RESIDENTIAL ENVIRONMENTS AND SLEEP-DISORDERED BREATHING IN BANGKOK THAILAND: A REPEATED CROSS-SECTIONAL STUDY

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Public Health
College of Public Health Sciences
Chulalongkorn University
Academic Year 2017

สภาพแวดล้อมในบ้านเรือนและภาวะการหยุดหายใจในขณะนอนหลับ ในกรุงเทพมหานคร ประเทศไทย:การศึกษาแบบสำรวจซ้ำ

นางสาวสัตตมาส ลรรพรัตน์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
สาขาวิชาสาธารณสุขศาสตร์
วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2560

Thesis Title	RESIDENTIAL ENVIRONMENTS AND SLEEP-DISORDERED BREATHING IN BANGKOK THAILAND: A REPEATED CROSS-SECTIONAL STUDY
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สัตตมาส ลรรพรัตน์ : สภาพแวดล้อมในบ้านเรือนและภาวะการหยุดหายใจในขณะนอนหลับ ในกรุงเทพมหานคร ประเทศไทย:การศึกษาแบบสำรวจซ้ำ (RESIDENTIAL ENVIRONMENTS AND SLEEP-DISORDERED BREATHING IN BANGKOK THAILAND: A REPEATED CROSS-SECTIONAL STUDY) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. ณัฏฐา ฐานีพานิชสกุล, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ผศ. พญ. นฤชา จิรกาลวสาน, 167 หน้า.

มลพิษทางอากาศในบ้านเรือนเป็นปัจจัยหนึ่งที่มีความสัมพันธ์กับภาวะการหยุดหายใจขณะนอนหลับ การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างความเข้มข้นของฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตร และความรุนแรงของภาวะการหยุดหายใจขณะนอนหลับในผู้ป่วย การศึกษาแบบการวัดซ้ำนี้ได้นำมาใช้เพื่อศึกษาผู้ป่วยจากศูนย์นิทราเวชของโรงพยาบาลจุฬาลงกรณ์ กรุงเทพมหานคร จำนวน 81 คน ระหว่าง มกราคม 2559 - เมษายน 2560 โดยแบ่งเป็นฤดูแล้ง (พฤษภาคม-สิงหาคม 2559) และฤดูฝน (ธันวาคม 2559-มีนาคม 2560) กลุ่มตัวอย่างได้ถูกสอบถาม ข้อมูลประชากร โรคประจำตัว และลักษณะสิ่งแวดล้อมภายในห้องนอน ในขั้นเริ่มต้นการศึกษาโดยใช้แบบสอบถาม ส่วนคุณภาพการนอนหลับ สภาวะสิ่งแวดล้อมภายในห้องนอน (ฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตร อุณหภูมิ และความชื้น) และระดับฮอร์โมนเมลาโทนินในปัสสาวะได้ถูกเก็บทั้งสองฤดูกาล ผลการวิจัย พบว่าประชากรส่วนใหญ่มีภาวะการนอนหลับที่ไม่ดี และมีภาวะการหยุดหายใจขณะนอนหลับขั้นรุนแรง เมื่อทำการหาความสัมพันธ์ระหว่างค่าเฉลี่ย 1 ปีของความเข้มข้นของฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตรกับดัชนีการหยุดหายใจและหายใจแผ่ว (Beta = 1.04, p value = 0.021) และดัชนีการหายใจผิดปกติ (Beta = 1.07, p value = 0.013) พบว่ามีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติ นอกจากนี้ อุณหภูมิภายในห้องนอนที่เพิ่มขึ้นขณะนอนหลับมีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับคุณภาพการนอนหลับที่แย่ลง (AOR = 1.46, 95% CI; 1.01, 2.10; p value = 0.044) เมื่อแบ่งตามฤดูกาล พบความสัมพันธ์ระหว่างค่าเฉลี่ยความเข้มข้นของฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตรกับดัชนีการหายใจผิดปกติ ซึ่งในฤดูแล้งพบว่ามีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติ (Beta = 0.59, p value = 0.040) แต่ไม่พบความสัมพันธ์ในฤดูฝน (Beta =0.39, p value = 0.215) อย่างไรก็ ตามไม่พบความสัมพันธ์ระหว่างค่าเฉลี่ยความเข้มข้นของฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตรกับคุณภาพการนอนหลับ นอกจากนี้ยังพบความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติระหว่างค่าเฉลี่ยความเข้มข้นของฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตรกับระดับฮอร์โมนเมลาโทนินในปัสสาวะที่ต่ำ (AOR = 1.06, 95% CI; 1.00, 1.11; p value = 0.048) และพบว่าเมื่อห้องนอนของกลุ่มตัวอย่างที่มีค่าเฉลี่ยความเข้มข้นของฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโคร เมตรเพิ่มขึ้น 1 ไมโครกรัมต่อลูกบาศก์เมตรมีความสัมพันธ์กับการเพิ่มความเสี่ยงของการลดลง (≤ 15.24 ng/mg) ของความเข้มข้นฮอร์โมนเมลาโทนิน ร้อยละ 7 อย่างมีนัยสำคัญทางสถิติ (AOR = 1.07; 95% CI : 1.01-1.13; p value = 0.034) สรุปผลการศึกษาได้ว่า ประชากรหรือผู้ป่วยที่มีภาวะการหยุดหายใจขณะนอนหลับควรได้รับความรู้เกี่ยวกับสภาวะสิ่งแวดล้อมภายในห้องนอนโดยเฉพาะอย่างยิ่งข้อมูลฝุ่นละอองขนาดเส้นผ่านศูนย์กลางเล็กกว่า 10 ไมโครเมตร เพื่อการปรับเปลี่ยนพฤติกรรมอันส่งผลต่อการรับสัมผัสฝุ่นละอองและสร้างสภาวะห้องนอนที่ดีในการลดระดับความรุนแรงภาวะการหยุดหายใจขณะนอนหลับ

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต .....

ปีการศึกษา 2560 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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5779174753 : MAJOR PUBLIC HEALTH
KEYWORDS: BEDROOM ENVIRONMENTS / PARTICULATE MATTER / OBSTRUCTIVE SLEEP APNEA / SLEEP QUALITY / URINARY MELATONIN

SATTAMAT LAPPHARAT: RESIDENTIAL ENVIRONMENTS AND SLEEP-DISORDERED BREATHING IN BANGKOK THAILAND: A REPEATED CROSS-SECTIONAL STUDY. ADVISOR: ASST. PROF. NUTTA TANEEPANICHSKUL, Ph.D., CO-ADVISOR: ASST. PROF. NARICHA CHIRAKALWASAN, M.D., 167 pp.

Since epidemiological associations have demonstrated the effects of long-term air pollution to OSA through a physiological mechanism linking particulate matter exposure to OSA. We enrolled 81 participants from the Excellence Center for Sleep Disorders at King Chulalongkorn Memorial hospital, Bangkok, Thailand. This study consists of two seasons (the wet and the dry seasons), which it started during the period of January in 2016 to April in 2017. Personal information, bedroom environmental characteristics, subjective sleep quality, underlying diseases, bedroom environmental conditions (PM_{10}, temperature, and relative humidity), and urinary melatonin were obtained by a face-to-face interview, medical record, field analysis, and laboratory analysis respectively. A big proportion of participants experienced poor sleep and was suffered from severe OSA. An elevation in 1-year mean PM_{10} concentration was significantly associated with an increase in an apnea-hypopnea index (Beta = 1.04, p value = 0.021), and respiratory disturbance index (Beta = 1.07, p value = 0.013). An increase of bedroom temperature during sleep was significantly associated with poorer sleep quality (AOR = 1.46, 95% CI; 1.01, 2.10; p value = 0.044). Associations between PM_{10} concentration and respiratory disturbance index were observed in the dry season (Beta = 0.59, p value = 0.040) but not in the wet season (Beta =0.39, p value = 0.215). PM_{10} was not associated with subjective sleep quality. A significant association between PM_{10} concentrations and low levels of urinary melatonin was found (AOR = 1.06, 95% CI; 1.00, 1.11; p value = 0.048), and participants whose bedroom had an elevation of PM_{10} concentrations, it has a statistically significant 1.07-fold increased odds of low melatonin concentrations (≤ 15.24 ng/mg) (95% CI; 1.01-1.13; p value = 0.034). This research suggests that lowering in exposure to particulate matter and suitable bedroom environments may lessen the severity of OSA, promote good sleep, and improve or maintain melatonin level.

Field of Study: Public Health
Academic Year: 2017

Student's Signature .....
Advisor's Signature .....
Co-Advisor's Signature .....

ACKNOWLEDGEMENTS

I owe my deepest gratitude to my major advisor, Asst. Prof. Dr. Nutta Taneepanichskul for her essential role in my doctoral work. It has been an honor to be her first Ph. D. student. I really appreciate all her contributions of time, feedback, advice, and encouragement. She has been extraordinary tolerant and wonderfully supportive to my PhD life. Moreover, I would like to show my greatest appreciation to my co-advisor, Asst. Prof. Naricha Chirakalwasan, M.D., which she provided me with every bit of guidance, assistance and expertise. Without their continuous optimism concerning this work, enthusiasm, encouragement and guidance this thesis would hardly have been completed.

Additionally, I would like to express my special thanks to Prof. Surasak Taneepanichskul, M.D., my chairman, for providing constructive feedback about my research. Also, I would like to thank Assoc. Prof. Wattasit Siriwong and Assoc. Prof. Ratana Somrongthong for being part of my thesis committee and giving insightful comments and suggestions. Advice and comments given by Assoc. Prof. Sirimon Reutrakul, M.D., my external committee, has been a great help in my research and journal.

This work would not be possible unless I receive full permission for a recruitment of participants from the Excellence Center for Sleep Disorders at King Chulalongkorn Memorial hospital. I also received generous support from sleep lab officers and participants. I would like to offer my special thanks to all lecturers and staffs of College of public health sciences for their guidance and assistance. I am particularly thankful to the 90th anniversary of Chulalongkorn university fund (Ratchadaphiseksomphot Endowment Fund), Chulalongkorn Academic Advancement into Its 2nd Century Project (CUAASC) and Risk Analysis Health Surveillance for Thai Population (C-RAHS) (GCURS_59_06_79_01 RAHS 11) for their financial support.

Away from work, special thanks go to my friends at my college, Dr. Parichat and Ms. Ratanee for their help and all the great times that we have shared. I am particularly thankful to Ms. Wanwara for her infinite patience and support. Finally, thanks must go to my parents and family for love and inspiration throughout my life.

