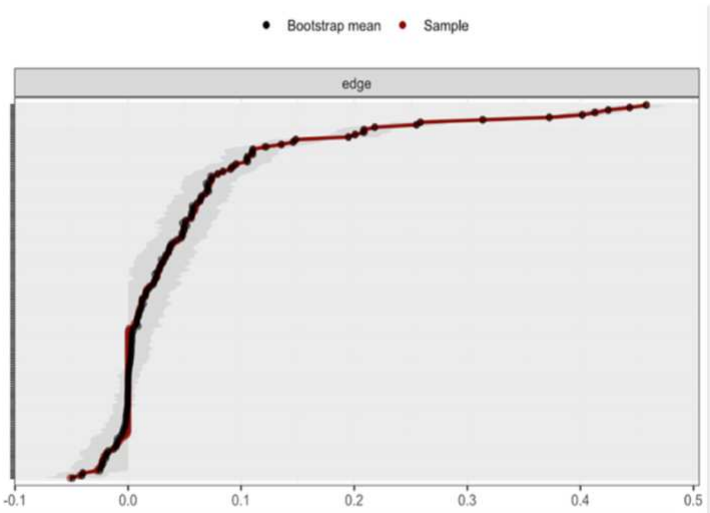
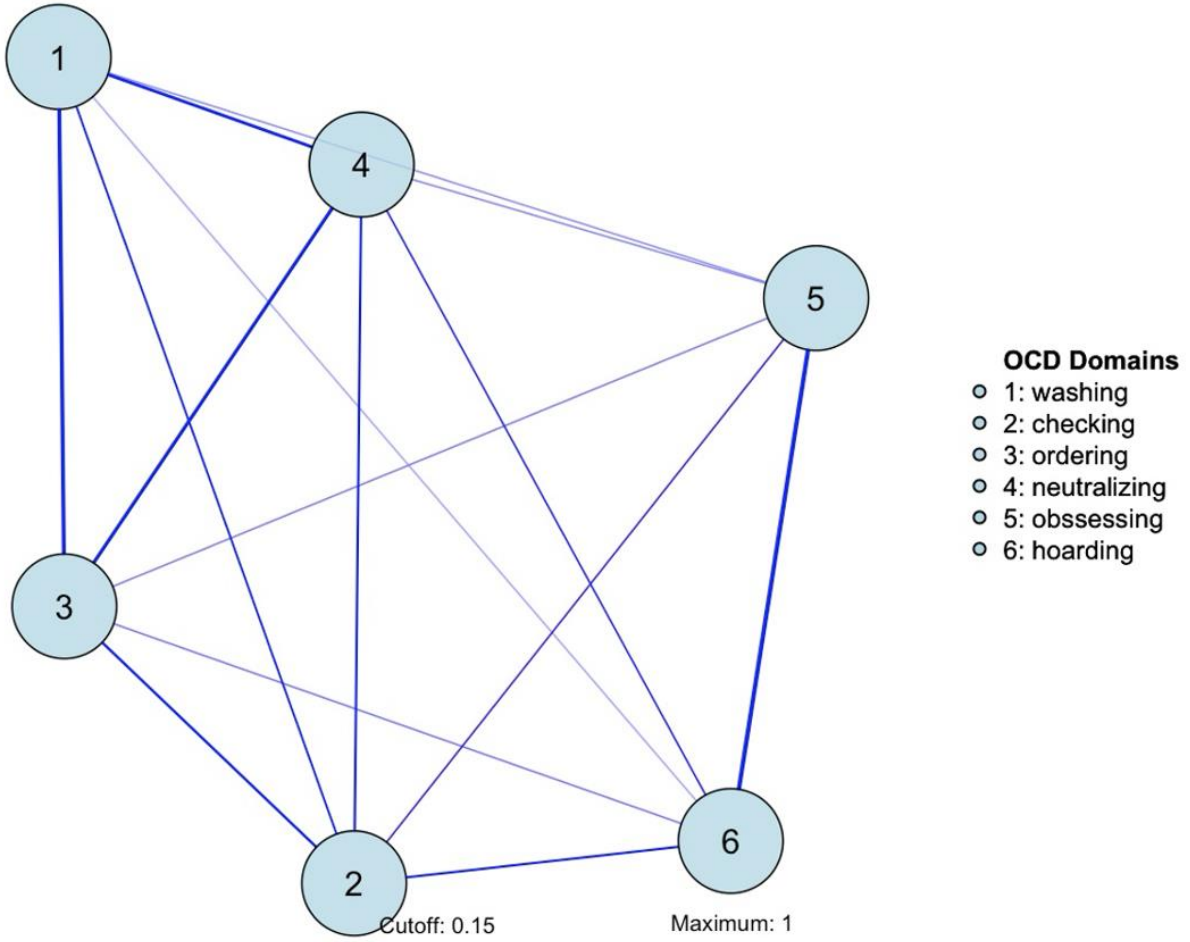


Figure 2A. Network analysis of Obsessive-Compulsive Disorder domains (i.e., Obsessive-Compulsive Inventory Revised- 6 domains as nodes). EBIC tuning parameter 0.5.



Legend: Extended Bayesian Information Criterion (EBIC) and Obsessive-Compulsive Disorder (OCD)

Figure 2B. Strength centrality plot and expected influence plot of OCD domains

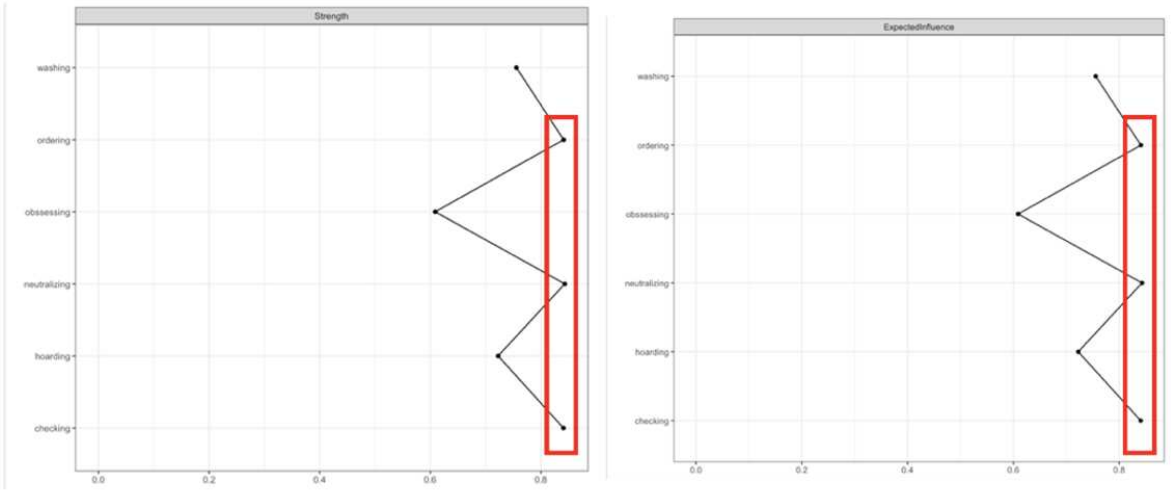


Figure 2C. Stability of strength centrality measure of OCD domains

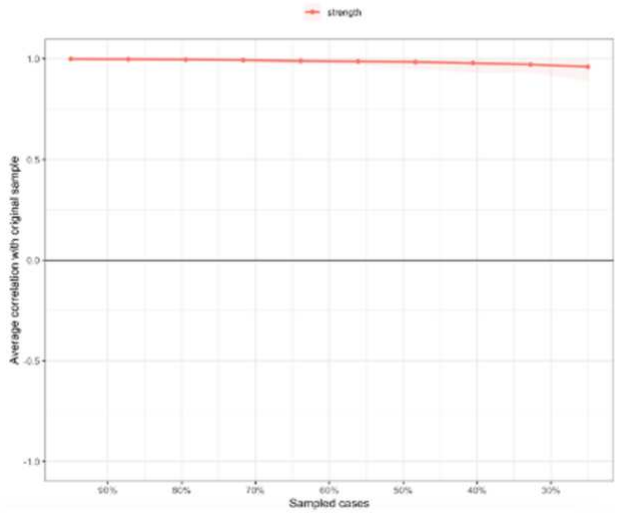


Figure 2D. Bootstrapped difference test of node strength centrality- OCD domains

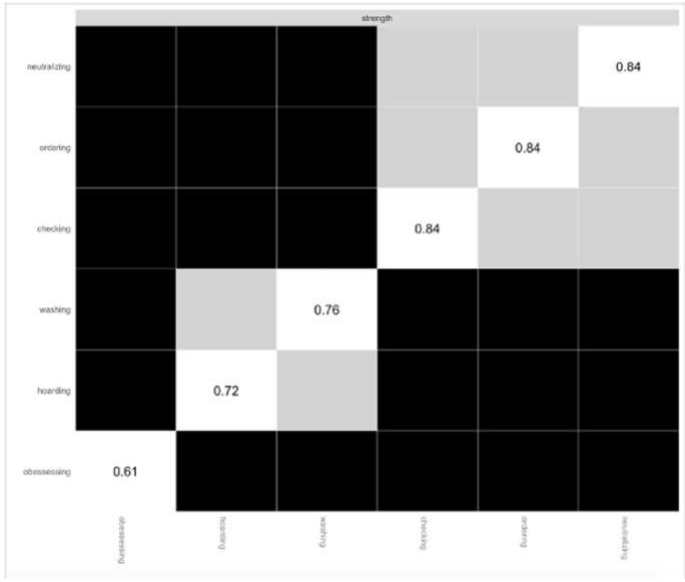


Figure 2E. Bootstrapped confidence intervals for estimated edge-weights- OCD domains network

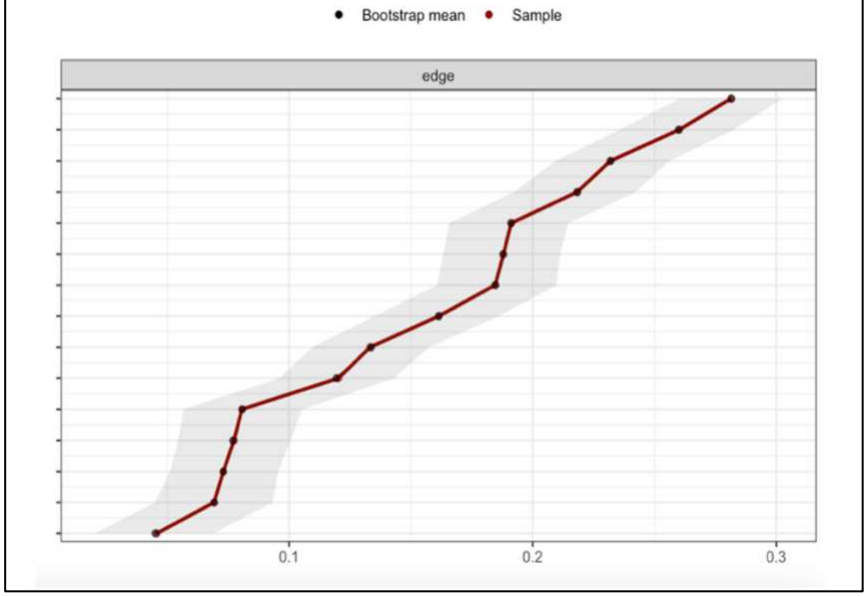
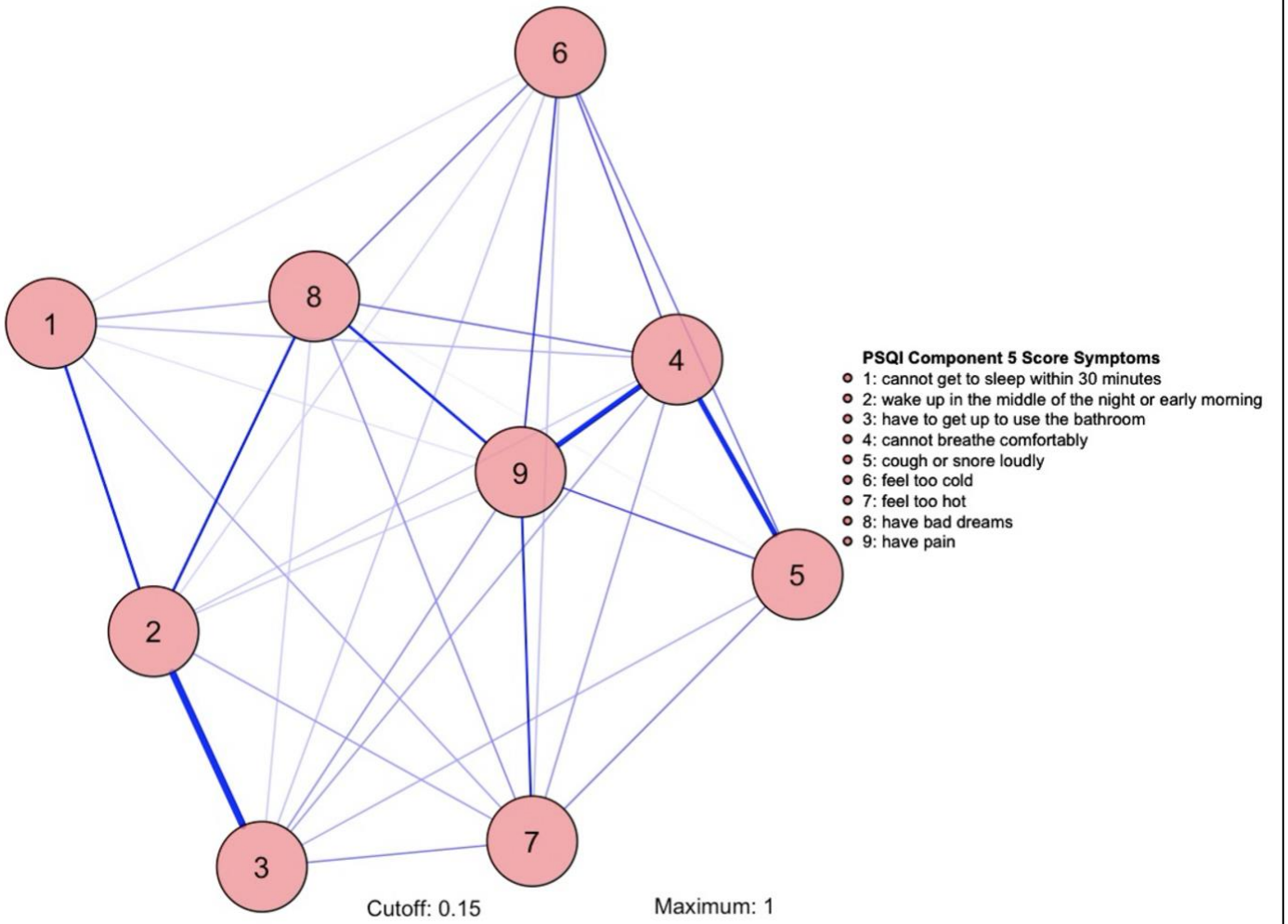


Figure 3A. Network analysis of PSQI Component 5 Score symptoms (i.e., Pittsburgh Sleep Quality Index- 1 sleep latency item and 8 sleep disturbances items). EBIC tuning parameter 0.5.



Legend: Extended Bayesian Information Criterion (EBIC) and Obsessive-Compulsive Disorder (OCD)

Figure 3B. Strength centrality plot and expected influence plot of PSQI Component 5 Score symptoms

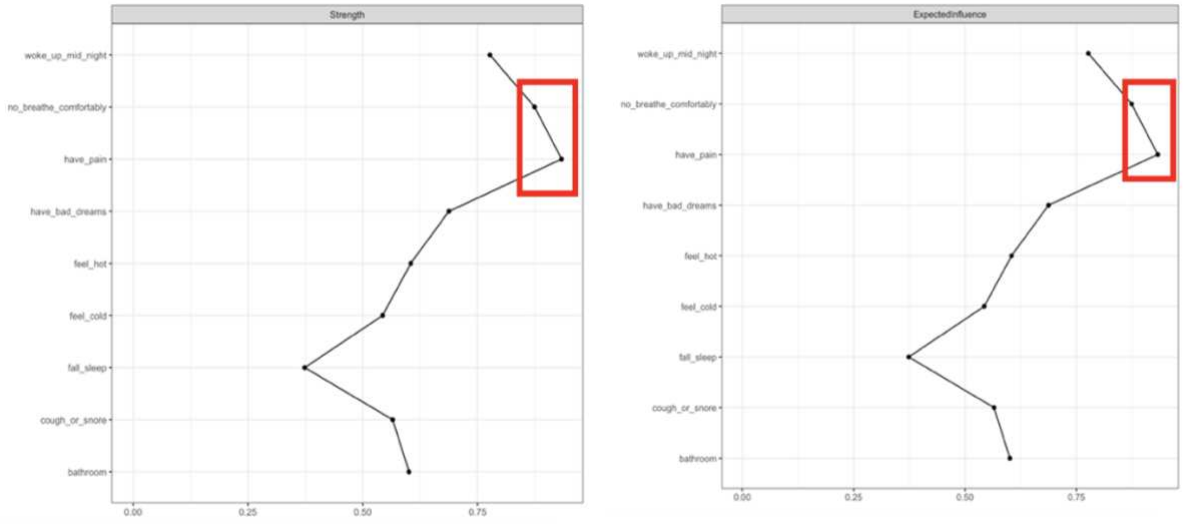


Figure 3C. Stability of strength centrality measure of PSQI Component 5 Score symptoms

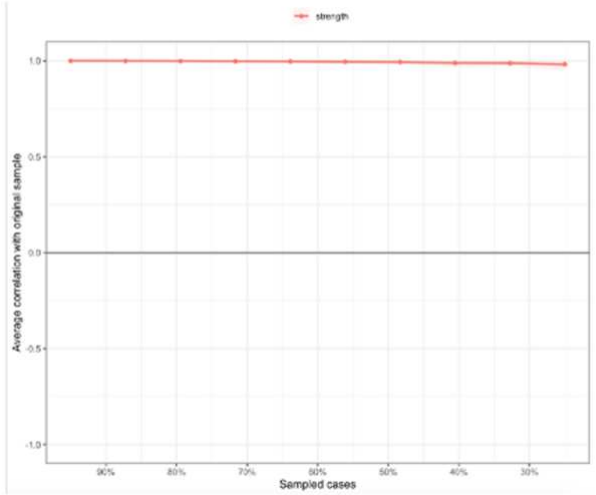


Figure 3D. Bootstrapped difference test of node strength centrality- PSQI Component 5 Score symptoms

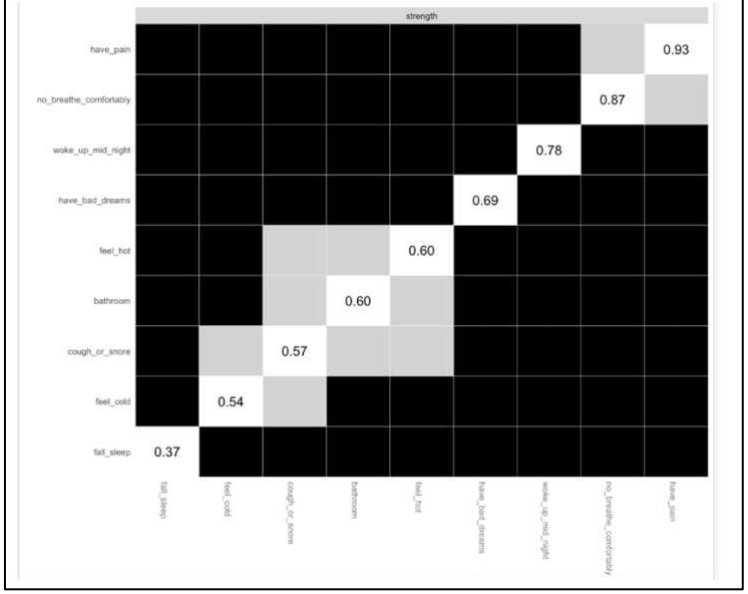


Figure 3E. Bootstrapped confidence intervals for estimated edge-weights- PSQI Component 5 Score network

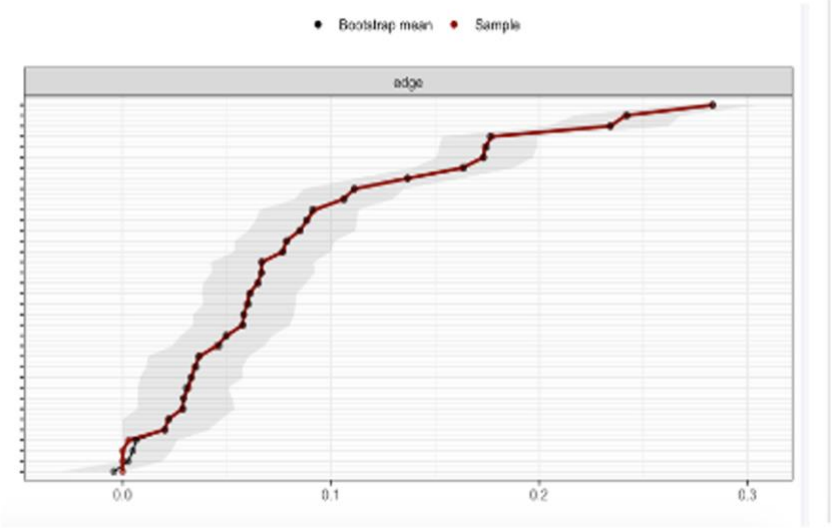
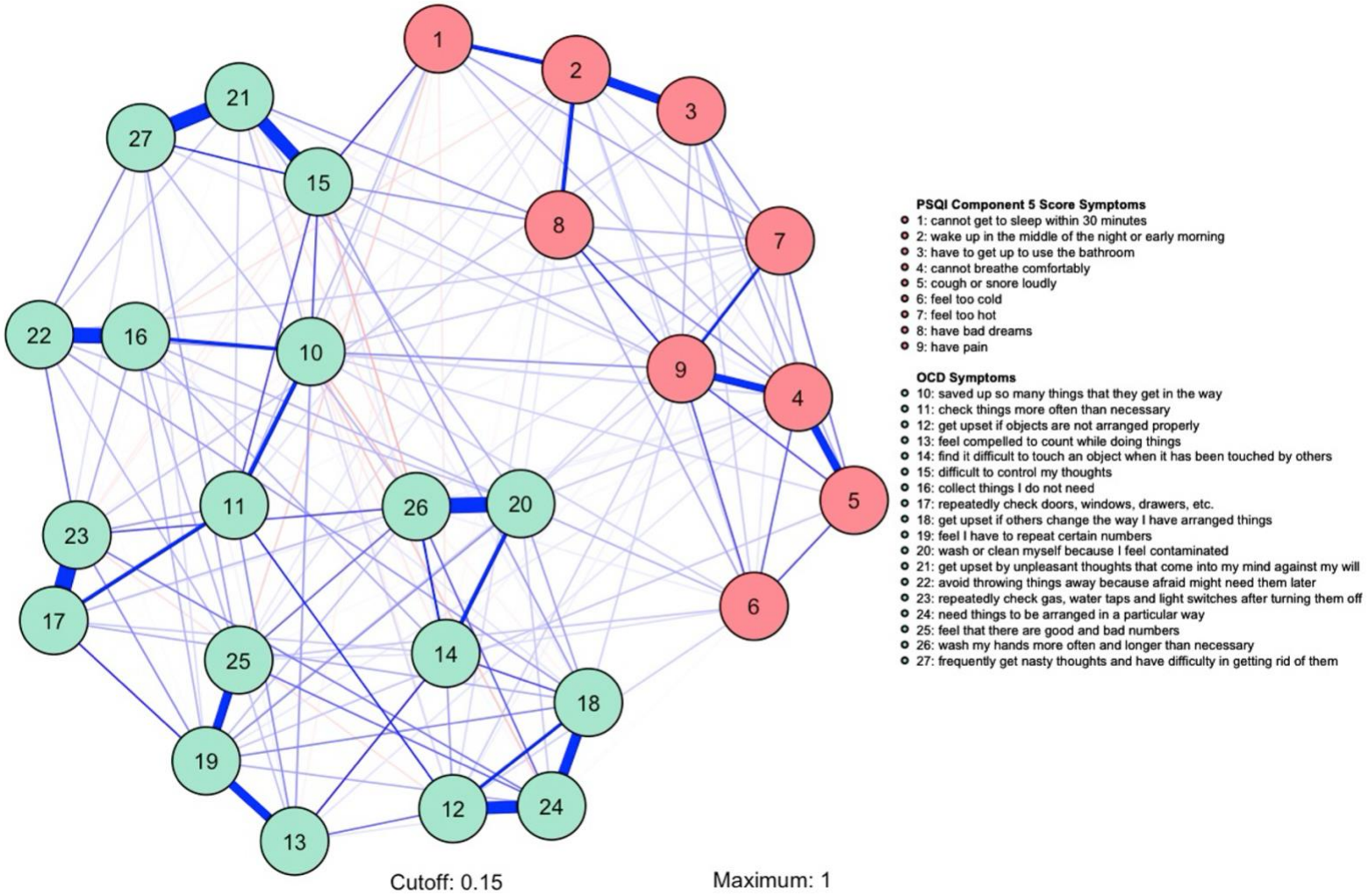


Figure 4A. Network analysis of Obsessive-Compulsive Disorder symptoms (i.e., Obsessive-Compulsive Inventory Revised Scale- 18 items as nodes) and PSQI Component 5 Score symptoms (i.e., Pittsburgh Sleep Quality Index- 1 sleep latency item and 8 sleep disturbances items). EBIC tuning parameter 0.5.