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ABBREVIATIONS

AASM	American academic of sleep medicine
AHI	Apnea-hypopnea index
aMT6s	A 6-sulfatoxymelatonin
BMI	Body mass index
CPAP	Continuous positive airway pressure
CSM	Chronotype of sleep disordered
ESS	Excessive daytime sleepiness
GAD-7	Generalized Anxiety Disorder
ISI	Insomnia Severity Index
NIOSH	National institute for occupational safety and health
OSA	Obstructive sleep apnea
PHQ-9	Patient Health Questionnaire-9
PM_{10}	Particulate matters with an aerodynamic diameter of less than 10 μm
PSG	Polysomnography
PSQI	Pittsburgh Sleep Quality Index
RDI	Respiratory disturbance index
REM	Rapid eye movement sleep
RH	Relative humidity
SDB	Sleep disordered breathing
SWS	Slow wave sleep
WHO	World health organisation

CHAPTER I

INTRODUCTION

1.1 Backgrounds and Rationale

Recently, the topic of sleep has been raised to be concerned due to its basic need of all living creatures and its essential for human being. Though, it remains a piece of the puzzle in biology (Sehgal & Mignot, 2011). Definition of sleep is variety that depends upon aspect of researchers. It might be characterized by brain-wave activity change, body temperature, heart rate, respiratory change and other physiological functions. Typically, sleep is either posture of lying down with eyes closed or decreased responsiveness to external stimuli (Hirshkowitz & Sharafkhaneh, 2005). It plays a crucial role in physiological procedure especially significant for restorative functions such as muscle growth, tissue repair, protein synthesis, and growth hormone release, which are critical for driving daytime function (Edwards et al., 2010). It is also critical to regulate the immune system (Prather et al., 2015), metabolism (Hanlon & Van Cauter, 2011), memory (Schonaue et al., 2014) , and learning (Rasch & Born, 2013). Moreover, sleep has an effect on emotions, behavior, and health (Thorpy, 2011).

There are many adverse health effects of inadequate sleep whether short term or long term consequences. The short-term consequences, poor sleep has an influence on analytical system, emotional state, skill of learning, fatigue, lack of energy, tiredness, and drowsiness, which can elevate the risk of serious accidents and injury (Sigurdson & Ayas, 2007). The long-term consequences, chronic sleep deprivation may cause metabolic dysfunction (Strine & Chapman, 2005), diabetes, obesity, high blood pressure, cardiovascular disease, stroke, cancer, mood disorder such as depression, anxiety, and mental stress, immune dysfunction, and even early mortality (Gallicchio & Kalesan, 2009; Luyster, Strollo, Zee, & Walsh, 2012). In addition, a chronic sleep insufficiency is probably linked to societal troubles such as

motor vehicle accidents, industrial failures, unhealthy behaviors, and other occupational inaccuracy (Grandner et al., 2015).

In the beginning, obstructive sleep apnea (OSA) was considered as a rare disorder, but it has been well known as a common syndrome in adult population recently (Kim et al., 2004). OSA is a chronic condition characterized by a recurrent collapse of the upper airway during sleep resulting in sleep disruption and ensuing daytime sleepiness (Punjabi et al., 2009). It is a subtype of sleep disordered breathing (SDB) which is one of the most common sleep disorders that occurs at all ages, although it is normally found amongst the middle-aged and elder population (Ancoli-Israel, 2009). OSA is being considered as a possible cause of morbidity (hypertension, cardiovascular disease, and diabetes) and mortality (Ancoli-Israel, 2009; Bixler et al., 2001; Naresh M. Punjabi, 2008; Young, Shahar, Nieto, & et al., 2002). Furthermore, it leads to cause motor vehicle and public transportation accidents, which it is now also considered a serious social concern, and gradually decline in quality of life (Engleman & Douglas, 2004). One research revealed men with OSA were significantly more likely to have at least 1 motor vehicle accidents in 5 years (AOR = 3.4 for habitual snorers, 4.2 for apnea-hypopnea index (AHI), AHI = 5-15, and 3.4 for AHI > 5) (Young et al., 1997). Although the burden of adverse health results, epidemiologic information whether on all-cause or cause-specific mortality in OSA is still limited and uncertainty remains with regard to effect modification by other factors.

Globally, OSA affects approximately 3 to 7% of male adults and 2 to 5% of female adults (Punjabi, 2008). Prevalent condition of OSA in the modern society, estimated to affect roughly 9% of women and 24% of men in general population but a majority of those remain in doubt (Young et al., 2002). The previous study pointed that men had the prevalence of OSA (AHI ≥ 10 and daytime symptoms) 3.9% and women 1.2%, terminate in an overall ratio of sleep apnea for men to women of 3.3:1 (p = 0.0006). It also showed the higher prevalence of OSA in menopausal compared with premenopausal women (1.2 and 0.6%, respectively) (Bixler et al., 2001). In adult population aged 65 to 95 years, Ancoli-Israel and colleagues indicated that the prevalence of OSA (AHI ≥ 20) was 39% in women and 51% in men (Ancoli-Israel et al., 1991). In the community dwelling of older women and men indicated

the prevalence of OSA (AHI ≥ 15) were 24% and 26%, respectively (Kezirian et al., 2009; Mehra et al., 2007).

Several studies on the SDB and OSA prevalence in Asian countries lately, the first study in Asia revealed the prevalence of SDB and OSA using full Polysomnography (PSG) was 8.1% and 4.1%, respectively amongst Chinese men aged 30-60 years. In the later year, the same researcher found the prevalence of SDB and OSA in women in the same age group was 3.7% and 2.7%, respectively (Ip et al., 2001; Ip et al., 2004). Moreover, the prior study showed the prevalence of SDB and OSA among employed Indian men aged 35-65 years in urban India with a limited PSG were 19.5% and 7.5%, respectively (Udwadia, Doshi, Lonkar, & Singh, 2004). Furthermore, the research on Korean middle-aged group aged 40-69 years reported the prevalence of OSA in women and men (AHI $\geq$ 5) were 16% and 27%, respectively (J. Kim et al., 2004). In Thailand, it troubles approximately 4.8% and 1.9% in Thai men and women, respectively (Neruntarat & Chantapant, 2011). It is a pandemic global public health problem in both developed and developing countries (Gottlieb et al., 2010; Redline et al., 2010). Also, it may show a higher prevalence in poorer urban environments (Mirrakhimov, Sooronbaev, & Mirrakhimov, 2013).

Causal risk factors of OSA are likely to be a vital key to address the high prevalence of OSA. There are severally potential modifiable risk factors for OSA, including obesity, alcohol consumption, tobacco use, nasal congestion, estrogen depletion in menopause (Peppard & Young, 2004), craniofacial shape (Lee, 2008), allergic rhinitis (Chirakalwasan & Ruxrungtham, 2014), and environmental exposures that increase airway inflammation or decrease neuromuscular output to the upper airway (Ruangkana et al., 2014). Moreover, genetics may partially describe in the ethnic clustering of these phenotypes, modified by cultural and environmental factors (Lee, 2008). Asian adults are at risk for a more severe degree of OSA even they got lower degrees of obesity when compared to Caucasians (Villaneuva et al., 2005). Another study compared 105 Asian patients with 99 Caucasians matched for age, gender and body mass index (BMI). The outcomes showed that ethnic group was associated with severe OSA, with an odds ratio of 2.51 compared to Caucasians (Ong & Clerk, 1998). However, there is none of studies have reported on an

association between severity of OSA and residential environments among OSA patients in Thailand, particularly in urban areas, where have high amounts of pollution.

Bedroom environments, such as light, ambient temperature, and humidity are connected to human sleep pattern (Grigsby-Toussaint et al., 2015). Nocturnal light exposure is a primary external factor that plays a crucial role in modulating sleep patterns and mood (Dumont & Beaulieu, 2007). There are two systems that manage sleep: 1) sleep-wake homeostasis and 2) the circadian biological clock, which nocturnal light exposure has an influence on both through melatonin hormones (Tsuzuki et al., 2015). A hundred lux of illumination is sufficient to suppress nocturnal melatonin secretion and delays the circadian rhythm (Diane et al., 1994). The previous study showed the adjusted odds ratio (AOR) of using light bulb and Pittsburgh Sleep Quality Index (PSQI) score of > 5 was 3.7 (95% confidence interval [CI], 1.1–12.6; P < 0.05) (Kayaba et al., 2014).

Ambient temperature is primarily regulated by water evaporation through breathing and by the release of human body heat through the skin. Ambient temperature within bedroom is likely to be an essential impact on the quality of sleep, which is concerned with change in sleep architectures (Haskell et al., 1981; Kayaba et al., 2014). Kayaba and colleagues reported that the adjusted odds ratio (AOR) for Pittsburgh Sleep Quality Index (PSQI) score of > 5 and without air conditioner in bedroom was 1.8 (95% CI, 1.0–3.3; P < 0.05) (Kayaba et al., 2014). Furthermore, humidity is considered as one crucial factor. It improves heat stress during sleep, which increases wakefulness and reduces slow wave sleep (SWS) and rapid eye movement sleep (REM). One research indicated the difference mean of wakefulness between two environments: 1) neutral and dry climate (ambient temperature (Ta) =26^{o}C, relative humidity (RH) =50%, ambient pressure (Pa)=12.6 Torr), 2) hot and humid climate (Ta=32^{o}C, RH=80%, Pa=28.5 Torr). The result showed that the amount of wakefulness increased significantly when the temperature was 26 ^{o}C to 32 ^{o}C (38.7±11.6) comparing to 26 (17.6±9.6), (T-value = -3.96) (Okamoto-Mizuno, Tsuzuki, Mizuno, & Iwaki, 2005). According to a prior study reported the best range of air temperature for good sleep is 24 to 26^{o}C at 50%RH (Minhee, Chungyoon,

& Jinkyu, 2010). However, Jokic and colleagues found that there was not a significant association significant association between humidity and the severity of OSA (Jokic et al., 1999). Furthermore, the previous study also indicated a strong relation between an increase in temperature and elevation in severity of OSA (Weinreich, Wessendorf, & Pundt, 2015).

One environmental factor that has received less attention in sleep studies is exposure to ambient air pollution in the residence, which can pose adverse health outcomes. Indoor particulate matter (PM) has variety sources, both natural and man-made, which including cigarette smoking, biomass burning whether in stoves or fireplaces, cooking, cleaning activities that may re-suspend dust, and outdoor PM that might move into the home (Breysse et al., 2010). Although PM inside home is dissimilar from outdoor PM in the term of concentration and chemical composition, there are many studies that have revealed an association between PM exposure with adverse health outcomes, such as asthma, chronic obstructive pulmonary disease (COPD), respiratory tract infections (pneumonia), cerebrovascular diseases, ischemic heart diseases (myocardial infarction, MI), heart failure and arrhythmia (Ahluwalia & Matsui, 2011; Koenig et al., 2005; McCormack et al., 2011).

Numerous studies have demonstrated epidemiological associations of the effects of long-term air pollution to OSA through a plausibly physiological mechanism linking particulate matter exposure to OSA (Dockery & Pope, 1994; Elder et al., 2006; Antonella Zanobetti et al., 2010). Particulate matters with an aerodynamic diameter of less than 10 μm (PM_{10}) are coarse particles, which primarily deposit in the upper airways. It can cause irritation or breathing problems (Dockery & Pope, 1994). Particulate matter may afflict with sleep through action on the central nervous system, as well as the upper airways (Elder et al., 2006). It moves from the nose up to the olfactory nerve and gets into the brain, including the striatum frontal cortex, and cerebellum (Wang et al., 2007). Of which is potentially link to elevate brain inflammatory responses (Campbell et al., 2005) and leads to change in neurotransmitter levels (Tin Tin et al., 2008). In addition, the previous study indicated that the elevation of SDB and decreased in sleep efficiency were associated with increasing levels of daily PM_{10} in the summer months, with 11.5% (95% CI: 1.96,

22.01) (Zanobetti et al., 2010). Thus, PM_{10} may play an essential role to OSA through direct mechanical and inflammatory effects on the upper respiratory system (Campbell et al., 2005; Elder et al., 2006; Pope et al., 1991; Tin Tin et al., 2008; Wang et al., 2007; Zanobetti et al., 2010). Additionally, the former study found that there was an association between long-term black carbon exposures with short sleep duration. However, sleep latency was not associated with these exposures (Fang et al., 2014). To the best of our knowledge, no study has comprehensively determined the association of indoor environment conditions with severity of OSA. Given the increased understanding of the effect of indoor air pollution on OSA severity, it is crucial to gain a better understanding of bedroom environment conditions, its relationship with OSA severity and sleep quality.

Melatonin is an endogenous neurohormone, which controls the sleep-wake cycle and serves as a marker of darkness. It is synthesized by the pinealocytes in pineal gland that is located in the brain. Not only pinealocytes can produce melatonin, but also other organs (the retina, gut, bone marrow, and lymphocytes) are known to produce locally melatonin (Carrillo-Vico et al., 2005; Conti et al., 2000). Melatonin and its metabolites can be measured from plasma, saliva, or urine. Therefore, it is widely utilized as a biomarker for detecting circadian rhythm, which can be useful in diagnosing sleep disorders. A 6-sulfatoxymelatonin (aMT6s) is a primary urinary metabolite of melatonin, it has been provided an accuracy of the nocturnal melatonin secretion peak as same as plasma melatonin secretion (Graham et al., 1998). As a nocturnal melatonin secretion has been implied as a key factor for controlling the proper function of sleep-wake cycle (Conti et al., 2000) and the Pittsburgh Sleep Quality Index (PSQI) has been served as a subjective standard tool to assess good and poor sleep quality (Buysse et al., 1989). Additionally, melatonin illustrated a significant effect in promoting sleep quality (Ferracioli-Oda, Qawasmi, & Bloch, 2013). Little known about the association between melatonin concentration and sleep quality. Therefore, this study determined a subjective sleep quality from PSQI among OSA patients was associated with nocturnal urinary melatonin level.

1.2 Objectives

1.2.1 General objective

To determine an association between bedroom environments and severity of OSA patients at King Chulalongkorn Memorial hospital

1.2.2 Specific objectives

1) To assess severity of OSA (AHI) that are associated with sleep quality (PSQI) and urinary melatonin
2) To determine an association between sleep quality (PSQI) and urinary melatonin
3) To investigate an association of bedroom environments with sleep quality (PSQI) and urinary melatonin
4) To compare bedroom environments, sleep quality, excessive daytime sleepiness, and urinary melatonin between the dry and wet seasons

1.3 Research Questions

1) Are bedroom environments associated with severity of OSA?
2) Is severity of OSA associated with sleep quality (PSQI) and urinary melatonin?
3) Is there an association between sleep quality (PSQI) and urinary melatonin?
4) Are bedroom environments associated with sleep quality (PSQI) and urinary melatonin?
5) Are there any differences in bedroom environments, sleep quality, and urinary melatonin when seasonal change?

1.4 Statistical Hypotheses

Hypothesis 1

- Alternative hypothesis (H_1): bedroom environments are associated with severity of OSA.

- Null hypothesis (H_0): bedroom environments are not associated with severity of OSA.

Hypothesis 2

- Alternative hypothesis (H_1): severity of OSA is associated with sleep quality (PSQI) and urinary melatonin.

- Null hypothesis (H_0): severity of OSA is not associated with sleep quality (PSQI) and urinary melatonin.

Hypothesis 3

- Alternative hypothesis (H_1): sleep quality (PSQI) is associated with urinary melatonin.

- Null hypothesis (H_0): sleep quality (PSQI) is not associated with urinary melatonin.

Hypothesis 4

- Alternative hypothesis (H_1): bedroom environments are associated with sleep quality (PSQI) and urinary melatonin.

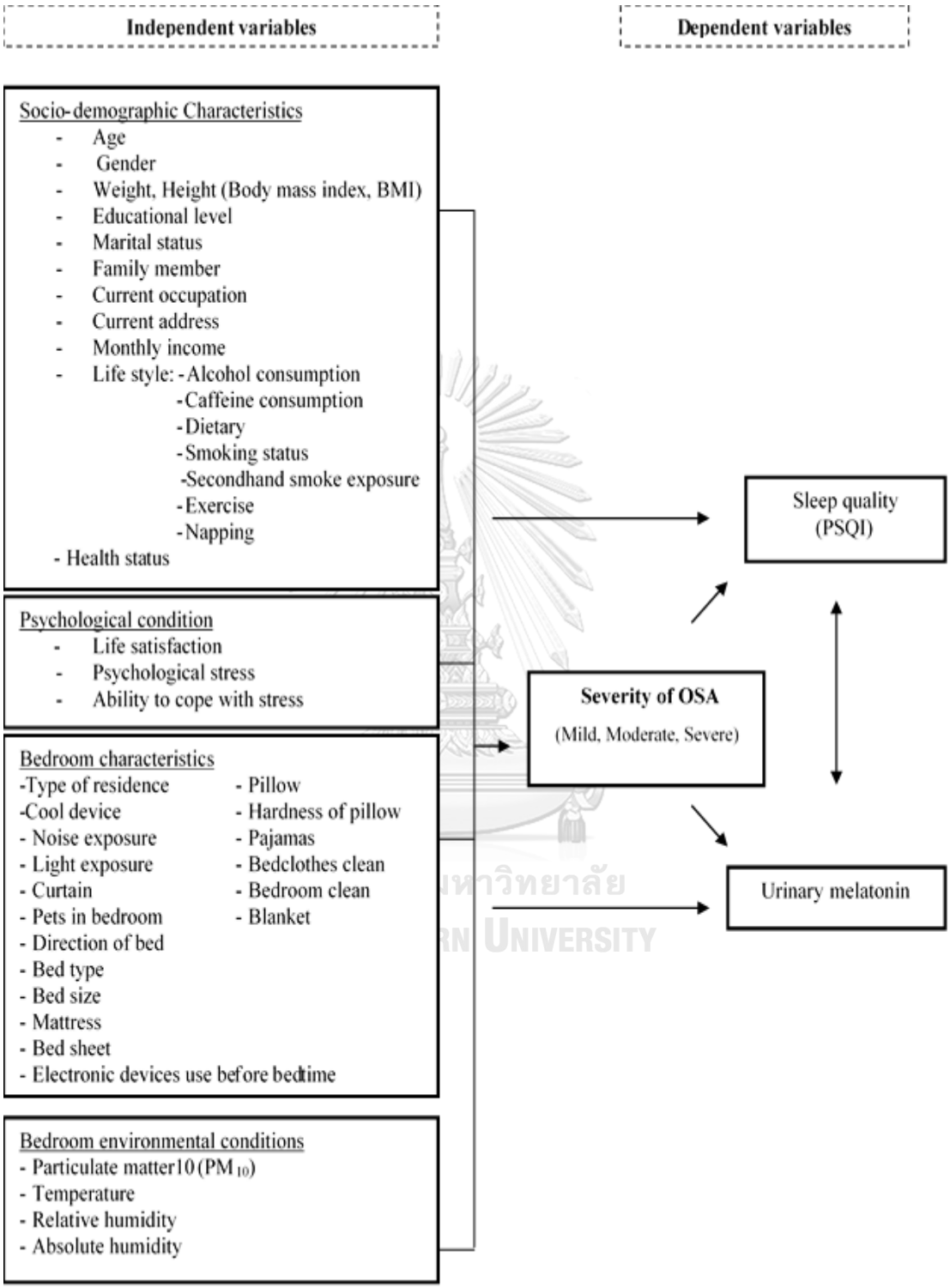
- Null hypothesis (H_0): bedroom environments are not associated with sleep quality (PSQI) and urinary melatonin.

Hypothesis 5

- Alternative hypothesis (H_1): there are differences in bedroom environments, sleep quality, daytime sleepiness and urinary melatonin when seasonal change.

- Null hypothesis (H_0): there are differences in bedroom environments, sleep quality, daytime sleepiness and urinary melatonin when seasonal change.

1.5 Conceptual Framework



1.6 Terms of Definitions

Age referred to at the time of research will be calculated from the date of birth and the date of study.

Gender mentioned to the actual gender of participants.

Weight and height was defined as the actual weight in kilogram and height in centimeter of participant at the study time for calculating body mass index (BMI)

Educational level described as the highest educational level of participants when they will be recruited in this study.

Marital status referred to the status of marriage, single, or widow of participants when they are participating in this study.

Family member was identified as a number of family members that stay in the same house.

Current address referred to the current location of the participants' residence in urban area.

Health status mentioned to respondents' status of health, which includes previous and present health problems.

Current occupation described as the job or career that the participants work for at the present time.

Monthly income mentioned to money that the participants earn it every single month from working.

Alcohol consumption referred to the average number of drink per week (wine, beer, and liquor).

Caffeine consumption described to the average number of drink per week (coffee, tea, and energy drink).

Dietary referred to a kind of food that participants usually have every day, and it also refers to vegetable and fruit consumption.

Current smoker was considered to subjects who smoke at least 5 cigarettes per week almost every week.

Heavy smoker was identified as subjects who smoke approximately 15 and 25 cigarettes per day (Neumann, Rasmussen, Heitmann, & Tønnesen, 2013).

Secondhand smoke exposure was defined as the presence of smoker in residence (Neumann et al., 2013).

Exercise described as activity requiring physical effort, which helps to sustain or improve health and fitness at least 30 minutes.

Napping was defined as an action of sleep in a short period, especially in daytime.

Life satisfaction described to an overall feelings and attitudes assessment about one's life at a particular point in time ranging from negative to positive. It is one of three major indicators of well-being that are life satisfaction, positive affect, and negative affect (Diener, 1984).

Psychological stress was explained by environmental demands exceed to one's perceptiveness, which has an influence on adaptive capacity (Cohen, Janicki-Deverts, & Miller, 2007).

Ability to cope with stress referred to the incidence of environments that are involving to judgment as a great amount of physical or mental effort, which one is able to handle or response to this overload situation (Cohen et al., 2007).

Residential environments referred to type of residence, participants' bedroom characteristics and bedroom environmental conditions. This information is collected by questionnaire and environmental sampling, particularly in bedroom.