Legend: Extended Bayesian Information Criterion (EBIC) and Obsessive-Compulsive Disorder (OCD)

Figure 4B. Strength centrality plot and expected influence plot of OCD symptoms and PSQI Component 5 Score symptoms

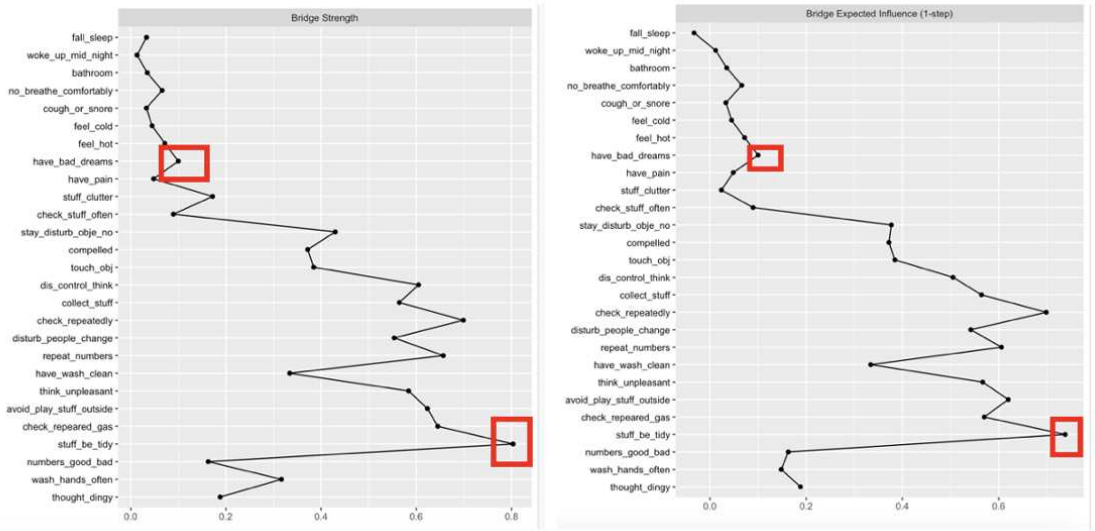


Figure 4C. Stability of strength centrality measure of OCD symptoms and PSQI Component 5 Score symptoms

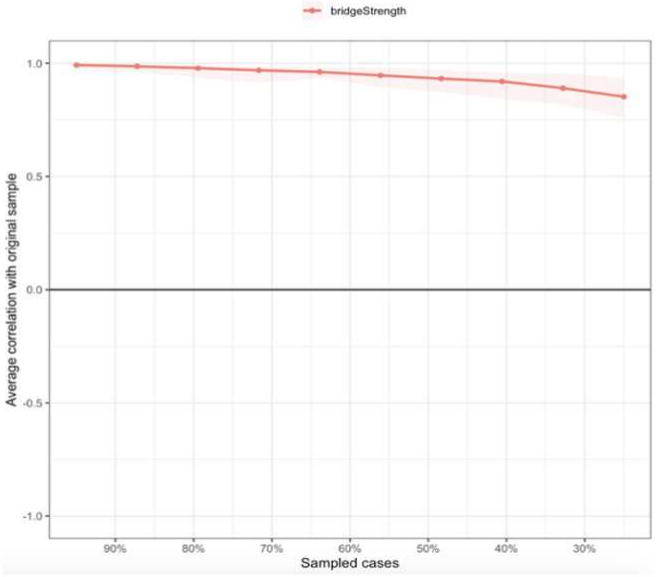


Figure 4D. Bootstrapped difference test of node strength centrality- OCD symptoms and PSQI Component 5 Score symptoms

Figure 4E. Bootstrapped confidence intervals for estimated edge-weights- OCD symptoms and PSQI Component 5 Score network

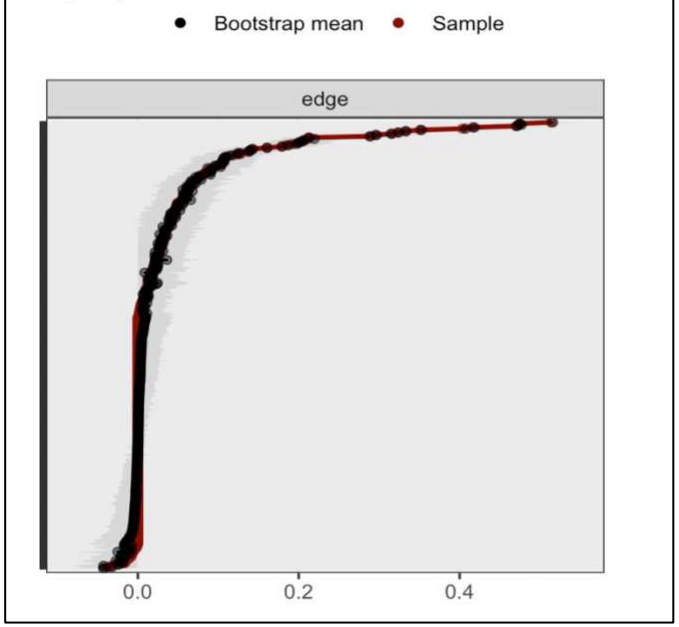
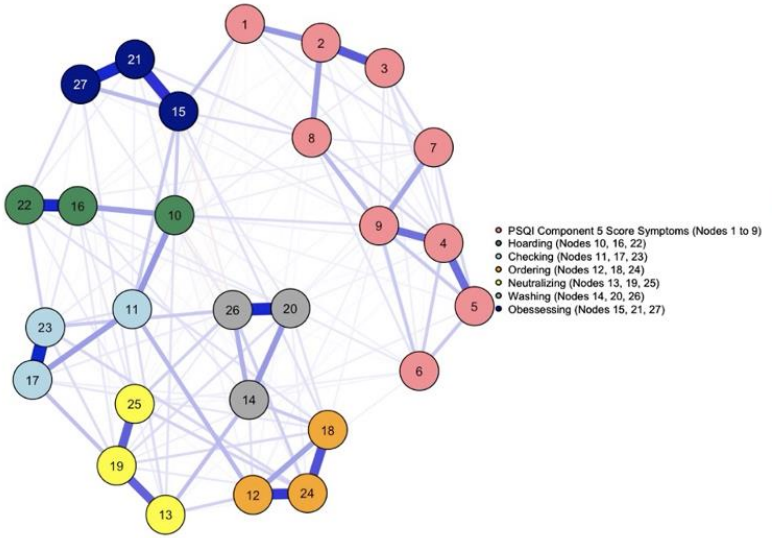
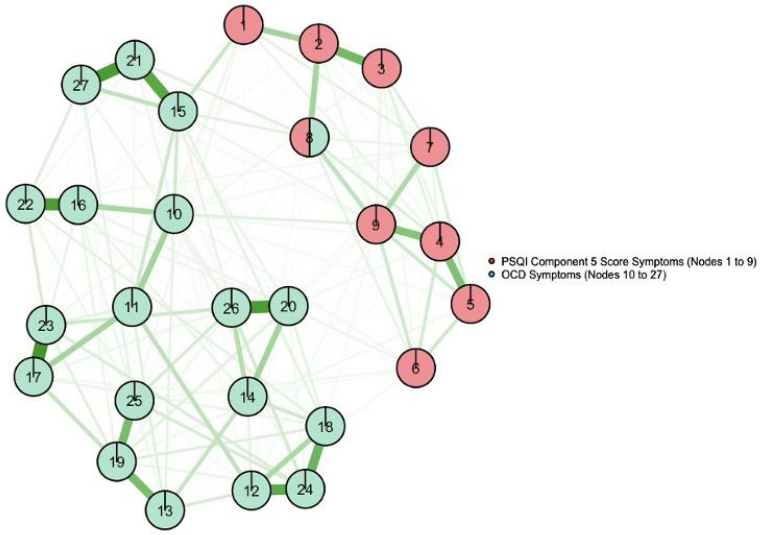


Figure 5. Community detection using the *Spinglass Algorithm* and *Clique Percolation Method (CPM)* among Obsessive-Compulsive Disorder (OCD) symptoms (i.e., Obsessive-Compulsive Inventory Revised Scale- 18 items as nodes) and PSQI Component 5 Score symptoms (i.e., Pittsburgh Sleep Quality Index- 1 sleep latency item and 8 sleep disturbances items).

Spinglass Algorithm



Clique Percolation Method (CPM)



PSQI Component 5 Score Symptoms (nodes 1 to 9)
Node 1: cannot get to sleep within 30 minutes
Node 2: wake up in the middle of the night or early morning
Node 3: have to get up to use the bathroom
Node 4: cannot breathe comfortably
Node 5: cough or snore loudly
Node 6: feel too cold
Node 7: feel too hot
Node 8: have bad dreams
Node 9: have pain

Hoarding (nodes 10, 16, 22)
Node 10: saved up so many things that they get in the way
Node 16: collect things I do not need
Node 22: avoid throwing things away because afraid might need them later

Checking (nodes 11, 17, 23)
Node 11: check things more often than necessary
Node 17: repeatedly check doors, windows, drawers, etc.
Node 23: repeatedly check gas, water taps, and light switches after turning them off

Ordering (nodes 12, 18, 24)
Node 12: get upset if objects are not arranged properly
Node 18: get upset if others change the way I have arranged things
Node 24: need things to be arranged in a particular way

Neutralizing (nodes 13, 19, 25)
Node 13: feel compelled to count while doing things
Node 19: feel I have to repeat certain numbers
Node 25: feel that there are good and bad numbers

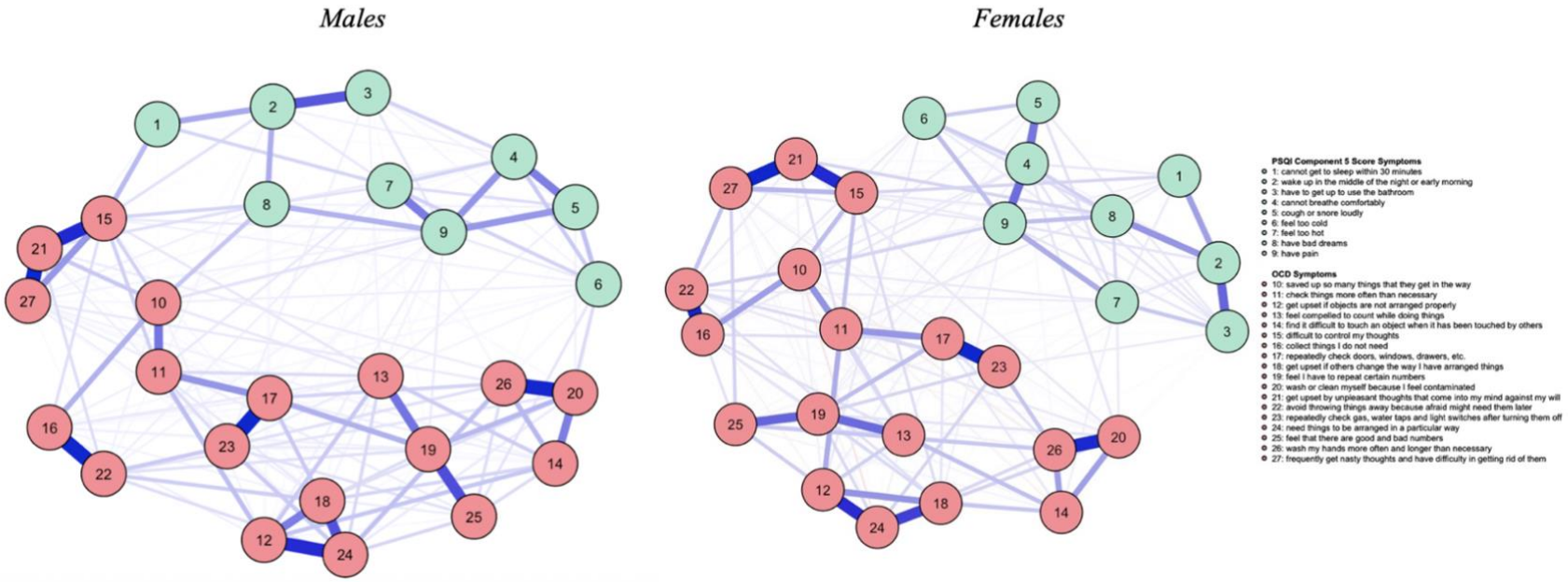
Washing (nodes 14, 20, 26)
Node 14: find it difficult to touch an object when it has been touched by others
Node 20: wash or clean myself because I feel contaminated
Node 26: wash my hands more often and longer than necessary

Obsessing (nodes 15, 21, 27)
Node 15: difficult to control my thoughts
Node 21: get upset by unpleasant thoughts that come into my mind against my will
Node 27: frequently get nasty thoughts and have difficulty in getting rid of them

PSQI Component 5 Score Symptoms (nodes 1 to 9)
Node 1: cannot get to sleep within 30 minutes
Node 2: wake up in the middle of the night or early morning
Node 3: have to get up to use the bathroom
Node 4: cannot breathe comfortably
Node 5: cough or snore loudly
Node 6: feel too cold
Node 7: feel too hot
Node 8: have bad dreams
Node 9: have pain

OCD Symptoms
Node 10: saved up so many things that they get in the way
Node 11: check things more often than necessary
Node 12: get upset if objects are not arranged properly
Node 13: feel compelled to count while doing things
Node 14: find it difficult to touch an object when it has been touched by others
Node 15: difficult to control my thoughts
Node 16: collect things I do not need
Node 17: repeatedly check doors, windows, drawers, etc.
Node 18: get upset if others change the way I have arranged things
Node 19: feel I have to repeat certain numbers
Node 20: wash or clean myself because I feel contaminated
Node 21: get upset by unpleasant thoughts that come into my mind against my will
Node 22: avoid throwing things away because afraid might need them later
Node 23: repeatedly check gas, water taps, and light switches after turning them off
Node 24: need things to be arranged in a particular way
Node 25: feel that there are good and bad numbers
Node 26: wash my hands more often and longer than necessary
Node 27: frequently get nasty thoughts and have difficulty in getting rid of them

Figure 6. Network Comparison Test (NCT) of Obsessive-Compulsive Disorder (OCD) (i.e., Obsessive-Compulsive Inventory Revised Scale- 18 items as nodes) and PSQI Component 5 Score symptoms (i.e., Pittsburgh Sleep Quality Index- 1 sleep latency item and 8 sleep disturbances items)- between males versus females. Global strength statistic of S=0.78, p-value =0.01.



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4. Examining Self-Reported Obsessive-Compulsive Symptoms and Sleep Disturbances in a Global Post-Secondary Student Cohort Over a 1-Year Period: UNILIFE-M

PREFACE

Goal addressed: To understand the bidirectional association between obsessive-compulsive symptoms and sleep disturbances through a longitudinal analysis and identify various clusters of OCD symptom profiles through a latent class analysis.

Author contributions: Saguna Katyal developed the research protocol, cleaned and merged the data by site, conducted the longitudinal and latent class analyses, and finished the manuscript. Dr. Ian Colman and Dr. Marco Solmi provided their clinical and methodological feedback on the research protocol, guided me through the analyses, supervised all aspects of the research paper, and reviewed the final manuscript. Dr. Felipe Schuch provided their clinical expertise on the research protocol and the final writing of the manuscript. All contributors who provided the UNILIFE-M data are part of the co-author list.

Ethics: Ethics approval was received to conduct secondary data analysis using UNILIFE-M data from the University of Ottawa Research Ethics Board (H-11-24-10937), as of November 14, 2024. Each site received approval from their respective research ethics board.

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Conflict of Interest: MS received honoraria/has been a consultant for Angelini, AbbVie, Boehringer Ingelheim, DynaMedex, Lundbeck, and Otsuka.