Bedroom characteristics were defined as characteristics of each participants' bedroom that describes bedroom information, such as cooling devices, curtain, noise at night, type of light, light exposure (turn on light during sleep), pets in bedroom, color of the light, type of bed, size of bed, fabric of bed sheet, fabric of duvet, type of mattress, type of pillow, direction of bed, bedroom cleaning, pajamas, sleep partner, and electronic devices use before bedtime. This information was obtained by questionnaire.

Type of residence described to the particular features of respondents' houses such as detached house, semi-detached house, condominium, or apartment.

Cooling devices referred to equipment that can decrease temperature in the room such as air conditioner or fan.

Curtain referred to the number of carpets in the participants' house and which area of the house that has a curtain.

Noise at night was defined as the noise that respondents usually hear at the nighttime while they are sleeping.

Type of light referred to the type of lighting that respondents use in their bedroom.

Light exposure was explained by illumination, which participants expose at night in the bedroom; for example, participants usually turn on the light while they are sleeping.

Pets in bedroom referred to many kinds of animal that participants treat them very well and take them to bedroom.

Color of the light referred to the color of the light that participants use in their bedroom, for example, white color or orange color.

Type of bed meant the specific features of respondents' bed.

Size of bed referred to the size of bed that participants have in their bedroom.

Fabric of bed sheet described to type of bed sheet material that participants use to cover their bed.

Fabric of duvet was mentioned to a kind of blanket material that respondents usually use to cover their body while they are sleeping.

Type of mattress referred to material of mattress that participants sleep on it every single night.

Type of pillow described to the material of pillow that participants select to sleep at nighttime.

Direction of bed referred to the direction where the bed of participants is located in.

Bedroom cleaning described to how often or how many times that the respondents clean their bedroom and what kind of equipment that they use to clean.

Pajamas referred to the type of sleepwear material that respondents always get on while they are sleeping.

Sleep partner described to the respondents have a bed partner whether or not.

Electronic devices use before bedtime referred to electronic devices or gadgets, such as, computer, laptop, smart phone, tablet, DVD player, and television that participants use them before bedtime, after light off or even middle of the night.

Bedroom environmental conditions were defined as participants' conditions of bedroom environments, such as particulate matter 10, temperature, relative humidity and absolute humidity. This information was obtained by personal air sampling and temperature/relative humidity data logger.

Particulate matter 10 (PM_{10}) was determined small solid and liquid particles that exist in the atmosphere, and its size less than 10 micrometers (μm) in diameter (C. A. Pope, Dockery, Spengler, & Raizenne, 1991).

Temperature referred to the measurement of ambient air temperature in bedroom to explore how hot or cold in the respondents' bedroom.

Relative humidity referred to the measurement of relative humidity in bedroom to explore the level of humidity in the respondents' bedroom.

Absolute humidity was defined as the measurement of water vapor in the air, regardless of temperature. It was calculate by the equation of absolute humidity (Mander, 2012).

Wet season described to the season has high amount of rain, which starts from late May to mid-August.

Dry season referred to the season, which rain becomes less frequent. It starts from late December to mid-May.

Sleep-disordered breathing (SDB) referred to the situation of individual's breathing repeated stop while sleep, and the most common of SDB is obstructive sleep apnea (OSA) (Callop & Cassel, 2002). Of which this study focused on OSA, especially the severity of OSA.

Severity of OSA described to measurement of OSA severity that was calculated on the average number of apnea and hypopnea events per hour of sleep. AHI was classified according to widely used cutoff points in the literature and clinical

practice: mild OSA (AHI 5-14); moderate OSA (AHI 15-29); and severe OSA (AHI ≥ 30) (Ruehland et al., 2009).

Sleep quality was identified as subjective feelings of depth of sleep, how well rested one feels after waking, and general satisfaction with sleep, measured with the Pittsburgh Sleep Quality Index, over the previous month (Buysse et al., 1989).

Urinary melatonin referred to a measurement of 6-sulphatoxymelatonin (aMT6s), which is the primary metabolite of melatonin, excreted into the urine (Conti et al., 2000).

CHAPTER II

LITERATURE REVIEW

2.1 The biology of sleep and wake

It is well known that sleep is an important activity and a basic need of human, despite the fact that the precise aim of sleep is still perplexed (Eidelman, 2002). Generally, sleep is not only defined as lying down with eyes closed but also meant less activity and reduce in response to external stimulation (Hirshkowitz & Sharafkhaneh, 2005). However, sleep is able to define based upon patterns of brain activity, and physiological changes (such as body temperature, respiratory, and cardiovascular activity). Previously, scientists thought that there was no any brain activity while people were sleeping. On the other hand, many researches have reported that brain still remains active through sleep time. Throughout wakefulness, body temperature goes up and down slightly, but prior falling asleep, body starts taking heat away to the environment as it helps to induce sleep and during sleep, central brain sets body temperature decreased in 1 to 2^{o}F and body temperature increases in the morning (Hobson & Pace-Schott, 2002).

Sleep-wake cycle is regulated by the interaction between sleep-wake homeostasis and circadian rhythms (internal biological clock) in **Figure 1**. Sleep-wake homeostasis describes as the process of maintaining human body in the steady state even the duration of sleep each single night is also controlled under this homeostasis. A circadian rhythm is defined as a cyclical change in body temperature, hormone levels, and sleep that happens over 24 hours. It contains a group of neurons in anterior hypothalamus brain, which called the suprachiasmatic nucleus (SCN) that can function a rhythm of sleep and wake. This rhythm is rapidly response to the external physical environment, especially light and caffeine (Stanley, 2005).

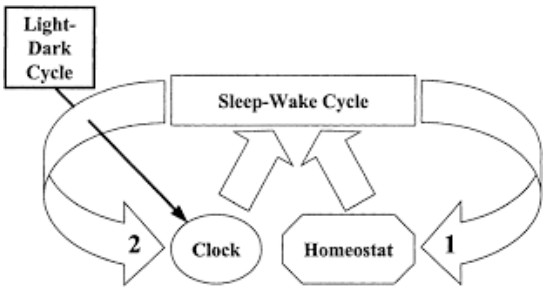


Figure 1 Sleep-wake cycle

2.2 Stage of sleep

There are 2 main types of sleep that are 1) rapid-eye-movement (REM) sleep and 2) non-rapid-eye-movement (NREM) sleep. REM sleep is also called active sleep. It is determined by its specific characteristics such as low amplitude (small), high frequency of brain wave, alpha rhythm, and eye movements. The reason of eye movement is usually concerned with dreams. Throughout REM sleep, it is interesting that arms and legs muscle are paralyzed in a short time. In the section of NREM sleep, it can divide to 3 stages that are N1, N2, and N3. Brain waves in these 3 stages become slow and synchronize. The deepest stage of sleep is in stage N3, which has a specific feature: high-amplitude (large), low frequency waves (slow) and spindles (Aserinsky & Kleitman, 1953).

Regularly, sleep among healthy adults starts with NREM sleep. The first stage of sleep or N1, its pattern of alpha activity links to wakefulness, which is identified by low-voltage, and pattern of mixing frequency; however, this stage has a particular wave that is vertex sharp wave (V wave). Normally, this stage takes 1 to 7 minutes. The second stage of sleep or N2, it has a specific brain signal that are sleep spindles and K complexes, this stage lasts for 10 to 25 minutes. The third stage of sleep or N3, it has the high-voltage and slow-wave activity. Typically, this stage takes 20 to 40 minutes. After stage N3, it moves to stage R or REM sleep. Brain wave in this stage is like N1 pattern but its unique pattern is low chin signal and eye movement activity. Ordinarily, healthy young adult without any sleep disorder will switch between non-REM and REM sleep about every 90 minutes, experiencing 4 to 6 sleep cycles per

night. The brain wave of each stage of sleep and cycle of sleep-wake among healthy adult is shown in **Figure 2** (Hirshkowitz & Sharafkhaneh, 2005).

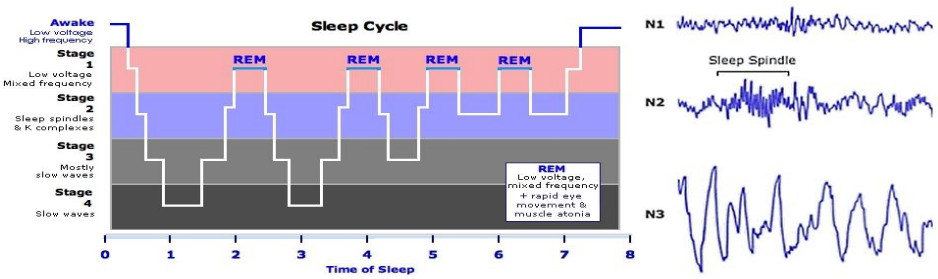


Figure 2 Sleep wave and sleep-wake cycle architecture

2.3 Impact of insufficient sleep

Sleep is a kind of mystery if we have got whether a long sleep (more than 9 hours) or a short sleep (less than 6 hours), both is possible to cause many negative effects to our health. Particularly, insufficient sleep has an effect on physiological and cognitive functions. Some of these functions comprise memory loss and lack of concentration, analytical thought, fatigue, motor reaction, or even emotional control (Banks & Dinges, 2007). Recently, many scientists discovered that a shortage sleep is associated with immune function, endocrine systems, as well as, chronic health problems, including obesity, diabetes, high blood pressure, stroke and heart disease. Then, these conditions may contribute to a shortened life expectancy **(**Gallicchio & Kalesan, 2009; Luyster et al**.**, 2012**)**.

Sleep deprivation adversely affects our emotion, our ability to concentrate, and our ability to access higher-level cognitive function. Add all of these factors are generally mean mental performance (Harrison & Horne, 2000). One research found the link insufficient sleep with anger, anxiety, and sadness. When the subjects were allowed to sleep about 4.5 hours a night for a week, the emotion score indicated that participants felt more stressed, angry, sad, and mentally exhausted, but when the subjects were allowed to get enough sleep, their emotion scores dramatically increased (Dement & Vaughan, 1999). Moreover, sleep deprivation is more likely to cause critically either an impairment of job performance or social problems. As the

evidence of insufficient sleep grows, it becomes increasingly crucial to take an action to alleviate the impact of inadequate sleep on safety and human well-being (Grandner et al., 2015).

Now, sleep is being seen as a potential risk factor of obesity as same as the most 2 common risk factors that are 1) lack of workout and 2) overeating. Some research raised the topic of association between insufficient sleep and obesity with the mechanisms involved in controlling metabolism and appetite. While we are sleeping, our bodies produce hormones, which its help to regulate desire of food, energy metabolism, and glucose processing. If we have a poor sleep, it can lead to imbalance hormone in our body, such as, increases in the secretion cortisol hormone (stress hormone), grows insulin hormone that controls glucose function and promotes fat storage. It the higher levels of insulin, the more weight gain, and then it can link to diabetes. Also, sleep deprivation is able to be concerned with decrease in the secretion of leptin hormone, which has an influence on warning the brain to have enough food, and increase in the levels of ghrelin hormone that motivate appetite. In a consequence of poor sleep, it probably results in food craving, especially, a sweet dish as a rapid energy boost (Hasler et al., 2004; Morselli, Leproult, Balbo, & Spiegel, 2010; Taheri, Lin, Austin, Young, & Mignot, 2004).

Besides, many research found that inadequate sleep probably results in type 2 diabetes by the way of affecting body glucose system (Yaggi, Araujo, & McKinlay, 2006). A short-term sleep restriction study showed that healthy subjects slept about 4 to 8 hours a night processed glucose more slowly than participants who slept 12 hours (Ayas et al., 2003). A lot of epidemiological research has revealed that adults who always slept less than 5 hours a night have more chance to get risk of developing diabetes (Yaggi et al., 2006). Moreover, scientist found that there is a correlation between obstructive sleep apnea (breathing difficulties during sleep) and the development of glucose control impairment that can lead to diabetes as well (Naresh M Punjabi et al., 2002).

Additionally, sleep deprivation connects to cytokine and immune function. One study found that lack of sleep has an impact on cytokines, which are the main messengers of immune system. For instance, inadequate sleep escalates the

secretion of interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), IL-1, IL-2, and inflammatory cytokines. All of these cytokines are related to a short sleep. This imbalance of the host defense cells can promote an inflammatory response and subsequent cell injury (Spiegel, Sheridan, & Van Cauter, 2002; Vgontzas et al., 2004). Therefore, people who get a poor sleep, have more chance to be ill and easily got an infection rather than people who usually get a proper sleep.

Numerous studies presented that sleep deprivation for a night in hypertension patients can affect to high blood pressure in the following day and also have the potential to elevate the risk of cardiovascular morbidity and mortality (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011; Lusardi et al., 1999). One study proved that healthy adults sleep approximately 7 to 8 hours per night could minimize the risk and incidence of cardiovascular diseases, which might ultimately result in death (Buxton & Marcelli, 2010; Cappuccio et al., 2011). Other study showed that short sleep duration (less than 6 hours) increased the risk of ischemic stroke and coronary heart disease (Chen et al., 2008), and long sleep duration (more than 9 hours) was associated with cardiovascular diseases and hypertension (Calhoun & Harding, 2010; Qureshi, Giles, Croft, & Bliwise, 1997). Moreover, there is prevalence of an association between obstructive sleep apnea and heart disease. Typically, people who have sleep apnea experience several awaking at night because they torture from surging of blood pressure and the obstruction of airway while they fall asleep. Several times, this can contribute to the chronic blood pressure elevation well documented as hypertension, which is a primary risk factor for cardiovascular disease (Naresh M. Punjabi et al., 2009).

2.4 Sleep quality

A shortage of sleep has been to be visibly adverse effect cognitive function despite sleep quality is likely to be more significant impact than sleep quantity. Many aspects of an individual's sleep habit, including sleep quantity, sleep latency, sleep efficiency or even sleep disturbances, are sleep quality (Pilcher, Ginter, & Sadowsky, 1997). One study indicated the measurement of sleep quality among college

students by the Pittsburgh Sleep Quality Index (PSQI) showed the higher association between health and well-being than a single sleep quantity. Moreover, it revealed the correlation between the reduction in sleep quality and the enlargement of emotion (anxiety, depression, anger, fatigue, confusion), excessive daytime sleepiness or whether dissatisfaction with life (Buysse et al., 1989; Harvey, Stinson, Whitaker, Moskovitz, & Virk, 2008)

Besides, several studies among SDB patients observed altered cognitive functions. The results showed that mostly participants reported about sleep complaints, for example, difficulties initiating sleep, difficulties maintaining sleep, or whether early morning awakening (Fortier-Brochu et al., 2012). Further, epidemiological studies indicate that over a half of elderly individuals report at least one sleep complaint (Foley et al., 1995). It could imply that SDB has an impact on a poor sleep quality. Lastly, sleep quality is a kind of subjective and objective combination, which influences the effectiveness of one's sleep. Additionally, it has been pointed that the involvement of several factors in sleep quality, makes it be more significant tool for assessing sleep (Harvey et al., 2008).

2.5 Sleep disordered breathing (SDB)

Lately, sleep disordered breathing (SDB) has become to be a popular issue as generally medical problems. As this syndrome afflicts with morbidity and mortality, which contributes to an extra burden of the public health and diminishes sleep quality (Harvey et al., 2008; Wright & Sheldon, 1998). Also, the American Academy of Sleep Medicine pins down SDB as 1 of 8 major categories of sleep disorders (Young et al., 2002). SDB can be explained either abnormal respiratory patterns or insufficient ventilation during sleep. For the abnormal respiratory patterns, it can give an explanation for the presence of apnea and hypopnea. When a patient stops breathing about 10 seconds or more, and then wakes up to take an enough breath, this is called "an apnea". If a patient does not stop taking a breath, but patient's breathing starts to be shallow (airflow starts reducing at least 30%) for 10 seconds or more, and it is also associated with oxygen desaturation or arousal. This is called "a

hypopnea" (Callop & Cassel, 2002). Moreover, the most common type of SDB is obstructive sleep apnea (OSA). In the case that the patient has an event of obstructed breathing at least 5 times per hour on an overnight polysomnography by deciding on an index of apnea-hypopnea (AHI), also respiratory disturbance index (RDI) and transient arousals with disruption of normal sleep architecture (Flemons et al., 1999). Furthermore, the patient has to have either excessive daytime sleepiness or choking or gasping from sleep at least 2 times. Also, the patient has a recurrent awakening from sleep those impacts on making a fresh start in the next day, fatigue in the daytime, or lose concentration (Callop & Cassel, 2002; Schwab, Goldberg, & Pack, 1998). Besides, AHI (the mean number of apnea plus hypopnea events per hour of sleep) has become to differentiate the severity of SDB. This AHI can categorize the SDB severity into 5 levels that are normal (AHI = 0), minimal SDB (AHI > 0 to ≤ 5); mild SDB (AHI 5 to ≤ 15); moderate SDB (AHI 15 to ≤ 30); and severe SDB (AHI ≥ 30) (Young et al., 2008).

2.6 Signs and symptoms of SDB

SDB affects one's sleep quality, morbidity, and mortality at the same time. There are various aspects of SDB that can imply the primary state of this disorder. Normally, signs of SDB are habitual snore, apnea, or even restless sleep. Term of symptoms, the key of SDB symptoms is excessive sleepiness. Also, other general symptoms include daytime somnolence, loss concentration, fatigue, feeling not fresh after sleep, nocturnal chocking or gasping, night sweat, depression, memory loss, and snore. Sometimes, the signs or symptoms of snoring, apnea, and hypopnea might cause by alcohol consumption before sleep including excessive body mass index (Flemons et al., 1999). However, patients suspected to have SDB should undergo an overnight polysomnography, which remains the gold standard for diagnosing SDB.

2.7 Causes of SDB

To know causal risk factors of SDB is an important clue to raise awareness of SDB. It is currently believed that SDB can be caused by many potential factors. These

may include obesity as it plays a crucial role in the pathogenesis of upper airway collapse, especially the deposition of fat in the neck and surrounding the pharyngeal airway, as well as intra-abdominal fat distribution (Isono, 2012). Craniofacial shape is one greater essential for SDB risk in Asians. It is about skeletal restriction that induces to develop more severe SDB at lower bodyweights (Sutherland, Lee, & Cistulli, 2012). Besides, alcohol consumption and tobacco use may exacerbate SDB severity by either pressing upper airway dilator tone or causing upper airway inflammation, orderly (K. S. Kim et al., 2012; Scanlan, Roebuck, Little, Redman, & Naughton, 2000). Also, nasal congestion, estrogen depletion in menopause (Peppard & Young, 2004), allergic rhinitis (Chirakalwasan & Ruxrungtham, 2014), age and gender (Kezirian et al., 2009; Young et al., 1993) can raise the risk of improving SDB, as well as, environmental exposures that increase airway inflammation or decrease neuromuscular output to the upper airway (Ruangkana et al., 2014).

Moreover, genetics may partially describe in the ethnic clustering of these phenotypes, modified by cultural and environmental factors **(**Lee, 2008**).** Asian adults are at risk for a more severe degree of OSA even they got lower degrees of obesity when compared to Caucasians **(**Villaneuva et al**.**, 2005**).** Another study compared 105 Asian patients with 99 Caucasians matched for age, gender and body mass index **(**BMI**).** The outcomes showed that ethnic group was associated with severe SDB, with an odds ratio of 2.51 compared to Caucasians **(**Ong & Clerk, 1998**).** However, there is no evidences have reported on an association between severity of SDB patients group and residential environments in Thailand, particularly in urban areas, where are full of air pollution**.**

2.8 Residential environments

The inside house environments, such as illumination, ambient temperature, and relative humidity are possible to afflict with human sleep pattern (Grigsby-Toussaint et al., 2015). An elementary external factor is nocturnal light exposure, which it plays an important role in modulating sleep patterns and mood (Dumont & Beaulieu, 2007). Also, nocturnal light exposure has an impact upon the circadian

biological clock directly (Tsuzuki et al., 2015). A hundred lux of illumination is sufficient to suppress nocturnal melatonin secretion and delays the circadian rhythm (West et al., 2010). The previous study showed the adjusted odds ratio (aOR) of using light bulb and Pittsburgh Sleep Quality Index (PSQI) score of > 5 was 3.7 (95% confidence interval [CI], 1.1–12.6; P < 0.05) (M. Kayaba et al., 2014). Recently, several research found that using an electronic devices such as laptop, tablets, smart phone, television, game console, and so on after light off can trigger to fall asleep difficultly as the specific type of light emission from the screens of these devices stimulates the brain to be active and interferes melatonin secretion (Van den Bulck, 2010). Moreover, many studies have revealed that using of electronic media, such as television, personal computers (Internet), and computer games, is associated with sleep disorders (Higuchi, Motohashi, Liu, & Maeda, 2005; Paavonen, Pennonen, Roine, Valkonen, & Lahikainen, 2006). One study found that the use of mobile phone whether calling or chatting after turning off the lights was associated with sleep disturbances (short sleep duration, subjective poor sleep quality, excessive daytime sleepiness, and insomnia symptoms) (Munezawa et al., 2011).

Ambient temperature is primarily regulated by water evaporation through breathing and by the release of human body heat through the skin. Ambient temperature within bedroom is likely to be an essential impact on the quality of sleep, which is concerned with change in sleep architectures (Haskell, Palca, Walker, Berger, & Heller, 1981; M. Kayaba et al., 2014). Kayaba et al. reported that the adjusted odds ratio (aOR) for Pittsburgh Sleep Quality Index (PSQI) score of > 5 and without air conditioner in bedroom was 1.8 (95% CI, 1.0–3.3; P < 0.05) (Kayaba et al., 2014). Furthermore, humidity is considered as one crucial factor. It improves heat stress during sleep, which increases wakefulness and reduces slow wave sleep (SWS) and rapid eye movement sleep (REM). One research indicated the difference mean of wakefulness between two environments: 1) neutral and dry climate (ambient temperature (Ta) =26^{o}C, relative humidity (RH) =50%, ambient pressure (Pa)=12.6 Torr), 2) hot and humid climate (Ta=32 ^{o}C, RH=80%, Pa=28.5 Torr). The result showed that the amount of wakefulness increased significantly under 26-32 (38.7±11.6) compared to 26 (17.6±9.6), (T-value = -3.96) (Okamoto-Mizuno et al., 2005).