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Abbreviations: OR= odds ratio, **95% CI**= 95% confidence intervals

Abstract

Background: Sleep disturbances are noted to play an important role in obsessive-compulsive disorder (OCD). However, limited research has investigated the bidirectional association between sleep disturbances and OCD symptoms in post-secondary students.

Methods: We used baseline and 1-year follow-up data from the University Students' Lifestyle and Mental Health Study (UNILIFE-M) with a global cohort of first-year post-secondary students from 8 countries, aged between 16-35. Participants completed an online survey regarding their mental health symptoms and lifestyle patterns at baseline and 1-year follow-up. Baseline was defined as the beginning of a post-secondary career. Multinomial regression models and latent class analyses were conducted in R Studio.

Results: A total of 1,783 students provided follow-up data. Multinomial regression analyses revealed a bidirectional correlation between obsessive-compulsive symptoms and sleep disturbances, using cross-sectional data. However, the longitudinal regression analyses showed that sleep disturbances at baseline (or beginning of academic year) were associated with higher OCD symptoms at 1-year follow-up. Participants who reported moderate or severe sleep disturbances at baseline had 1.67 greater odds (95% CI=1.08-2.60) of experiencing moderate OCD symptoms at 1-year follow-up and 2.50 greater odds (95% CI=1.72-3.63) of experiencing severe OCD symptoms at 1-year follow-up, even after adjusting for depression threshold. Latent class analyses classified OCD symptom profiles into 5 classes in both baseline and 1-year follow-up data: 1) checking and ordering, 2) checking, hoarding and obsessive thoughts using baseline data, versus 2) obsessive thoughts using follow-up data, 3) no OCD symptoms, 4) moderate OCD symptoms, and 5) severe OCD symptoms. Regression analyses showed that the OCD class of "Checking and Ordering" at both baseline (OR= 1.13, 95%CI=1.07-1.18) and follow-up (OR= 1.09, 95%CI=1.03-1.14) was associated with sleep disturbances.

Conclusion: Findings from this study indicated a bidirectional association, with stronger support for sleep disturbances at beginning of academic year to be associated with higher obsessive-compulsive symptoms at follow-up.

Keywords: obsessive-compulsive disorder, sleep, longitudinal analysis, latent class analysis, post-secondary students

4.1. Introduction

Sleep disturbances are often comorbid with mental health disorders.[1,2] Disrupted sleep patterns have been causally linked with poorer mental health outcomes, lower quality of life, and higher disorder severity.[3] Emerging evidence in the literature has suggested that sleep disturbances may be associated with obsessive-compulsive disorder (OCD).[4–6] OCD is a chronic mental illness known to affect approximately 1-3% of the population across the globe.[7,8] It is defined by two components: obsessions (unwanted, intrusive, and distressing thoughts) and compulsions (mental acts or behaviors in response to obsessions).[9]

Previous meta-analyses have shown that individuals with OCD are more likely to experience reduced sleep time, longer sleep latency, and lower sleep efficiency compared to controls.[10–13] In clinical samples, some evidence has also indicated that sleep latency, daytime dysfunction, and subjective sleep quality may predict the response to treatment among patients with severe symptoms of OCD.[14] In non-clinical samples, poor sleep patterns have also been associated with OCD symptoms. For example, a cross-sectional study conducted on 370 medical students indicated that poor sleep quality was an important predictor associated with obsessive-compulsive symptoms.[15] Another study involving 212 undergraduates found that those with delayed bedtimes had a greater number of intrusive thoughts compared to those with non-delayed bedtimes.[16] Another cross-sectional study in 191 university students indicated that sleep disturbances may be linked to the OCD symptom of checking behaviors.[17] However, most of these studies were cross-sectional, obscuring possible conclusions regarding temporality; thus, it is still unclear whether disrupted sleep is a risk factor for OCD symptoms or an outcome of OCD symptoms. Furthermore, a systematic review of 20 studies among adolescents has also showed preliminary evidence for a bidirectional association between poor sleep patterns and OCD.[18]

Therefore, to examine the directionality of association between disrupted sleep and OCD, we carried out a longitudinal analysis using baseline (beginning of post-secondary career) and 1-year follow-up data from the University Students' Lifestyle and Mental Health Study (UNILIFE-M), a global cohort of post-secondary students. It is important to note that the average onset of OCD occurs between the ages of 14-29.[19] Therefore, our study focused on a student cohort between the ages of 16-35, which is an important period for early prevention in this population. To the

authors' knowledge, this study is the first to conduct a longitudinal analysis of sleep disturbances and obsessive-compulsive symptoms among a global, post-secondary student cohort.

In addition to the longitudinal analyses, we also conducted a latent class analysis using baseline and follow-up data to identify different OCD symptom profiles. So far, latent class analyses of OCD symptoms have shown mixed results- with some studies showing support for a three-class solution, that only differs in severity of OCD symptoms [20], whereas, some have suggested a two-class solution identifying autogenous obsessions (i.e., intrusive thoughts without an external stimuli such as sexual, aggressive, and immoral thoughts) and reactive obsessions (i.e., intrusive thoughts evoked by an external stimuli such as contamination, symmetry).[21,22] Therefore, we carried out a latent class analysis to better understand the various clusters of OCD symptom patterns in the student population.

4.2. Methods

4.2.1 Study design and inclusion criteria

Data was used from the University Students' Lifestyle and Mental Health Study (UNILIFE-M).[23] UNILIFE-M is a multicenter cohort study in which first-year post-secondary students were surveyed regarding their lifestyle and mental health patterns. The survey was administered online through REDCap (Research Electronic Data Capture) platform. Students were recruited using an approach that involved social media campaigns, posters on campus, face-to-face recruitment, e-mail invitations, and a study website. The inclusion criteria were as follows: between the ages of 16-35 years old, enrolled in a first-year university/college program in 2023 or 2024, and willing to provide their consent to participate in the follow-up survey. Students were surveyed in the first term after their enrollment in their university/college career, defined as a baseline measurement. Students were then followed up after 1 year to complete the same survey again, defined as a 1-year follow-up. This was a multi-site study involving participants from 8 countries (Australia, Austria, Brazil, Chile, Colombia, Germany, Japan, and Spain). Data for this study is based on both baseline and 1-year follow-up assessments. However, this is an ongoing study, therefore, we used partial baseline and follow-up data.

4.2.2 Ethics

Participants provided informed consent before starting the survey. The current study, involving secondary data analyses, received ethical approval from the University of Ottawa Health Sciences Research Ethics Board (H-11-24-10937) in November 2024. In addition, approval to conduct the UNILIFE-M study was obtained from the Ethics Committee of the Federal University of Santa Maria (CAE: 63025822.8.1001.5346). All participating study sites also obtained ethical approval from their respective review boards.

4.2.3. Measures

OCD symptoms

The Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) Cross-Cutting Symptom Measure (CCSM) was used to determine the initial threshold for OCD symptoms. This tool has been shown to be internally consistent and a valid measure of self-reported psychopathology.[24,25] Participants were asked, "During the past two weeks, how much (or how often) have you been bothered by the following problems?" If individuals answered "2-mild/several days" or greater to any of these 2 questions: "Unpleasant thoughts, urges, or images that repeatedly enter your mind" or "Feeling driven to perform certain behaviours or mental acts over and over again" then individuals moved on to complete the Obsessive-Compulsive Inventory-Revised (OCI-R) scale. OCI-R asked the question "How much that experience has distressed or bothered you during the past month?" – with 18 items on the scale. Participants rated themselves on a Likert scale (0=Not at all, 1=A little, 2= Moderately, 3=A lot, and 4= Extremely). The OCI-R has demonstrated strong psychometric properties, including high internal consistency (Cronbach's α= 0.84-0.88) and good test-retest reliability, as reported in previous validation studies.[26–28] Some OCI-R items included: "I have saved up so many things that they get in the way", "I check things more often than necessary," and "I get upset if objects are not arranged properly." The total score from all items was summed up, which ranged from 0 to 72, with higher scores indicating higher severity of OCD symptoms. The OCI-R scores were classified as mild (0 to 15), moderate (16 to 27), and severe ($\geq$ 28).[29] Those participants who did not meet the initial threshold to be administered the OCI-R survey were reclassified as not at all (0).

Sleep disturbances

Similarly, the DSM-5 Self-Rated Cross-Cutting Symptom Measure was utilized to determine the threshold for sleep disturbances. Participants were asked, "During the past two weeks, how much (or how often) have you been bothered by the following problems?" If individuals rated themselves at least "2- mild/ several days" or greater to the question: "Problems with sleep that affected your sleep quality over" then they moved on to complete the 'Pittsburgh Sleep Quality Index (PSQI).[30] PSQI is an ordinal scale in which the scores are calculated based on 19 self-reported questions assessing 7 domains (sleep quality, sleep latency, average sleep duration, habitual sleep efficiency, sleep disturbances, sleeping medication use, and daytime dysfunction).[31] Our survey only included the PSQI Sleep Disturbances Domain, composed of 8 items. The PSQI survey asked "5). During the past month, how often have you had trouble sleeping because you: b). wake up in the middle of the night or early morning, c) have to get up to use the bathroom, d). cannot breathe comfortably, e). cough or snore loudly, f). feel too cold, g). feel too hot, h) have bad dreams, and i) have pain." Response options for each item ranged from 0 (not during the past month), 1 (less than once a week), 2 (once or twice a week), or 3 (three or more times a week). To determine the PSQI score, we calculated the sum of the sleep disturbances' domain (5b-5i) for a total score ranging from 0 to 27. This sub-score domain was then reclassified into- no difficulty (0), mild difficulty (1-9), moderate difficulty (10-18), or severe difficulty (19-27).[32] Those participants who did not meet the initial threshold to be administered the PSQI survey were reclassified as no difficulty (0).

Covariates

We included covariates such as sex[33], age, sexual orientation, ethnicity[34], body mass index (BMI)[35], depression threshold[36], and work status.[37]

Sex was measured using the item "What is your biological gender?" with two response options: "Male" or "Female." Age was assessed using an open-ended question (i.e., "What is your age?") and participants provided their exact age. Sexual orientation was measured using the item, "Regarding your sexual orientation, are you?" with five response options: "Heterosexual", "Homosexual", "Bisexual", "Pansexual" or "Other." Ethnicity was measured using the item "What is your ethnic group?" with six response options: "Asian", "Black", "Brown", "White",

"Indigenous" or "Other." For our analyses, we grouped together Asian (i.e., East Asian) and Brown (i.e., Hispanic/South Asian/Middle Eastern). To calculate BMI, open-ended questions were asked regarding height and weight (i.e., "What is your height, in m, approximately?" and "What is your weight, in kg, approximately?"). Work status was measured using the item, "Are you currently working?" with two response options- "Yes" or "No." Depression threshold was measured using the DSM-5 Self-Rated Cross-Cutting Symptom Measure. Participants were asked, "During the past two weeks, how much (or how often) have you been bothered by the following problems?" If individuals answered "2-mild/several days" or higher to any of these two items: "Little interest or pleasure in doing things", or "Feeling down, depressed or hopeless" then individuals were coded as "Yes" for meeting the depression threshold. However, if they scored less than "2-mild/several days" then they were coded as "No" for depression threshold.

4.2.4. Data analytical plan

Mean difference and standard deviation were calculated for PSQI and OCI-R scores, respectively. To understand the bidirectional association, we conducted two types of multinomial regression analyses: 1) baseline OCD symptoms associated with sleep disturbances at 1-year follow-up and 2) baseline sleep disturbances associated with OCD symptoms at 1-year follow-up. We modeled predictors as continuous as well as categorical. Models assumed a maximum marginal likelihood.[38] We fitted logistic regression models using the *glm* function with a binomial family in R Studio. For outcomes with more than two categories, we used the *multinom* from the *nnet* package in R Studio. OCI-R scores were divided into 3 categories- mild (OCI-R $\leq$ 15), moderate (15 <OCI-R < 28), and severe (OCI-R $\geq$ 28), and PSQI Sleep Disturbances domain was divided into 2 categories- mild (PSQI $\leq$ 9) and moderate or severe (PSQI > 9). PSQI moderate and severe scores were grouped together because there were very few number of participants with severe sleep symptoms. In our models, we adjusted for sex, age, sexual orientation, ethnicity, BMI, depression threshold, and work status. We also adjusted for baseline OCD symptoms when assessing the association between baseline sleep disturbances and follow-up OCD symptoms and adjusted for baseline sleep disturbances when assessing the link between baseline OCD symptoms and follow-up sleep disturbances. Odds ratios (OR) and 95% confidence intervals (CI) were calculated to measure the association between obsessive-compulsive symptoms and sleep disturbances. All analyses were carried out in R Studio.

Handling Missing Data

Multiple imputation was carried out for multinomial regression models and logistic regression models, using the *mice* package in R, with 10 iterations and 10 imputations, as there was more than 10% missing data for most predictors.

Sensitivity analysis

Multinomial regression modeling was conducted to examine whether 1) baseline sleep disturbances predict the onset of obsessive-compulsive symptoms, among those who did not meet the initial threshold of obsessive-compulsive symptoms at baseline and whether 2) baseline obsessive-compulsive symptoms predict the onset of sleep disturbances, among those who did not meet the initial threshold of sleep disturbances at baseline. These predictors were modeled as continuous variables.

Latent class analysis

Latent Class Analysis based on a Structural Equation Modeling (SEM) framework was used.[39] This approach used the maximum likelihood estimation, specifically the Estimation-Maximization (EM) algorithm, to estimate categories into classes.[40] The purpose of this analysis was to determine specific subgroups of individuals who were similar in their response patterns. LCA was conducted separately on baseline and follow-up OCD symptoms. Model fit was assessed using AIC (Akaike Information Criterion), SABIC (Sample-Size Adjusted Bayesian Information Criterion), entropy, and posterior probabilities- this allowed us to compare models with different numbers of classes (ex., 3 vs 4 class model).[41] We chose the model with a lower SABIC, higher entropy (closer to 1), and higher posterior probabilities (ideally above 0.7). These analyses were carried out using the *polCA* package, and graphs were made using the *ggplot* package in R Studio.

To understand the association between LCA identified OCD classes and PSQI sleep disturbance items, we conducted multinomial logistic regression using the *multinom* function from the *nnet* package in R Studio. We carried out these analyses separately for OCD classes identified from

baseline versus 1-year follow-up data. In our models, we adjusted for sex, age, sexual orientation, ethnicity, BMI, work status, and depression threshold.

4.3. Results

4.3.1. Descriptive data

The sample consisted of 3,259 post-secondary students at baseline. Of these students, only 1,783 completed follow-up at 1 year (45.29% drop out rate). Table 1A shows the descriptive characteristics of participants included at follow-up versus those lost to follow up. Those who dropped out at follow-up were more likely to belong from Oceania, identify as heterosexual and Indigenous, have a higher BMI, more likely to be working and be single. These results were statistically significant at $p < 0.05$, with effect sizes above 0.20. Those who dropped out also scored significantly higher on the PSQI Sleep Disturbances Domain, and the OCI-R scale. Therefore, we used data from the 1,783 sample (i.e., participants who completed both baseline and follow-up surveys) for our analyses.

Table 1B shows the descriptive characteristics of the 1,783 post-secondary student cohort. The mean age of participants at baseline was 20.05, and at follow-up was 21.04. Out of 1,783 students, 813 participants (45.60%) met the initial threshold of sleep problems at baseline, and 728 participants (40.83%) met the threshold at follow-up. Out of 1,783 students, 807 (45.26%) met the initial threshold of OCD symptoms at baseline, and 695 (38.98%) met the threshold at follow-up. The mean scores on the Obsessive-Compulsive Inventory-Revised (OCI-R) were between 8.51-10.16, indicating mild obsessive compulsive symptoms at both baseline and follow-up. The mean scores on the PSQI Sleep Disturbances Domain were between 2.99-3.15, indicating very mild sleep disturbances. Comparing the variability between baseline versus follow-up, the mean OCI-R scores were slightly greater at baseline than follow-up (Cohen's d: 0.12, $p < 0.05$), whereas the mean PSQI Sleep Disturbances domain scores remained stable across time (Cohen's $d = 0.04$, $p > 0.05$).

4.3.2. Longitudinal analyses

Tables 2A and 2B report the results from the multinomial regression models examining the bidirectional association between sleep disturbances and OCD symptoms.

Table 2A reports on Models A1 and A2, which assess OCD symptoms as a continuous predictor for sleep disturbances. Model A1 depicts the baseline time point. Each unit increase in the OCI-R score at baseline was associated with 5% higher odds of reporting moderate or severe sleep disturbances at baseline (95% CI= 1.04-1.06). Model A2 demonstrates follow-up. Each unit increase in the OCI-R score at baseline was associated with 1% higher odds of reporting moderate or severe sleep disturbances at follow-up (95% CI= 1.00-1.02), but this was not statistically significant at alpha 0.05 as the 95% CI included 1.

Table 2A also reports on Models B1 and B2 assessing sleep disturbances as a continuous predictor for OCD symptoms. Model B1 demonstrates the baseline time-point. Each unit increase in the PSQI Sleep Disturbances Domain score at baseline was associated with 10% higher odds of reporting moderate OCD symptoms (95% CI= 1.07-1.13) and 20% higher odds of reporting severe OCD symptoms (95% CI= 1.16-1.24) at baseline. Model A2 depicts follow-up. Each unit increase in the PSQI Sleep Disturbances Domain score at baseline was associated with 6% higher odds of reporting moderate OCD symptoms at follow-up (95% CI= 1.03-1.10) and 8% higher odds of reporting severe OCD symptoms at follow-up (95% CI= 1.05-1.11). These results were significant at alpha 0.05 as the 95% CI excluded 1.

Table 2B shows Models C1 and C2 assessing OCD symptoms as a categorical predictor for sleep disturbances. Model C1 demonstrates the baseline time point. Those with moderate OCD symptoms had 3.21 times greater odds (95% CI= 2.19-4.70), and those with severe OCD symptoms had 6.41 times higher odds (95% CI= 4.44-9.28) of having moderate or severe sleep disturbances at baseline. Model C2 assesses the follow-up time-point. Those with moderate OCD symptoms at baseline had 1.12 times higher odds (95% CI= 0.72-1.75) and those with severe OCD symptoms at baseline had 1.48 times greater odds (95% CI= 0.96-2.26) of developing moderate or severe sleep disturbances at follow-up. However, the results of Model C2 were not statistically significant at alpha 0.05 as the 95% CI included 1.

Table 2B shows Models D1 and D2 examining sleep disturbances as a categorical predictor for OCD symptoms. Model D1 depicts baseline time-point. Those who had moderate or severe sleep disturbances at baseline had 3.22 times higher odds (95% CI= 2.20-4.71) of having moderate OCD symptoms and 6.40 times greater odds of having severe OCD symptoms (95% CI= 4.43-9.23) at baseline. Model D2 assesses the follow-up time-point. Those who had moderate or severe sleep disturbances at baseline had 1.67 times higher odds (95% CI= 1.08-2.60) of developing moderate OCD symptoms at follow-up and 2.50 times greater odds (95% CI= 1.72-3.63) of developing severe OCD symptoms at follow-up. Results of Model D1 and D2 were statistically significant at alpha 0.05 as 95% CI excluded 1.

Sensitivity analyses

Table 2C shows Models E1 and E2. Model E1 examined whether baseline obsessive-compulsive symptoms predict the onset of sleep disturbances at follow-up, among those who did not meet the sleep disturbances threshold at baseline. Each unit increase in the OCI-R score at baseline was associated with 1% higher odds of reporting sleep disturbance symptoms at follow-up (95% CI= 1.00-1.03). Model E2 investigated whether baseline sleep disturbance symptoms predict the onset of obsessive-compulsive symptoms at follow-up, among those who did not meet the obsessive-compulsive symptom threshold at baseline. Each unit increase in the PSQI Sleep Disturbances Domain score at baseline was associated with 6% higher odds of reporting obsessive-compulsive symptoms at follow-up (95% CI= 1.00-1.13). However, both E1 and E2 models showed statistically non-significant results at alpha 0.05 as 95% CI included 1.

4.3.3. Latent Class Analysis (LCA) of OCD symptoms

Baseline

Table 3A shows the fit statistics across various latent classes using baseline OCD symptoms. The entropy for 2-class model was 0.88, 3-class model was 0.87, 4-class model was 0.88, 5-class model was 0.89, 6-class model was 0.90, and 7-class model was 0.91 (see Figure 1). Table 3B shows the posterior probabilities by each class and all the probabilities were above 0.7. Based on these fit indices, a 5-class factor solution seemed to fit the best as the entropy was maximized, posterior probabilities were above 0.7, and SABIC was low. Table 3C shows the classification of OCD symptoms into 5 categories: 1) checking and ordering, 2) checking, hoarding, and

obsessive thoughts, 3) no OCD symptoms, 4) moderate OCD symptoms, and 5) severe OCD symptoms.

Follow-up

Table 4A shows the fit statistics across various latent classes using follow-up OCD symptoms. The entropy for the 2-class model was 0.88, 3-class model was 0.87, 4-class model was 0.88, 5-class model was 0.89, 6-class model was 0.90, and 7-class model was 0.90 (see Figure 2). Table 4B shows the posterior probabilities by each class and all the probabilities were above 0.7. A 5-class OCD model was chosen because the posterior probabilities were above 0.7, and SABIC was low, but also to remain consistent with the 5-class solution obtained using the baseline OCD symptoms. Table 4C shows the classification of OCD symptoms into 5 categories: 1) checking and ordering, 2) obsessive thoughts, 3) no OCD symptoms, 4) moderate OCD symptoms, and 5) severe OCD symptoms.

4.3.4. Multinomial regression modeling between OCD classes and sleep disturbances

Table 5 demonstrates multinomial regression modeling between 5-class OCD latent classes and PSQI sleep disturbance items, using baseline and follow-up data. PSQI Sleep Disturbance Domain was associated with two classes: “Severe OCD symptoms” and “Checking and Ordering.” In baseline data, PSQI Sleep Disturbance Domain scores were associated with higher odds of reporting OCD symptoms of "Checking and Ordering" (OR= 1.13, 95% CI=1.07-1.18). Similarly, in 1-year follow-up data, PSQI Sleep Disturbance Domain scores were associated with higher odds of reporting OCD symptoms of "Checking and Ordering" (OR= 1.09, 95% CI= 1.03-1.14). PSQI Sleep Disturbance scores were also linked to the class of “Severe OCD symptoms” in both baseline data (OR=1.24, 95% CI=1.17-1.30) and follow-up data (OR=1.19, 95% CI= 1.13-1.26).

4.4. Discussion

This study presents a novel perspective as it bidirectionally examined the longitudinal association between sleep disturbances and obsessive-compulsive symptoms in a large cohort of post-secondary students. In our sample, the mean OCI-R scores indicated mild severity of OCD symptoms, while the mean PSQI scores suggested very mild sleep disturbances in this

population. Interestingly, we also found that the OCI-R scores decreased from baseline to follow-up, but PSQI scores remained stable. Previous studies have noted a considerable fluctuation in mental health symptoms but not sleep symptoms among university students.[42,43] Some have even reported that depressive symptoms tend to improve among students during the second half of the first academic year,[44] likely because as students' progress through their post-secondary career, they tend to adjust to their academic routines and lifestyle changes.[45]

In our regression analyses, we noted that both sleep disturbances and OCD symptoms were risk factors for each other, using cross-sectional data. This aligns with a previous meta-analysis of 20 studies in youth that indicated preliminary evidence for a bidirectional relationship between sleep problems and obsessive-compulsive symptoms.[18] Evidence in the literature has also shown that sleep disturbances are bidirectionally linked to other mental health disorders in youth, such as depression, anxiety,[46] and Attention-Deficit Hyperactivity Disorder (ADHD).[47] Furthermore, in the longitudinal analyses, we found a statistically significant positive association between baseline sleep disturbances and OCD symptoms at 1-year follow-up, even after adjusting for baseline OCD symptoms and depression threshold. This is in line with the hypothesis that sleep disturbances may be a risk factor for OCD. Preliminary evidence for a diathesis-stress model in OCD has been proposed, indicating that genetic predisposition for OCD might interact with environmental stressors such as sleep disturbances.[48,49] This is because sleep disturbances are linked to deficits in inhibitory control and altered activity in thalamic and frontal brain circuits, which are similar to the neurocircuit pathways involved in OCD.[50] Thus, sleep disturbances might interact with genetic predisposition for OCD, which may increase the susceptibility of OCD onset. Results from these analyses indicate that sleep interventions may be a valuable target for improving mental health symptoms, including OCD symptoms, in post-secondary students.

The latent class analysis (LCA) in the baseline and follow-up data identified a five-class solution for OCD symptoms. Three of the five classes differed in the severity of OCD symptoms (i.e., mild, moderate, severe). This is similar to a previous study using 61 obsessive-compulsive symptoms from the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS), which indicated a three-class solution for OCD symptoms that only differed in the frequency and severity of symptoms.[20] However, in our analyses, the remaining two classes data were: "Checking and

Ordering" and "Checking, Hoarding and Obsessive thoughts" at baseline, while at follow-up it was only "Obsessive Thoughts." This differs from previously published latent class models that suggested classes such as autogenous obsessions (i.e., sexual, aggressive, religious intrusive thoughts), reactive obsessive-compulsive (i.e., hoarding, symmetry obsessions, checking and counting compulsions) and reactive compulsive (i.e., somatic obsessions, checking compulsions, repeating compulsions, ordering and counting compulsions).[21,22] This discrepancy in the results may be due to a difference in the OCD instrument, as previous studies utilized Y-BOCS, a clinician administered instrument that focusses on severity of symptoms, whereas, we used the OCI-R, a self-reported questionnaire that assesses the severity of the six OCD domains.

Multinomial regression analyses showed that PSQI sleep disturbance items were found to be associated with OCD symptoms of checking behaviors and ordering. Prior studies have also noted that individuals who engage in compulsive checking behaviors are more likely to have sleep problems.[17] Specifically, checking compulsions have been noted to be the most common form of compulsions in OCD.[51] Checking has been conceptualized as an anxiety-driven behavior that involves engaging in constant checking compulsions, which results in a lack of memory recall, leading to a self-perpetuating cycle of checking and memory distrust. Furthermore, ordering was another OCD symptom in our study found to be associated with sleep disturbances. This symptom also known as, "the need for symmetry" has been correlated to higher OCD severity scores, longer OCD duration and greater risk of suicidal behaviours.[52,53] We also noted that in both baseline and follow-up data, obsessive thoughts were identified as an important part component of the fifth class (Baseline: "Checking, Hoarding and Obsessive Thoughts" and Follow-up: "Obsessive Thoughts") and were correlated with sleep disturbances. This is consistent with the existing literature indicating that the "unacceptable thoughts" dimension of obsessions may be strongly linked to sleep disturbances than compulsions.[54,55] For instance, in a study of 253 university students, insomnia severity was strongly associated with unacceptable thoughts of OCD.[56] Hence, these results suggest that targeting specific OCD dimensions such as checking, ordering, and obsessive thoughts may be important in post-secondary students.

This study has several limitations. First, the self-reported questionnaires may have been prone to recall bias, as individuals might have miscalculated their frequency of sleep difficulties and OCD

symptoms. Second, our longitudinal study only included students from two timepoints (beginning of academic year and 1-year follow-up), this does not capture the mental health of students at the end of their academic year. Third, a subset of the PSQI scale was utilized; only 8 sleep disturbance items were included; this may have limited our ability to capture a variety of sleep problems. Fourth, this study had a relatively high attrition rate (45.29%). Finally, we only analyzed data from students with supra-threshold symptoms of OCD and sleep symptoms. Despite these limitations, this study involved the use of validated questionnaires with good psychometric properties [57,58] and collected a comprehensive set of sociodemographic variables from a large sample of post-secondary students. As such, results from this study may be relatively generalizable to similar populations.