Another environmental factor that has received less attention in sleep studies is exposure to ambient air pollution in the residence, which can pose adverse health outcomes. Indoor particulate matter (PM) has variety sources, both natural and man-made, which including cigarette smoking, biomass burning whether in stoves or fireplaces, cooking, cleaning activities that may re-suspend dust, and outdoor PM that might move into the home (Breysse et al., 2010). However, the concentration of particulate matter indoor air depends upon 1) Outside source of particulate matter: if the outdoor air has a high concentration of particulate matter, it can cause a high concentration of particulate matter to indoor air as well as the outdoor air penetrates to indoor air. 2) Areas arrangement: if the area where are plenty of particulate matter, it can disperse to the cleaning zone then, it seems to be contaminated with the same amount of the dirt area. 3) Ventilation system: with good ventilation in household is an essential to minimize particulate matter, but it should be appropriate to the type of the building, size of area, a number of members in home, and air exchanged rate. 4) Cleaning: the more we clean household, the less concentration of particulate matter remains inside the home, as well as, a good arrangement of stuff. 5) Geographic area: it is one factor that affects to concentration of particulate matter, such as, disparity in season, pressure, whether or area surrounding with mountain (Maroni & Lindvall, 1995). Even though PM inside home is dissimilar from outdoor PM, concentration and chemical composition, it can cause many adverse health effects to residents, who expose for long time. There are many studies that have revealed an association between PM exposure with adverse health outcomes, such as asthma, chronic obstructive pulmonary disease (COPD), respiratory tract infections (mainly pneumonia), cerebrovascular diseases, ischemic heart diseases (especially myocardial infarction (MI)), heart failure and arrhythmia (Ahluwalia & Matsui, 2011; Koenig et al., 2005; McCormack et al., 2011). In recently, some research showed the link of SDB and air pollution, which it escalated risk of autonomic dysfunction (Wang et al., 2008). Mehra and colleagues found the connection between adverse cardiac and SDB because of clinically significant apnea/hypopnea-induced hypoxemia and respiratory acidosis (Mehra et al., 2006). Other one pointed the association between high levels of particulate matter and

reduction in oxygen saturation by ventilation–perfusion mismatch (DeMeo et al., 2004). Particulate matter may afflict with sleep through action on the central nervous system, as well as the upper airways (Elder et al., 2006). In addition, it has been shown to move from the nose up to the olfactory nerve and get into the brain, including the striatum frontal cortex, and cerebellum (Wang et al., 2007). These are able to link to elevated brain inflammatory responses (Campbell et al., 2005) and lead to changes in neurotransmitter levels (Tin Tin et al., 2008). One research indicated that elevation of SDB and decreased in sleep efficiency were associated with increasing levels of daily PM_{10} in the summer months, with 11.5% (95% confidence interval: 1.96, 22.01) increase per interquartile range increase (25.58 F) in temperature (Zanobetti et al., 2010). As far as we concerned, the effect of residential environments on sleep quality in SDB patients have not been investigated previously. **Figure 3** showed the potential mechanism of the association between air pollution and sleep disordered (Fang et al., 2014).

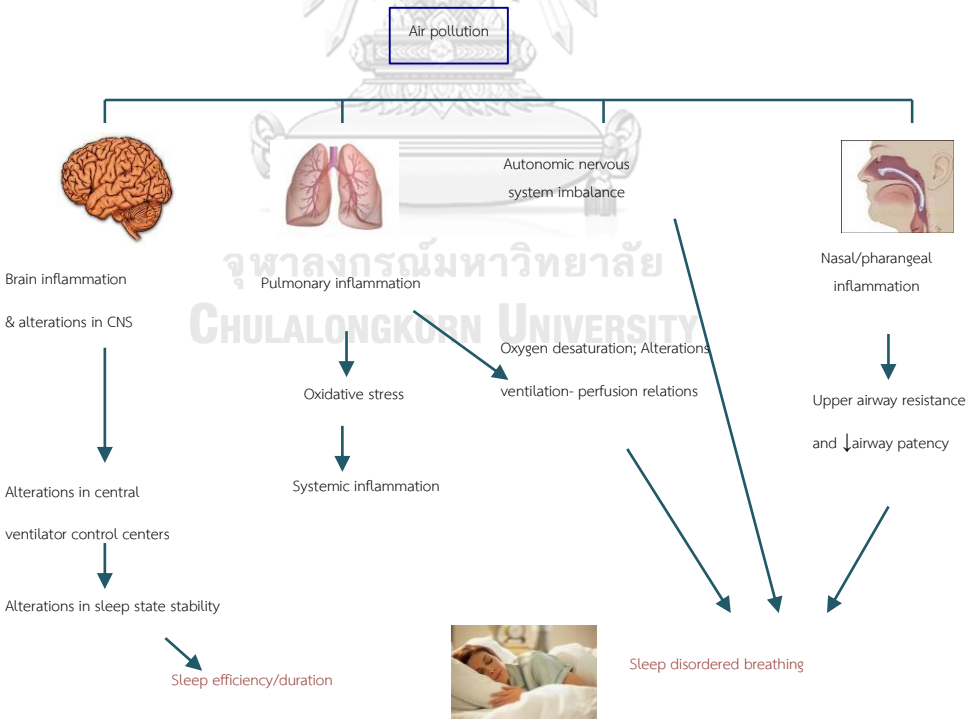


Figure 3 The potential mechanism of air pollution and sleep disordered

2.9 Sleep environments

Poor sleep environments may lead to or exacerbate sleep disturbances among middle-aged population with SDB or insomnia. Whole conditions having a possible impact on sleep must be taken into consideration in order to promote a good sleep. Most importance is environmental factors including with quality and comfort of the bed system, bed sheets, sleep garment, pillows, position of the bed, ambient conditions, disturbing noises at night, variations of light in the bedroom, changes in external temperature, or even bad ventilation have been reported to delay sleep (Bader & Engdal, 2000; Haex, 2005). However, there is lack of evidences, which investigates poor sleep environmental factors and sleep disturbances. Therefore, to see the various environmental factors, which may interfere with sleep quality is interesting.

Sleepwear and fabric of bed sheets mainly have an impact on the exchange of heat and moisture between body and bedclothes. Therefore, top layer of bed that touches skin whether or night garments should preferably be made of natural material such as cotton, wool, linen, or silk. Also, sleepwear should be adequate, loose and comfortable in order not to disturb sleep. For good sleep comfort, thin, loose-fitting nightwear, pajamas, nightshirt or negligee should be recommended. Tight clothing may contribute to be restricted and result in awakenings. On the other hand, too loose clothes can twist tightly around the body if a person moves about too much during sleep, causing restriction as well and hindering posture changes. In case naked sleeping, without any covers in a humid environment, will remain slightly wet, and then this may result in a chill (Dickson, 1984; Libert et al., 1988; Okamoto-Mizuno et al., 2005).

Furthermore, type of bed, size of bed, mattress, and pillow can improve sleep quality as well. There is no standard for choosing type of mattress because it depends on personal physiology such as obese, slim, short, or tall and also individual need. A size of bed can interfere a good sleep due to movements and posture changes while people are sleeping. Thus, a bed should wide enough to allow moving easily and should be longer than the height of sleeping person at least 15-20 cm.

Also, the bed should not be flat on the floor but upraised to enable good air circulation and get in or out of the bed conveniently. Type of pillow is possible to be one factor to minimize the quality of sleep. Pillow should be designed to support head and neck perfectly in order to release the tension of the muscles. Using a soft pillow might feel comfortable and supportive, but it can hinder head movements during sleep, which can cause awakening. If the pillow is too soft, the head is likely to sink into it that can worsen breathing (Bader & Engdal, 2000; Suckling, Koening, Hoffman, & Brooks, 1957). Very few studies published about sleeping environments and sleep quality among SDB patients, particularly in Thailand. Therefore, to know this kind of information may help to increase public awareness about these issues and improve a good quality of sleep as well.

2.10 Urinary melatonin

Urinary 6-Sulfatoxymelatonin (aMT6-s) is the first metabolite of melatonin, which is excreted through urine. It is also a non-invasive method, which provides a good data of melatonin in serum. Urinary aMT6-s will be quantified by using the Buhlmann 6-Sulfatoxymelatonin enzyme-linked immunosorbent assay (ELISA) kit. The primary benefits of ELISA are high specificity and sensitivity. The process of analyzing is not time consuming as well. Additionally, the precision of the ELISA is similar to radioactive immunoassay (RIA), which the sensitivity is correctly within the range of urinary sample. Also, the correlation between ELISA and RIA is high; thus, it is able to be a good representative technique for direct measurement of aMT6s in urine (Peniston-Bird et al., 1996). Additionally, aMT6-s concentration in urine is 20-30 times greater than non-metabolic melatonin (Schernhammer, Kroenke, Dowsett, Folkerd, & Hankinson, 2006). Further, the former studies have illustrated a strong correlation between urinary aMT6-s and serum melatonin ($r = 0.86$; $p < 0.0001$) (Kovács et al., 2000).

A nocturnal melatonin secretion has been implied as a key factor for controlling the proper function of sleep-wake cycle (Peniston-Bird et al., 1996) and the Pittsburgh Sleep Quality Index (PSQI) has been used as a primary measurement

to assess good and poor sleep quality (Buysse et al., 1989). Additionally, melatonin illustrated a significant effect in promoting sleep quality. Little known about the association between amount of melatonin and sleep. Therefore, this study determined whether several subjective sleep parameters in sleep disordered breathing patients were associated with concentration of melatonin's major urinary metabolite, 6-sulfatoxymelatonin (aMT6s) in urine.

Although a comparison between sleep and awake indicated that total nocturnal melatonin was higher correlated with sleep (Morris et al. 1990) and a lower aMT6s concentration was correlated to a worse sleep efficiency significantly (Haimov et al., 1994), melatonin was not associated with sleep quality (Lushington, Dawson, Kennaway, & Lack, 1999). Additionally, age-related sleep maintenance problems was not correlated with aMT6s levels (Baskett et al., 2001). Neither subjective sleep quality nor respiratory disturbance was associated with urinary melatonin (aMT6s). However, it showed a significantly negative association between excessive daytime sleepiness and aMT6s. Also, shorter sleep time and worse sleep efficiency were significantly associated with aMT6s (Saksvik-Lehouillier et al., 2015). Between the group of elderly subjects without sleep problems and young men did not demonstrate a significant difference in melatonin secretion (Haimov et al., 1994). In the contrary, one research gave an inverse correlation significantly in age and nighttime aMT6s (Lushington et al., 1998).