4.5. Conclusion

Findings from this study demonstrated a bidirectional, positive correlation between sleep disturbances and obsessive-compulsive symptoms. Sleep disturbances at the beginning of academic career may be a risk factor for the onset of OCD symptoms at follow-up among post-secondary students. Certain OCD symptoms of checking and ordering were linked with greater sleep disturbances. These results may inform educational campaigns/initiatives in post-secondary institutions, however, future research from longitudinal studies in clinical samples is warranted.

Tables/Figures

Table 1A. Descriptive characteristics of the study population stratified by completion status at 1-year follow-up

Participant Characteristics	*Included at Follow-up* **(n= 1,783)**	*Lost to Follow-up^* **(n= 1,476)**	*Effect size (p-value)*
Sex, n (%)			
Female	1323 (74.37%)	1032 (70.01%)	0.10 (<0.05)
Age, Mean [S.D]	20.05 [2.96]	19.73 [3.23]	0.10 (<0.05)
Sexual orientation, n (%)			
Heterosexual	1072 (60.67%)	1034 (70.68%)	**0.21 (<0.05)**
Gender identity, n (%)			
Cisgender	1656 (93.77%)	1398 (95.82%)	0.09 (<0.05)
Ethnicity, n (%)[#]			
Caucasian	426 (52.72%)	508 (35.88%)	**0.34 (<0.05)**
Hispanic/East Asian/ South Asian/Middle Eastern	237 (29.33%)	393 (27.75%)	0.10 (<0.05)
African American/ Northern or Sub-Saharan African	50 (6.19%)	14 (0.99%)	**0.30 (<0.05)**
Indigenous	10 (1.24%)	62 (4.38%)	**0.20 (<0.05)**
Other	85 (10.52%)	439 (31.00%)	**0.52 (<0.05)**
Region, n (%)			
Europe	1082 (60.69%)	40 (2.71%)	**1.46 (<0.05)**
South America	487 (27.31%)	471 (31.92%)	0.10 (<0.05)
Oceania	162 (9.09%)	964 (65.31%)	**1.27 (<0.05)**
Asia	52 (2.92%)	1 (0.07%)	0.12 (<0.05)
Clinical Diagnosis of OCD, n (%)			
Yes	24 (1.35%)	33 (2.24%)	0.07 (>0.05)
Meets depression threshold, n (%)			
Yes	1196 (67.72%)	954 (68.44%)	0.01 (>0.05)
BMI, Mean [S.D]	22.62 [4.19]	23.63 [5.02]	**0.22 (<0.05)**
Marital status, n (%)			
Single	1378 (77.55%)	1284 (87.41%)	**0.26 (<0.05)**
Working status, n (%)			
Yes	469 (26.41%)	627 (42.57%)	**0.34 (<0.05)**
PSQI Sleep Disturbances Domain, Mean [S.D]**	3.15 [4.66]	9.30 [4.78]	**1.30 (<0.05)**
OCI-R Score, Mean [S.D]**	10.16 [14.04]	25.36 [14.22]	**1.08 (<0.05)**

Abbreviations: number (n), standard deviation (S.D.), PSQI (Pittsburgh Sleep Quality Index), OCI-R (Obsessive-Compulsive Inventory-Revised)

[#]55% missing data for ethnicity- it was not reported from Germany and Austria, 10-12% missing data for other covariates.

^57% missing data for OCI-R scores and 64% for PSQI scores among those lost to follow-up

**PSQI and OCIR scores were only reported from those who met the respective threshold of DSM-5 Self-Rated Cross-Cutting Symptom Measure for sleep disturbances and OCD symptoms. If individuals did not meet this threshold, they were assigned a score of 0.

Table 1B. Descriptive characteristics of the study population who completed the 1-year follow-up survey[#]

Participant characteristics variable at baseline versus follow-up* (n=1,783)	**Baseline**	**1-year Follow-up**	**Effect size (p-value)**
Age, Mean [S.D]	20.05 [2.96]	21.04 [3.74]	**0.29 (<0.05)**
Marital status, n (%)			
Single	1378 (77.55%)	1331 (74.78%)	0.06 (>0.05)
Meets depression threshold			
Yes	1196 (67.72%)	1089 66.08%)	0.03 (>0.05)
Working status, n (%)			
Yes	469 (26.41%)	752 (42.25%)	**0.34 (<0.05)**
BMI, Mean [S.D]	22.62 [4.19]	23.13 [6.89]	**0.09 (<0.05)**
PSQI Sleep Disturbances Domain, Mean [S.D] **	3.15 [4.66]	2.99 [4.53]	0.04 (>0.05)
OCIR Score, Mean [S.D] **	10.16 [14.04]	8.51 [12.96]	**0.12 (<0.05)**

Abbreviations: Number (n), Body Mass Index (BMI), Standard Deviation (S.D), Pittsburgh Sleep Quality Index (PSQI), Obsessive-Compulsive Inventory Revised (OCI-R)

*Baseline is defined as after initial enrollment in a university/college program, and follow-up is defined as 1 year following enrollment in a university/college program

[#] 55% missing data for ethnicity- it was not reported from Germany and Austria, 10-12% missing data for other covariates.

**PSQI and OCIR scores were only reported from those who met the respective threshold of DSM-5 Self-Rated Cross-Cutting Symptom Measure for sleep disturbances and OCD symptoms. If individuals did not meet this threshold, they were assigned a score of 0.

Table 2A. Examining the bidirectional relationship between sleep disturbances and obsessive-compulsive symptoms: Multinomial and logistic regression models, predictor modeled as a continuous factor (n=1,783)[#]

Baseline Predictor	***Model A1**** ***(baseline sleep disturbances)*** **OR [95% CI]**		***Model A2**** ***(follow-up sleep disturbances)*** **OR [95% CI]**	
	Mild PSQI Sleep Disturbance Symptoms	Moderate or Severe PSQI Sleep Disturbance Symptoms	Mild PSQI Sleep Disturbance Symptoms	Moderate or Severe PSQI Sleep Disturbance Symptoms
OCI-R score	Ref	**1.05 [1.04-1.06]**	Ref	1.01 [1.00-1.02]

Baseline Predictor	***Model B1**** ***(baseline OCD symptoms)*** **OR [95% CI]**			***Model B2**** ***(follow-up OCD symptoms)*** **OR [95% CI]**		
	Mild OCI-R Symptoms	Moderate OCI-R Symptoms	Severe OCI-R Symptoms	Mild OCI-R Symptoms	Moderate OCI-R Symptoms	Severe OCI-R Symptoms
PSQI Sleep Disturbance Domain score	Ref	**1.10 [1.07-1.13]**	**1.20 [1.16-1.24]**	Ref	**1.06 [1.03-1.10]**	**1.08 [1.05-1.11]**

Abbreviations: OR (odds ratio), CI (confidence interval), OCD (obsessive-compulsive disorder), OCI-R (Obsessive-Compulsive Inventory-Revised), PSQI (Pittsburgh Sleep Quality Index)

[#]Baseline timepoint was defined as initial enrollment in a university/college program, and follow-up is 1 year following enrollment in a university/college program.

*Note: Logistic regression model: obsessive-compulsive symptoms were measured continuously using the OCI-R. The outcome (PSQI Sleep Disturbances domain) was dichotomized as mild (PSQI ≤ 9) and moderate or severe (PSQI > 9). Models A1 and A2 were adjusted for sex, age, sexual orientation, ethnicity, BMI, work status, depression threshold, and Model A2 was additionally adjusted for baseline sleep disturbances.

**Note: Multinomial regression model: sleep disturbances were measured continuously using the PSQI Sleep Disturbances domain. The outcome (OCI-R scores) was categorized into mild (OCI-R ≤ 15), moderate (15 <OCI-R < 28), and severe (OCI-R ≥ 28). Models B1 and B2 were adjusted for sex, age, sexual orientation, ethnicity, BMI, work status, depression threshold, and Model B2 was additionally adjusted for baseline OCD symptoms.

Table 2B. Examining the bidirectional relationship between sleep disturbances and obsessive-compulsive symptoms: Multinomial and logistic regression models, predictor modeled as a categorical factor (n=1,783)[#]

Baseline Predictor	***Model C1**** ***(baseline sleep disturbances)*** **OR [95% CI]**		***Model C2**** ***(follow-up sleep disturbances)*** **OR [95% CI]**	
	Mild PSQI Sleep Disturbance Symptoms	Moderate or Severe PSQI Sleep Disturbance Symptoms	Mild PSQI Sleep Disturbance Symptoms	Moderate or Severe PSQI Sleep Disturbance Symptoms
OCI-R score				
Mild OCI-R	Ref	Ref	Ref	Ref
Moderate OCI-R		**3.21 [2.19-4.70]**		1.12 [0.72-1.75]
Severe OCI-R		**6.41 [4.44-9.28]**		1.48 [0.96-2.26]

Baseline Predictor	***Model D1**** ***(baseline OCD symptoms)*** **OR [95% CI]**			***Model D2**** ***(follow-up OCD symptoms)*** **OR [95% CI]**		
	Mild OCI-R Symptoms	Moderate OCI-R Symptoms	Severe OCI-R Symptoms	Mild OCI-R Symptoms	Moderate OCI-R Symptoms	Severe OCI-R Symptoms
PSQI Sleep Disturbances Domain score						
Mild PSQI	Ref	Ref		Ref	Ref	
Moderate or severe PSQI	Ref	**3.22 [2.20-4.71]**	**6.40 [4.43-9.23]**	Ref	**1.67 [1.08-2.60]**	**2.50 [1.72-3.63]**

Abbreviations: OR (odds ratio), CI (confidence interval), OCD (obsessive-compulsive disorder), OCI-R (Obsessive-Compulsive Inventory-Revised), PSQI (Pittsburgh Sleep Quality Index)

[#]Baseline timepoint was defined as initial enrollment in a university/college program, and follow-up is 1 year following enrollment in a university/college program.

*Note: Logistic regression model: obsessive-compulsive symptoms were categorized into mild (OCI-R ≤ 15), moderate (15 <OCI-R < 28), and severe (OCI-R ≥ 28). The outcome (PSQI Sleep Disturbances domain) was dichotomized as mild (PSQI ≤ 9) and moderate or severe (PSQI > 9). Models C1 and C2 were adjusted for sex, age, sexual orientation, ethnicity, BMI, work status, depression threshold, and Model C2 was additionally adjusted for baseline sleep disturbances.

**Note: Multinomial regression model: sleep disturbances were dichotomized as mild (PSQI ≤ 9) and moderate or severe (PSQI > 9). The outcome (OCI-R scores) was categorized into mild (OCI-R ≤ 15), moderate (15 <OCI-R < 28), and severe (OCI-R ≥ 28). Models D1 and D2 were adjusted for sex, age, sexual orientation, ethnicity, BMI, work status, depression threshold, and Model D2 was additionally adjusted for baseline OCD symptoms.

Table 2C. Assessing the onset of obsessive-compulsive symptoms and sleep disturbances among those below the DSM-5 Cross-Cutting Symptom Threshold[#]

Baseline Predictor	***Model E1**** ***(follow-up sleep disturbances onset)*** **OR [95% CI]**	
	No	Yes
OCI-R score	Ref	1.01 [1.00-1.03]
Baseline Predictor	***Model E2***** ***(follow-up OCD onset)*** **OR [95% CI]**	
	No	Yes
PSQI Sleep Disturbance Domain score	Ref	1.06 [1.00-1.13]

Abbreviations: OR (odds ratio), CI (confidence interval), OCD (obsessive-compulsive disorder), OCI-R (Obsessive-Compulsive Inventory-Revised), PSQI (Pittsburgh Sleep Quality Index)

[#]Baseline timepoint was defined as initial enrollment in a university/college program, and follow-up is 1 year following enrollment in a university/college program. Both Models E1 and E2 were adjusted for sex, age, sexual orientation, ethnicity, BMI, work status, and depression threshold

*Note: Logistic regression model: obsessive-compulsive symptoms were measured continuously using the OCI-R. The outcome (PSQI Sleep Disturbances domain) was dichotomized as "No" onset of sleep disturbances (PSQI ≤ 9) and "Yes" onset of sleep disturbances (PSQI > 9). This model was only among individuals who did not meet the DSM-5 Cross-Cutting Symptom Threshold for Sleep Disturbances at baseline (n=956).

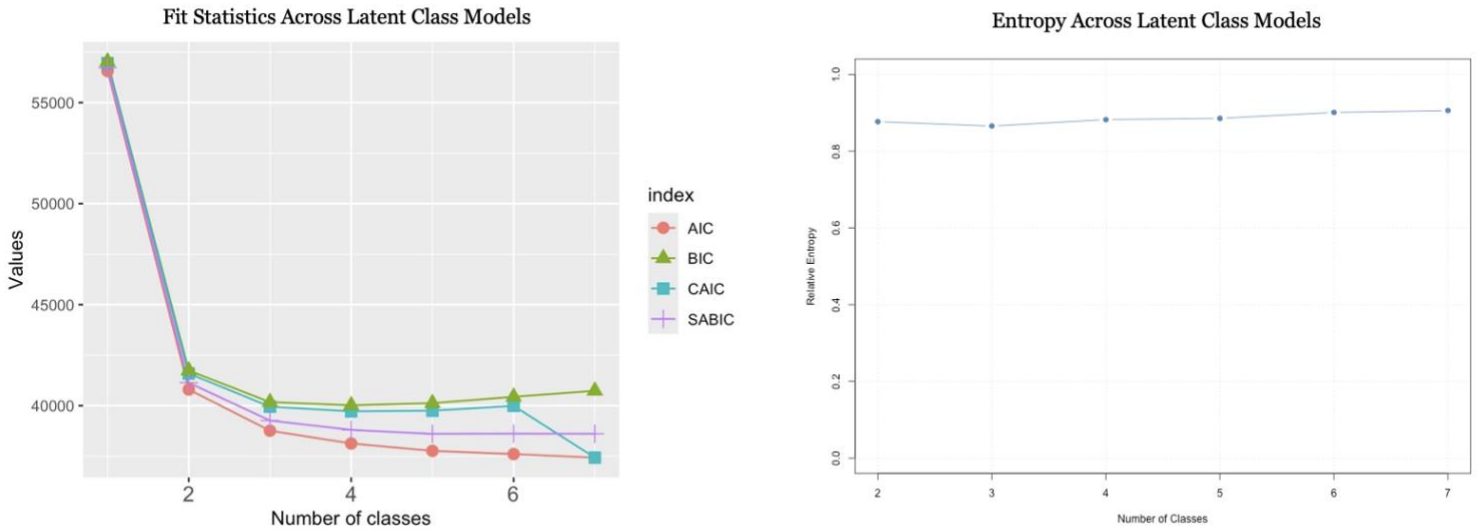
**Note: Logistic regression model: sleep disturbances were measured continuously using the PSQI Sleep Disturbances domain. The outcome (OCI-R scores) was categorized into "No" OCD onset (OCI-R ≤ 17) and "Yes" OCD onset (OCI-R > 17). This model was only among individuals who did not meet the DSM-5 Cross-Cutting Symptom Threshold for Obsessive-Compulsive Symptoms at baseline (n=957).

Table 3A. Fit statistics from latent class analysis of baseline obsessive-compulsive symptoms

Fit Statistics	*Number of Classes*					
	2 classes	**3 classes**	**4 classes**	**5 classes**	**6 classes**	**7 classes**
AIC	40873.12	38869.54	38273.51	37944.33	37829.54	37808.59
BIC	41861.26	40354.48	40255.25	40422.87	40804.88	41280.73
SABIC	41291.07	39497.62	39111.72	38992.67	39088.01	39277.19
G^2	27683.14	25497.56	24719.53	24208.35	23911.56	23708.61
X^2	1.77e+17	8.53e+12	1.39e+13	6.30e+12	5.72e+12	6.89e+12
Maximum log-likelihood	-20255.56	-19162.77	-18773.75	-18518.16	-18369.77	-18268.29
Df	1555	1464	1373	1282	1191	1100
Sample size	1736	1736	1736	1736	1736	1736

Abbreviations: AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion), SABIC (Sample-Adjusted Bayesian Information Criterion), G^2 (Likelihood ratio/deviance statistic), X^2 (Chi-Square), Df (Degrees of Freedom), OCD (Obsessive-Compulsive Disorder)

Figure 1. Fit Statistics and Entropy Across Latent Classes Examining Baseline Obsessive-Compulsive Symptoms



Abbreviations: AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion), SABIC (Sample-Adjusted Bayesian Information Criterion), CAIC (Consistent Akaike Information Criterion)

Table 3B. Posterior probabilities across latent classes examining baseline obsessive-compulsive symptoms

Number of Classes	**Posterior Probability**						
2 Classes	1.00	1.00	-	-	-	-	-
3 Classes	0.97	0.96	1.00	-	-	-	-
4 Classes	0.94	1.00	0.96	0.94	-	-	-
5 Classes	0.97	0.93	0.94	0.92	1.00	-	-
6 Classes	0.97	1.00	0.89	0.92	0.94	0.91	-
7 Classes	0.93	0.94	0.93	0.90	1.00	0.98	0.93

Table 3C. Classification of baseline obsessive-compulsive symptoms into 5 classes

OCIR items	Class 1 Checking & Ordering (14.06%)	Class 2 Checking, Hoarding & Obsessive Thoughts (9.45%)	Class 3 No OCD Symptoms (54.90%)	Class 4 Moderate OCD Symptoms (14.34%)	Class 5 Severe OCD Symptoms (7.26%)
Saved up so many things that they get in the way	0.00	**0.15**	0.00	0.00	**0.27**
Check things more often than necessary	**0.12**	**0.21**	0.00	**0.04**	**0.49**
Get upset if objects are not arranged properly	0.07	0.09	0.00	0.00	**0.33**
Feel compelled to count while doing things	0.03	0.00	0.00	**0.01**	**0.17**
Find it difficult to touch an object when it has been touched by others	0.04	0.00	0.00	0.00	**0.18**
Difficult to control my thoughts	0.06	**0.53**	0.00	**0.01**	**0.70**
Collect things I do not need	0.00	0.09	0.00	0.00	**0.26**
Repeatedly check doors, windows, drawers, etc.	0.03	0.02	0.00	0.00	**0.34**
Get upset if others change the way I've arranged things	**0.11**	0.08	0.00	0.00	**0.43**
Feel I've to repeat certain numbers	0.00	0.00	0.00	0.00	**0.26**
Wash or clean myself because I feel contaminated	0.06	0.02	0.00	0.00	**0.28**
Get upset by unpleasant thoughts that come into my mind against my will	0.01	**0.41**	0.00	0.00	**0.67**
Avoid throwing things away because afraid might need them later	0.04	**0.16**	0.00	**0.02**	**0.39**
Repeatedly check gas, water taps, and light switches after turning them off	0.02	0.00	0.00	0.00	**0.29**
Need things to be arranged in a particular way	0.07	0.03	0.00	0.00	**0.31**
Feel that there are good and bad numbers	0.03	0.05	0.00	**0.01**	**0.21**
Wash my hands more often and longer than necessary	0.05	0.00	0.00	0.00	**0.13**
Frequently get nasty thoughts and have difficulty in getting rid of them	0.00	**0.22**	0.00	0.00	**0.42**

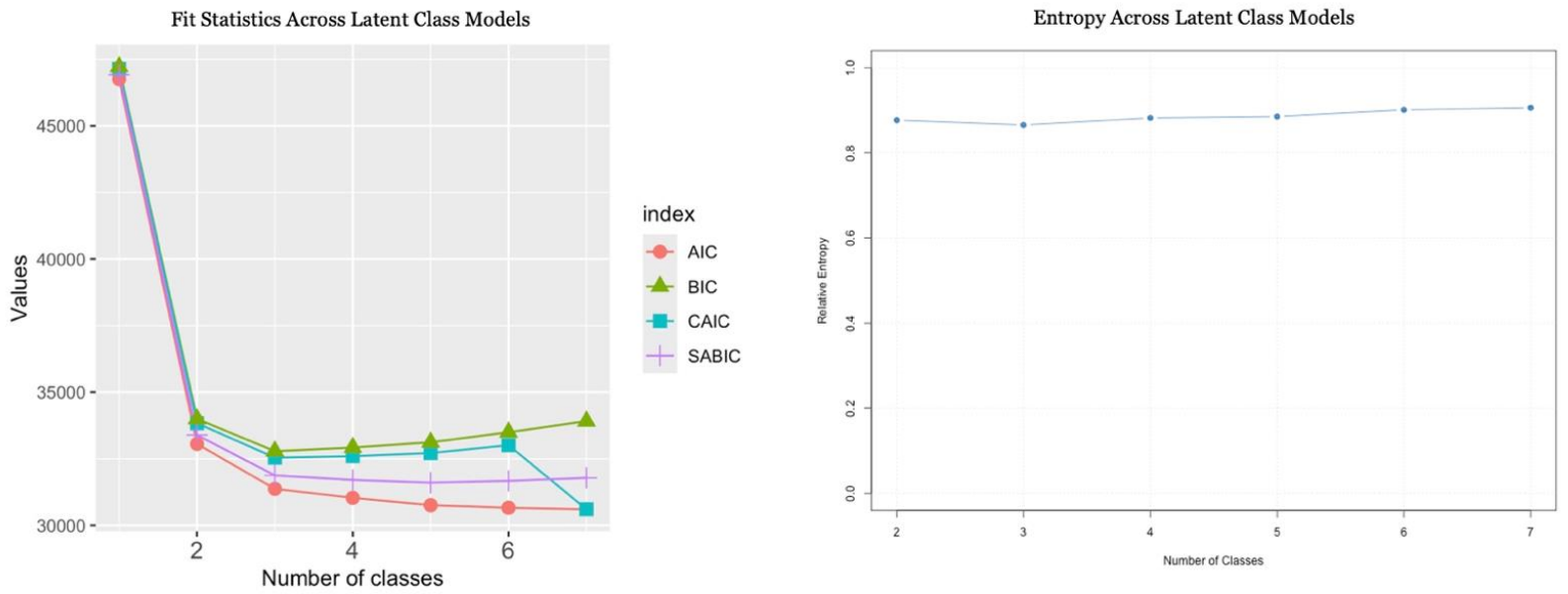
Abbreviations: OCIR (Obsessive-Compulsive Inventory-Revised), OCD (obsessive-compulsive disorder)

Table 4A. Fit statistics from latent class analysis of 1-year follow-up obsessive-compulsive symptoms

Fit Statistics	*Number of Classes*					
	2 classes	**3 classes**	**4 classes**	**5 classes**	**6 classes**	**7 classes**
AIC	33055.98	31369.37	31033.34	30758.36	30660.55	30602.92
BIC	33835.21	32540.9	32597.18	32714.5	33008.99	33343.66
SABIC	33390.81	31872.76	31705.29	31598.88	31669.63	31780.57
G^2	22306.2	20473.59	19991.56	19570.58	19326.77	19123.14
X^2	2.52e+16	7.25e+12	9.37e+12	6.77e+12	5.53e+12	5.29e+12
Maximum log-likelihood	-16382.99	-15466.68	-15225.67	-15015.18	-14893.27	-14791.46
Df	1449	1376	1303	1230	1157	1084
Sample size	1594	1594	1594	1594	1594	1594

Abbreviations: AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion), SABIC (Sample-Adjusted Bayesian Information Criterion), G^2 (Likelihood ratio/deviance statistic), X^2 (Chi-Square), Df (Degrees of Freedom)

Figure 2. Fit Statistics and Entropy Across Latent Classes Examining 1-Year Follow-up Obsessive-Compulsive Symptoms



Abbreviations: AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion), SABIC (Sample-Adjusted Bayesian Information Criterion), CAIC (Consistent Akaike Information Criterion)

Table 4B. Posterior probabilities across latent classes examining 1-year follow-up obsessive-compulsive symptoms

Number of Classes	**Posterior Probability**						
2 Classes	0.99	0.99	-	-	-	-	-
3 Classes	0.99	0.97	0.96	-	-	-	-
4 Classes	0.99	0.96	0.95	0.92	-	-	-
5 Classes	0.99	0.96	0.96	0.93	0.91	-	-
6 Classes	0.99	0.96	0.96	0.95	0.94	0.94	-
7 Classes	0.99	0.97	0.95	0.95	0.93	0.93	0.90

Table 4C. Classification of 1-year follow-up obsessive-compulsive symptoms into 5 classes

OCIR items	Class 1 Checking & Ordering (7.80%)	Class 2 Obsessive Thoughts (9.90%)	Class 3 No OCD Symptoms (60.20%)	Class 4 Moderate OCD Symptoms (15.30%)	Class 5 Severe OCD Symptoms (6.80%)
Saved up so many things that they get in the way	0.05	0.03	0.00	**0.02**	**0.23**
Check things more often than necessary	**0.18**	0.09	0.00	**0.02**	**0.47**
Get upset if objects are not arranged properly	**0.18**	0.00	0.00	0.00	**0.21**
Feel compelled to count while doing things	0.06	0.00	0.00	0.00	**0.16**
Find it difficult to touch an object when it has been touched by others	0.09	0.00	0.00	**0.01**	**0.10**
Difficult to control my thoughts	0.06	**0.13**	0.00	**0.08**	**0.75**
Collect things I do not need	0.05	0.01	0.00	**0.01**	**0.27**
Repeatedly check doors, windows, drawers, etc.	0.10	0.02	0.00	**0.01**	**0.26**
Get upset if others change the way I've arranged things	**0.27**	0.01	0.00	**0.01**	**0.33**
Feel I've to repeat certain numbers	0.03	0.01	0.00	0.00	**0.13**
Wash or clean myself because I feel contaminated	0.12	0.01	0.00	**0.02**	**0.15**
Get upset by unpleasant thoughts that come into my mind against my will	0.07	**0.09**	0.00	**0.05**	**0.66**
Avoid throwing things away because afraid might need them later	0.09	0.03	0.00	**0.01**	**0.43**
Repeatedly check gas, water taps, and light switches after turning them off	0.07	0.02	0.00	0.00	**0.21**
Need things to be arranged in a particular way	**0.15**	0.00	0.00	0.00	**0.19**
Feel that there are good and bad numbers	0.10	0.01	0.00	0.00	**0.15**
Wash my hands more often and longer than necessary	0.06	0.01	0.00	0.00	**0.12**
Frequently get nasty thoughts and have difficulty in getting rid of them	0.03	0.03	0.00	**0.02**	**0.53**

Abbreviations: OCIR (Obsessive-Compulsive Inventory-Revised), OCD (obsessive-compulsive disorder)

Table 5. Multinomial regression between 5-latent class obsessive-compulsive symptoms and sleep disturbances

Model 1**	**Baseline 5-OCD classes***	**OR [95% CI]**
PSQI Sleep Disturbances Domain Score	No OCD Symptoms	Reference
	Moderate OCD Symptoms	1.04 [0.98-1.10]
	Severe OCD Symptoms	**1.24 [1.17-1.30]**
	Checking and Ordering	**1.13 [1.07-1.18]**
	Checking, Hoarding and Obsessive Thoughts	**1.15 [1.10-1.21]**
Model 2**	**Follow-up 5-OCD classes***	**OR [95% CI]**
PSQI Sleep Disturbances Domain Score	No OCD Symptoms	Reference
	Moderate OCD Symptoms	0.96 [0.86-1.08]
	Severe OCD Symptoms	**1.19 [1.13-1.26]**
	Checking and Ordering	**1.09 [1.03-1.14]**
	Obsessive Thoughts	**1.06 [1.02-1.10]**

Abbreviations: obsessive-compulsive disorder (OCD), Obsessive-Compulsive Inventory-Revised (OCI-R), Pittsburgh Sleep Quality Index (PSQI), odds ratio (OR), confidence interval (CI)

*Baseline is defined as initial enrollment in a university/college program, and follow-up is 1 year following enrollment in a university/college program.