The previous study found that sleep efficiency and sleep latency among unhealthy elderly insomniacs was improved after receiving melatonin treatment, but the treatment had no impact on total sleep time (Garfinkel et al., 1995). In contrast, the latter research indicated that whether sleep quality or sleep duration in elder with age-related sleep maintenance problems did not improve after obtaining melatonin treatment (Baskett et al., 2003). Both good and poor sleepers did not show any difference in melatonin excretion (Haimov et al., 1994). However, another showed a significantly positive correlation between sleep quality and aMT6s nighttime among good sleepers (Lushington et al., 1998).

2.11 Related article

Table 1 Summary of sleep disordered breathing prevalence with Polysomnography (PSG) assessment

Authors, Year of publication	Population	Study design	Measurement tool	Criteria for SDB or OSA	Results
Young et al., 1993	352 men and 250 women employee (aged 30-60 years) in America	Cross-sectional study	- Mailed questionnaire - Polysomnography (PSG)	AHI ≥ 5, ≥ 10, ≥ 15	- Prevalence of SDB was 9% for women and 24% for men. - Male gender and obesity were strongly associated with SDB.
Bixler et al., 2001	Phase I: 12,219 women: 4,364 men [age 20-100 years old] Phase II: 1000 women: 741 men [selected from phase I] in Spain	Clinical study	- Screening sleep apnea questionnaire (snoring, daytime sleepiness, obesity, hypertension, and menopause) - Sleep lab test (only phase II)	OA/HI≥15 = severe SDB OA/HI<15 = mild SDB	- Ratio for sleep apnea of men: women (AHI > 15) was 3.3:1, p = 0.0001. - Prevalence of AHI > 15 was 0.6% (aged 20-44 year) compared with 7.0% (aged > 65 year) [RR=11.1 (3.0, 32.6), p=0.0002]. -Prevalence of sleep apnea in post-menopausal women without hormone treatment was significantly higher than premenopausal women with hormone treatment (2.7: 0.6%, p = 0.02).
Ip et al., 2001	784 men (153 underwent PSG) (mean age was 41.2 years and mean BMI was 23.9 kg/m^2) in Hong Kong, China	Cross-sectional study	- Sleep questionnaire - PSG	AHI ≥ 5, ≥ 10, ≥ 15	- 23% had snoring. - 41.8% were diagnosed with OSA by PSG. - Prevalence of OSA and OSAS was 8.8% and 4.1%, respectively.
Ip et al., 2004	884 women (105 underwent PSG) (mean age was 41.6 years and mean BMI was 22.4 kg/m^2) in Hong Kong, China	Cross-sectional study	- Sleep questionnaire - PSG	AHI ≥ 5, ≥ 10, ≥ 15	- 15% had snoring. - Found 30% AHI ≥ 5, 15% AHI ≥ 10 and 10% AHI ≥ 15. - Prevalence of OSA and OSAS was 3.7% and 2.1%, orderly.
Udawia et al., 2004	Urban employed men in India (aged 35-65 years)	Cross-sectional study	- Sleep questionnaire - Sleep lab test (PSG)		- Prevalence of SDB and OSA was 19.5% and 7.5%, respectively.
Kim et al., 2004	457 Korean men and women (aged 40-69 years) underwent PSG	Cross-sectional study	- Sleep questionnaire - PSG	AHI < 5 = SDB AHI ≥ 5+EDS = OSA	- SDB was found in 27.1% of men and 16.8% of women. - OSA was found in 4.5% of men and 3.2% of women.
Neruntarat and Chantapant, 2011	2,685 Thai participants (199 men and women underwent PSG) (mean age was 37.2 ± 9.2 years and mean BMI was 24.7 ± 5.4 kg/m^2)	Cross-sectional study	- Sleep questionnaire - PSG	AHI >5 = SDB AHI > 5+ EDS = OSA	- The percentage of habitual snorers in the study population was 26.4%. - The prevalence of SDB was 11.4%. - The prevalence of OSA was 4.4%. - The prevalence of SDB and OSA in men was 15.4% and 4.8%, orderly. - The prevalence of SDB and OSA in women was 6.3% and 1.9%, respectively.

Table 2 Summary of sleep disordered breathing and environmental factors

Authors, Year of publication	Population	Study design	Measurement tool	Environmental factor	Results
Tsuzuki et al., 2004	9 healthy young men (mean age was 25 ± 3.8 years) in Japan	Experimental study	- Sleep questionnaire - PSG - Urinary melatonin	- Temperature - Relative humidity	- 17.13% periods of wakefulness and 5.91% stage 1 of sleep increased significantly at 32 ^{O}C/ RH 80 compared to 26 ^{O}C/ RH 50 (P<0.02; 0.04). - Sleep stage 2 (12.95%) and stage 4 (5.46%) were significantly shorter at 32 ^{O}C/ RH 80 than at 26 ^{O}C/ RH 50 (P<0.03; 0.03). - No significant differences in melatonin secretion between 32 ^{O}C/ 26 ^{O}C/ RH 50 RH 80 and - Urinary melatonin tended to be lower at 32 ^{O}C/ RH 80 than at 26 ^{O}C/ RH 50 (P<0.08)
Okamoto-Mizuno et al., 2005	8 male subjects (mean age was 25 ± 3.77 years) in Japan	Experimental study	- Sleep questionnaire - PSG	- The first test (at 26 ^{O}C/ RH 50 for first 3 h. and 45 min. and then 32 ^{O}C/ RH 80 for 30 min) - The second test (at 26 ^{O}C/ RH 50 and 32 ^{O}C/ RH 80 for the first 3h. and 45 min. then 26 ^{O}C/ RH 50 for 30 min)	- First test found wakefulness and sleep stage 1 increased significantly over the last 4 h. and also mean skin temperature and clothing microclimate temperature were significantly higher during the last 3 h and 45 min. - Second test found sleep efficiency index (SEI) decreased significantly when 32-26 compared to 26 and the amount of wakefulness after sleep onset increased significantly under 26-32 compared to 26.
Kim et al., 2010	Total 24 Korean subjects (22 subjects participated all measurement in summer, spring, winter) Separated into 4 groups: teenager, twenties, thirties to fifties, and over sixties.	Cross-sectional study	- Sleep environment measured equipment - A nasal cannula connected to ResMed's ApneaLink	- Temperature - Relative humidity - Noise (dB) - Illumination (lux) - Seasonal change - Carbon dioxide	- Relative humidity was lower in winter and spring. - Average AHI for the 22 subjects who participated in all seasons were 5.59, 5.18, and 6.91 in winter, spring, and summer, orderly. - The over sixties, their average AHI were 16.0, 10.8, and 16.7 in winter, spring, and summer, respectively. - The best range air temperature for good sleep quality is 24–26°C, and the upper limit of air temperature for good sleep is 28.1°C.
Zanobetti et al., 2010	6,441 participants whose aged more than 39 years) in America	Cross-sectional study	- PSG	-PM_{10}	- In the summer period, for every interquartile increase in short-term PM10 levels, there were 12.9% increase (95% CI: 2.77, 24.09) in RDI, 19.4% increase (95% CI: 3.67, 37.5) in percentage of sleep time at <90% oxygen saturation, and 1.20% decrease (95% CI: −2.40, −0.004) in sleep. - Air pollution associated with raised in respiratory disturbance index and decrease in sleep efficiency.

Table 2 Summary of sleep disordered breathing and environmental factors (Continued)

Authors, Year of publication	Population	Study design	Measurement tool	Environmental factor	Results
Abou-Khadra, 2013	Parents of 276 school children (aged 6-13 years) in Egypt	Cross-sectional study	- Self-report questionnaire	- PM_{10}	- PM_{10} and disorder of initiation and maintaining sleep were significantly associated ($P = 0.012$) - PM_{10} was significantly associated with DIMS and sleep hyperhidrosis and there was marginal significant association between PM_{10} and global sleep disturbance.
Kayaba et al., 2014	From 1,000 subjects in Japan (only 351 respondents who answered all question items, enabling the calculation of a PSQI score.	Cross-sectional study	- Self-report questionnaire	- Cooling devices in bedroom - Noise at night - Lighting equipment	- Mean Pittsburgh Sleep Quality Index (PSQI) score was 4.9 (±2.7), and 123 (35.0%) participants had scores of >5. - PSQI scores of >5 without installation of air conditioner was 1.8 (95% CI, 1.0–3.3; P < 0.05), using of a light bulb was 3.7 (95% CI, 1.1–12.6; P < 0.05), and noise was 2.1 (95% CI, 1.1–4.1; P < 0.05).
Weinreich et al., 2015	1,773 subjects (aged 50-80 years) in Germany	Cross-sectional study	- A nasal cannula connected to ResMed's ApneaLink	- PM_{10} - Ozone - Temperature	- Increasing in temperature (8.6°C) and ozone (39.5 μg·m−3) was associated with a 10.2% (95% CI 1.2–20.0%) and 10.1% (95% CI 2.0–18.9%) increased in AHI, orderly. - Temperature was associated with summer, yielding a 32.4% (95% CI 0.0–75.3%) increased in AHI per 8.6°C (p-value for season–temperature interaction 0.08). - AHI was not associated with PM_{10}.

Table 3 Summary of using electronic media devices in bedroom and sleep problems

Authors, Year of publication	Population	Study design	Measurement tool	Electronic devices	Results
Shochat et al., 2010	470 Israeli adolescents	Cross-sectional study	- Self-report questionnaire - Sleep habit survey - Electronic media and fatigue questionnaire	- Television - Computer	- During weekdays, later bedtime was associated with an increased frequency of sleep-wake problem (r = 0.28), daytime sleepiness (r = 0.20), fatigue (r = 0.21) and longer television (r = 0.21) and internet use (r = 0.24) and Longer sleep latency was associated with an increased frequency of sleep-wake problem behaviours (r = 0.27), increased fatigue (r = 0.19) [$p \leq 0.002$, with Bonferroni correction].
Brunborg et al., 2011	2,500 Norwegian (aged 16-40 years)	Cross-sectional study	- Self-report questionnaire: - Insomnia questionnaire - Anxiety and depression questionnaire	- Television - Computer - Game console - DVD player - Mobile phone	- Using of computers and mobile telephones in the bedroom was likely to be associated with poor sleep habits among adults. - These media use in the bedroom was not related to any symptoms of insomnia.
Fossum et al., 2014	532 subjects (aged 18-39 years) in Norway	Cross-sectional study	- Self-report questionnaire: - Insomnia questionnaire - Daytime sleepiness - Chronotype questionnaire	- Television - Computer - Game console - Tablets - Mobile phone	- Using of a mobile phone for playing, surfing, and texting in bed was associated with a relatively late chronotype. - Excessive use of mobile phones in bed causes a phase delay of the circadian rhythm. - Except computers and mobile phones, no other media devices used in bed were significantly related to insomnia, chronotype, or morningness.
Hysing et al., 2015	9,846 adolescents whose aged 16–19 years in Western Norway	Cross-sectional population based study	- Self report questionnaire	- Television - Computer - MP3-player - Tablet - Game console	- Bedtime and daytime use of electronic devices were related to an increased risk of short sleep duration, long sleep onset latency and increased sleep deficiency. - A dose and response emerged between sleep duration and use of electronic devices: the association between computer use and risk of sleep less than 5 h (OR=2.70, 95% CI 2.14- 3.39, $p < 0.001$). – The association between use of cellphone and sleep less than 5 h (OR= 1.85, 95%CI 1.45- 2.35, $p < 0.001$).