**Model 1 and 2 adjusted for sex, age, ethnic group, sexual orientation, BMI, work status, and depression threshold

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5. Discussion

5.1. Addressing literature gap

Young adulthood is associated with significant changes in an individual's social, financial, and academic demands, resulting in an elevated risk of developing obsessive-compulsive symptoms and sleep disturbances.[1,2] Hence, it is important to target early diagnosis and intervention in this population. Previous research studies have consistently indicated a positive association between disrupted sleep and obsessive-compulsive symptoms.[3–5] Despite this robust relationship, sleep disturbances remain excluded from the diagnostic criteria for OCD in the Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5).[6] However, the diagnostic criteria for other mental health disorders, such as major depressive disorder and generalized anxiety disorder, include sleep difficulties as important.[7–9] A possible reason for this exclusion in the OCD criteria may be due to limited research from small, cross-sectional samples, obscuring their ability to infer temporality or causality.[10–13] Therefore, to address this literature gap, this thesis comprehensively examined the association between obsessive-compulsive symptoms and sleep disturbances through network analyses, longitudinal analyses and a latent class analysis in a large, global post-secondary student cohort.[14]

5.2. Summary of findings

Through network analyses, I explored the relationship between sleep disturbances and OCD dimensions (i.e. checking, washing, ordering, hoarding, obsessing and neutralizing). To our knowledge, this is the first study to conduct a network analysis of sleep symptoms and OCD symptoms among a student cohort. Network analysis offers an important point of view in the field of mental health research, as this approach takes into account the individual symptoms of a mental health disorder.[15] This method goes beyond simply adding individual items on an instrument to determine an overall score, instead it analyzes complex relationships and identifies clusters of interactions between symptoms.[16] Factors that are more central in the network have an influential effect on other variables. In the present study, OCD symptoms of ordering, checking, unpleasant thoughts and sleep disturbance symptoms of nightmares were found to be more central in our networks. The OCD symptom of unpleasant thoughts was also weakly correlated

with the sleep disturbance of having nightmares. Findings from the network analyses indicate the importance of these symptoms for targeted treatments in post-secondary students.

The bidirectionality between sleep disturbances and obsessive-compulsive symptoms was examined through a longitudinal analysis. Both hypotheses were considered: 1) OCD symptoms at baseline associated with sleep disturbances at 1-year follow-up and 2) sleep disturbances at baseline associated with OCD symptoms at 1-year follow-up. The present study found stronger support for sleep disturbances to be a potential risk factor for the onset of obsessive-compulsive symptoms. Students reporting higher sleep disturbances in the first year of post-secondary career were more likely to experience OCD symptoms at 1-year follow up, even after adjusting for baseline OCD symptoms, depression threshold and sociodemographic variables. However, further research from non-clinical samples is needed to investigate the role of poor sleep patterns in the onset of OCD symptoms.

Individuals with OCD have a common feared consequence, whether it is of contamination, imperfection, or harm to themselves or others. As a result, OCD presents with a significant amount of heterogeneity in its subtypes (e.g., checking, hoarding, ordering, etc.) which is also why OCD is one of the most misunderstood psychiatric conditions.[17,18] To better understand the heterogeneity of OCD symptom profiles, I also conducted a latent class analysis. Five classes were identified in both baseline and 1-year follow-up data: 1) checking and ordering and 2) checking, hoarding and obsessive thoughts using baseline data, and 2) obsessive thoughts using follow-up data, 3) no OCD symptoms, 4) moderate OCD symptoms and 5) severe OCD symptoms. Furthermore, the OCD class of checking, and ordering/symmetry was found to be specifically linked to sleep disturbances. The identification of five OCD classes indicates the heterogeneity of this disorder and this may also be clinically valuable as interventions may consider the OCD subtype when treating patients.

5.3. Implications

Results from this thesis indicated that sleep disturbances in the first-year of post-secondary career may be a potential risk factor for OCD symptoms at the 1-year follow-up among post-secondary students. In align with this result, a recent large-scale study of 10,460 university

students found that insomnia, sleep duration and sleep latency at baseline were associated with the onset of a major depressive episode and generalized anxiety disorder (GAD) at 1-year follow-up.[19] These findings suggest that sleep disturbances may be an important risk factor for mental health symptoms. Furthermore, previous research, using pre-post study designs and randomized controlled trials, has found that sleep-focused interventions can moderately improve sleep problems and may also have a small improvement in depression and anxiety scores.[20,21] So far, cognitive behavioral therapy and behavioral therapy have both shown promise in decreasing sleep problems among young adults.[22] Therefore, findings from this thesis suggest policy implications, for example, student campus initiatives may be implemented to raise awareness regarding the importance of regular sleep patterns. Post-secondary institutions may also conduct psychoeducational interventions including sleep hygiene workshops as part of wellness programs. As a result, these sleep interventions may reduce mental health symptoms, including OCD symptoms, in young adults.

From a clinical perspective, understanding the link between OCD and sleep disturbances is important, as there is limited knowledge regarding OCD subtypes. OCD is an underdiagnosed mental illness, with many individuals not seeking treatment for their mental health symptoms.[18,23] A previous systematic review has noted that there is a significant delay between the onset of symptoms and the beginning of treatment, with a mean delay ranging from 3 years to 17 years.[24] Some studies have also suggested that delays in treatment initiation may be due to a lack of recognition of OCD symptoms by healthcare providers. In fact, a cross-sectional study among 208 primary physicians found that approximately 50% of OCD cases may be misdiagnosed.[25] They noted that the subtype of OCD played a significant role in determining whether the physician provided a correct diagnosis or not. Therefore, in the present thesis, network analyses and a latent class analysis were explored to identify clusters of OCD symptoms that were most importantly linked with sleep disturbances.

Findings from both the studies in this thesis found checking and ordering to be important OCD symptoms. Previous literature has noted both of these dimensions to be the most common symptoms of OCD.[26,27] A few examples of checking rituals include constantly re-checking if appliances are off before leaving home or replaying a conversation in one's mind multiple times

to check that nothing "wrong" was said. An example of an ordering symptom may include arranging things in a symmetrical way until it feels "just right." Both checking and ordering are forms of compulsions that can be extremely time-consuming, distressing, and have been specifically shown to be linked to sleep debt and sleep disturbances.[28] Some neuropsychological models have suggested that checking can be associated with a lack of behavioral control due to impairment in working memory and executive function.[29] Furthermore, compulsive checking has also been linked to higher doubt, anxiety and lower confidence.[30] Similarly, the ordering/symmetry dimension has been associated with poorer insight, and it has been noted that individuals with this subtype are less likely to seek treatment.[31,32] Both of these dimensions, checking and ordering, may play a crucial role in the symptomology of OCD, including post-secondary student populations. Educational campaigns/initiatives regarding OCD subtypes may be important to decrease misdiagnosis of this mental disorder. However, further research regarding OCD subtypes and their association with sleep disturbances is required.

5.4. Strengths and limitations

This thesis presents several strengths. First, the data source for both the studies in this thesis was from the UNILIFE-M study, including a diverse student cohort from various countries. This suggests that our findings may have strong external validity. Second, we utilized OCI-R and PSQI Sleep Disturbances domain to examine OCD symptoms and sleep disturbances. Both of these instruments have good psychometric properties and internal-external validity, providing a granular assessment of these symptoms. Third, this study involved the collection of self-reported data at the beginning of the academic career and at 1-year follow-up, allowing for a comprehensive examination of subjective experiences among students over a period of time. Fourth, this study was conducted among post-secondary students who are at the highest risk of developing mental health symptoms and sleep problems, therefore, capturing the most vulnerable period. Fifth, this thesis utilized a variety of methodological approaches such as network analyses which provided a novel perspective by highlighting the complex relationship between OCD symptoms and sleep disturbances.

However, this thesis also has few limitations. First, participants self-reported their OCD symptoms and sleep disturbances, which may have increased the likelihood of response bias, as

some cultures tend to have a mental health stigma that might have led to underreporting of OCD symptoms.[33] Second, self-reported questionnaires may have been prone to recall bias, as individuals may have miscalculated their frequency of sleep difficulties and OCD symptoms. Third, we used a convenience sampling approach, which may have introduced selection bias. Students with mental health problems may have been overrepresented in this sample because they might have been interested in the topics of the survey. A few sites also used incentives (i.e., bonus study credits or gift cards) which may have further increased selection bias as students who were in need of study credits or gift cards may have been more likely to participate in this survey. Fourth, we only analyzed data from those students with supra-threshold symptoms of OCD and sleep symptoms. As a result, we cannot generalize these findings to students who do not present with any sleep symptoms or OCD symptoms. Fifth, the longitudinal study had an attrition rate of 45.29% suggesting that those who dropped out of the study before follow-up assessment may have been different in their characteristics than those who remained in the study.

Despite these limitations, this thesis presented an innovative and methodologically robust approach to examine the association between sleep disturbances and obsessive-compulsive symptoms, with potential policy implications for early intervention in student populations.

5.5. Future research scope

Further research addressing the association between OCD and sleep is required as it not only leads to individual suffering but also presents with substantial economic costs. OCD is a widely disabling psychiatric condition that severely impacts an individual's quality of life.[34] Individuals with this illness spend a considerable amount of time engaging in obsessions and compulsions, with some estimates suggesting that obsessions take up an average of 5.90 hours per day and compulsions take up an average of 4.60 hours per day.[35] As a result, OCD has been associated with absenteeism from work and presents a significant burden in terms of societal costs.[36] Individuals with OCD often take time off from work, resulting in financial loss to them and also detrimentally affecting their career. Furthermore, previous research has also shown that sleep disturbances may further increase the risk of unemployment and lead to lost productivity.[37] Even caregivers of individuals with OCD have reported absenteeism from work, stress, depression and

decreased relationship satisfaction. Therefore, further research exploring the relationship between OCD and its potential risk factors, such as sleep disturbances, is important.

As previously mentioned, most research studies examining sleep disturbances and OCD symptoms have been conducted in small clinical samples. However, future research should focus on extending longitudinal analyses to larger cohorts of clinical samples, so clinicians can better understand the role of sleep disturbances in the onset of OCD. Furthermore, the present longitudinal study had a relatively high attrition rate (45.29%), so future longitudinal studies in clinical samples can consider incorporating more retention strategies to reduce dropout.

Future research may also conduct pragmatic trials investigating the effectiveness of sleep interventions among individuals with OCD. As opposed to randomized-controlled trials, pragmatic trials allow clinicians to evaluate interventions in real-world settings.[38] For instance, a recent pragmatic trial among individuals with insomnia disorder found sleep restriction therapy to improve insomnia symptoms compared to a sleep hygiene intervention.[39] Previous studies have also shown support for digital sleep interventions such as mobile app-based cognitive behavioral therapy for insomnia (MCBTi) in improving insomnia, depression and quality of life.[40] Similarly, future studies may carry out pragmatic trials to examine the role of sleep interventions, including digital sleep interventions, in improving OCD symptoms. Furthermore, young adulthood is the period most prone to the development of mental health symptoms, therefore, these sleep interventions targeting early prevention of OCD symptoms, may also be highly valuable for post-secondary students.

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Appendices

Appendix A: Ethics Certificate from the University of Ottawa Research Ethics Board

17/11/2025

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-11-24-10937
Titre du projet / Project Title	Investigating the Association Between Obsessive-Compulsive Symptoms and Sleep Patterns in a Global Post-Secondary Student Cohort- UniLife-M
Type de projet / Project Type	Thèse de maîtrise / Master's thesis
Statut du projet / Project Status	Renouvelé / Renewed
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	14/11/2024
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	13/11/2026

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Saguna KATYAL	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Chercheur Principal / Principal Investigator
Ian COLMAN	Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health	Superviseur / Supervisor

Conditions spéciales ou commentaires / Special conditions or comments

17/11/2025

Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout évènement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completedfour weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Coordonateur / COORDINATOR
Coordonnateur de l'éthique / Ethics Coordinator
Pour/For **Daniel LAGAREC** Président(e) du/ Chair of the **Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board**

Appendix B: Obsessive Compulsive Inventory-Revised Instrument (OCI-R)

The following statements refer to experiences that many people have in their everyday lives. Circle the number that best describes **HOW MUCH** that experience has **DISTRESSED or BOTHERED you during the PAST MONTH.** The numbers refer to the following verbal labels: 0 = Not at all, 1= A little, 2 = Moderately, 3 = A lot and 4= Extremely.

Items	0= Not at all	1= A little	2 = Moderately	3 = A lot	4= Extremely
1. I have saved up so many things that they get in the way.					
2. I check things more often than necessary.					
3. I get upset if objects are not arranged properly.					
4. I feel compelled to count while I am doing things.					
5. I find it difficult to touch an object when I know it has been touched by strangers or certain people.					
6. I find it difficult to control my own thoughts.					
7. I collect things I don't need.					
8. I repeatedly check doors, windows, drawers, etc.					
9. I get upset if others change the way I have arranged things.					
10. I feel I have to repeat certain numbers.					
11. I sometimes have to wash or clean myself simply because I feel contaminated.					
12. I am upset by unpleasant thoughts that come into my mind against my will.					

Appendix C: Pittsburgh Sleep Quality Index (PSQI) Component 5 Score Items

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reasons, please describe:				