Table 4 Summary of urinary melatonin and sleep quality

Authors, Year of publication	Population	Study design	Measurement tool	Sleep variables	Results
Morris, et al., 1990	- 8 healthy adults subjects (5 male, 3 female, mean age= 27) without sleep problems	- Experimental design (night asleep condition and night awake condition)	- Urinary 6-sulphatoxymelatonin (6-SMT) Radioimmunoassay (RIA) (collected 24 hours) - EEG, EMG, and EOG recording	- Total sleep time	- There was no significant correlation between total sleep time in the sleep condition and total nocturnal melatonin in both the sleep condition (r =0.27, df=6, P>0.01) and in the awake condition (r =0.05, df=6, P>0.10. - The correlation between 24-hour nocturnal melatonin percentage and total sleep time in both sleep condition was significant (r = +0.765, df=6, $p<0.05$).
Haimov, et al., 1994	- 4 groups of subjects that were a) 8 with insomnia (4 men, 4 women, mean age = 73.1 [SD=3.9]) b) 15 with insomnia (5 men, 10 women, mean age=82.1 [8.8]) had lived in nursing home at least 6 months c) 25 elderly without sleep disordered (19 men, 6 women, mean age 71.4 [5.2]) living in community d) 12 young men (mean age 24 [1.6]) without sleep disorders	- Cross-sectional study	- Urinary 6-sulphatoxymelatonin (6-SMT) (collected every 2 hours for 24/38 hours) - Wrist actigraphy	- Sleep duration - Sleep efficiency - Mean activity level	- There was a significant difference in sleep efficiency and activity level between elderly subjects without sleep disorders and those with insomnia (t=4.32, $p<0.0001$, t= 4.40, $p<0.0001$, orderly). - There was no significant difference in melatonin secretion between the elderly patients without sleep disorders and the young men (Z=1.18, P>0.24). - Spearman correlation (1-tailed) pointed that lower peak of 6-SMT concentration correlated with lower sleep efficiency (r=0.43, $p<0.002$).
Garfinkel, et al., 1995	-12 unhealthy elderly insomniac subjects (7 males, 5 females) - Mean age was 76 years (range 68-93 years of age, SD =8)	- Randomized, double-blind, crossover design - Subjects were treated for 3 weeks with 2 mg melatonin/night, and for 3 weeks with placebo, with a week's washout period.	- Urinary 6-sulphatoxymelatonin (6-SMT) (RIA) (collected every 3 hours during 1 night) - Wrist actigraphy (used 3 consecutive nights)	- Sleep quality - Sleep latency - Sleep efficiency - Total sleep time - Wake after sleep onset (WASO)	- Mean amount of 6-SMT excreted in urine/hour was greater in (3.00-6.00 am). - There was no significant different of mean sleep variables from pretreatment and placebo period. - Mean of sleep efficiency was significantly higher after melatonin than after placebo (83 [SE 4] vs. 75 [3]%, $p<0.001$). - Mean of WASO was significantly shorter (49 [14] vs. 73 [13] min, $p<0.001$) - Sleep latency decreased, but not significantly (19 [5] vs. 33 [7] min, p=0.088) - Melatonin did not affect to total sleep time.
Lushington, K., et al., 1998	- 52 subjects with good sleeping (control) (19 males, mean age =65.3 [SD=7.4]), (33 females, mean age = 63.5 [6.4]). - 56 subjects with insomniacs (21 males, mean age =66.2 [8.7]), (35 females, mean age = 64.3 [6.7]). - Divided subjects into 4 groups of medication: 1) no medication 2) anti-inflammatory agent (AI), 3) hormone replacement therapy (HRT), and 4) Other medication	-Cross-sectional study	- 7 days of sleep diary - 7 days of wrist actigraphy - 5 days of urinary 6-sulphatoxymelatonin (aMT6s) (RIA) (collected 12 hours 2 periods (8.00-20.00, 20.00-8.00)	- Sleep efficiency - Sleep quality	- There was no significant main effect for sleep status or sex on aMT6s excretion, or significant sleep status by sex interaction (all p>0.1). - Good sleeping and insomniacs gave the similar mean daytime, night-time, 24-h total and night-ration aMT6s values. - Women and men also gave the similar mean aMT6s values (38.9 (4.6) vs. 38.3 (5.1), orderly in good sleeping group), and (37.9 (5.3) vs.34.7 (5.0), orderly in insomniacs) for 24-h aMT6s excretion. - A one-way anova showed no significant main effect of medication grouping on any aMT6s variable (analyses involving sex was not performed as only female subjects were on HRT) (p>0.1). - No medication, AI, HI, and other medication gave the similar result of aMTs6s. - A three-factors anova pointed that there was no significant main effect of sleep status, sex, or medication on aMT6s (all p>0.07). - The correlation between sleep efficiency and aMT6s nighttime in good sleeping and insomniacs was 0.08 and 0.20, orderly (no significant). - The correlation between sleep quality and aMT6s nighttime in good sleeping and insomniacs was 0.30 ($p<0.05$), -0.11, orderly. - The results showed an inverse correlation significantly in age and nighttime aMT6s of good sleeping group (r= -0.28, $p<0.05$). - The results also showed an inverse correlation significantly in age and night-ratio aMT6s in good sleeping group (r=-.048, $p<0.005$).

Table 4 Summary of urinary melatonin and sleep quality (Continued)

Authors, Year of publication	Population	Study design	Measurement tool	Sleep variables	Results
Lushington et al., 1999	- 16 good sleeping (11 females, 5 males) (mean age = 65.4 (SD=7.4)) - 16 insomniacs (11 females, 5 males) (mean age = 64.3 (7.2))	-Cross-sectional study	- Polysomnography (PSG) 4 consecutive nights (for 26 hour) - Urinary 6-sulphatoxymelatonin (aMT6s) (RIA) (collected on even hour)	- Total sleep time (TST) - Sleep efficiency - Sleep quality	- Independent t-test analyses showed no significant between good sleeping and insomniac in any melatonin parameter (all p>0.1). - There was no significant linear relationship between PSG sleep parameters and aMT6s. - Melatonin-sleep phase synchrony was not associated with sleep quality. - A significant negative relationship was found between melatonin rhythm curve fit reliability and sleep onset latency [r (29)= -0.49, p<0.005]. - A significant positive relationship melatonin rhythm curve fit reliability and sleep efficiency [r (29)= 0.40, p<0.005].
Baskett et al., 2001	- 57 normal sleepers (40 females and 17 males) (range age 65-84 years) - 53 sleep maintenance problems (35 females and 18 males) (range age 65-84 years)	- A comparison with aged matched(cross-sectional study)	- Urinary 6-sulphatoxymelatonin (aMT6s) (RIA) (collected 24 hours) - PSQI		- Total melatonin excreted over 24 hours was 6.82 µg (95% CI 5.65-8.22) in normal sleepers and 7.50 µg (95% CI 6.97-9.43) in people with sleep maintenance problems. - There was a wide variation in aMT6s 24-hour excretory rates and levels among subjects in both groups. - There was no any difference in melatonin excretion when categorizes of good and poor sleep by PSQI. -There was no association between age-related sleep maintenance problems and aMT6s levels. - There was no significant difference in aMT6s between normal and problem sleepers in 24-hour melatonin secretion, night secretion, or night/day ratios.
Baskett, J., et al., 2003	- 20 normal sleepers - 20 sleep maintenance problem	- Randomized crossover trial	- Urinary 6-sulphatoxymelatonin (aMT6s) (RIA) (collected 24 hours) - Sleep diary - Wrist actigraphy	- Sleep efficiency - Sleep quality - Sleep latency	- There was no a significant effect of melatonin on sleep efficiency, sleep quality, and sleep latency between normal sleepers and sleep maintenance problem group. - There was lack of any effect of melatonin apparent on sleep duration or quality. - A 5 mg of melatonin did not improve sleep duration or sleep quality in people age over 65 years with age-related sleep maintenance problems.
Saksvik-Lehouillier et al., 2015	- 2,821 male subjects (mean age = 76 years (SD=5)	- Cohort study	- Urinary 6-sulphatoxymelatonin (aMT6s) ELISA - Wrist actigraphy (24 hours) - PSQI (sleep quality questionnaire) - Excessive daytime sleepiness questionnaire - Polysomnography	- Excessive daytime sleepiness (ESS) - Sleep efficiency -Total sleep time	- There was a significantly inverse association between ESS and aMT6s (MV OR, = 1.32; 95%CI, 0.95-1.84; p < 0.02). - There was a significantly association between aMT6s with shorter sleep time (< 5 hours) (MV OR, = 1.62; 95%CI, 1.21-2.99; p < 0.01). - Also, there was a significant association between aMT6s with worse sleep efficiency (< 70%) (MV OR, = 1.41; 95%CI, 1.28-2.65; p < 0.001), when restricting men without beta-blocker medicine use. - There was no an association between subjective sleep quality or respiratory disturbance with aMT6s.

CHAPTER III

METHODOLOGY

3.1 Study design

The research design of this study was a repeated cross-sectional study that was conducted to monitor changes in bedroom environmental conditions in patients with OSA, who resided in the city, from King Chulalongkorn memorial hospital, Bangkok, Thailand. It consisted of two cross-sectional observational surveys that were 1) a cross-sectional observational survey in the wet season, and 2) a cross-sectional observational survey in the dry season. Personal information was obtained including age, gender, weight, height, alcohol consumption status, smoking status, secondhand smoke exposure, mental health, bedroom environmental characteristics, subjective sleep quality, underlying diseases, bedroom environmental conditions (PM_{10}, temperature, and relative humidity), and urinary melatonin were obtained by a face-to-face interview, medical record, field analysis, and laboratory analysis respectively. The severity of OSA data was obtained from the Excellence Center for Sleep Disorders at King Chulalongkorn Memorial hospital. This study started during the period of January in 2016 to April in 2017.

3.2 Study area

The area of this study was purposively selected that was King Chulalongkorn Memorial hospital, where there is an important sleep center and it provides treatment services to public in the central of Bangkok. The researcher recruited all participants, who met the eligible criteria of the study from the Excellence Center for Sleep Disorders at King Chulalongkorn Memorial hospital, where most patients troubled with sleep problems. Map of King Chulalongkorn Memorial hospital was shown in **Figure 4**.

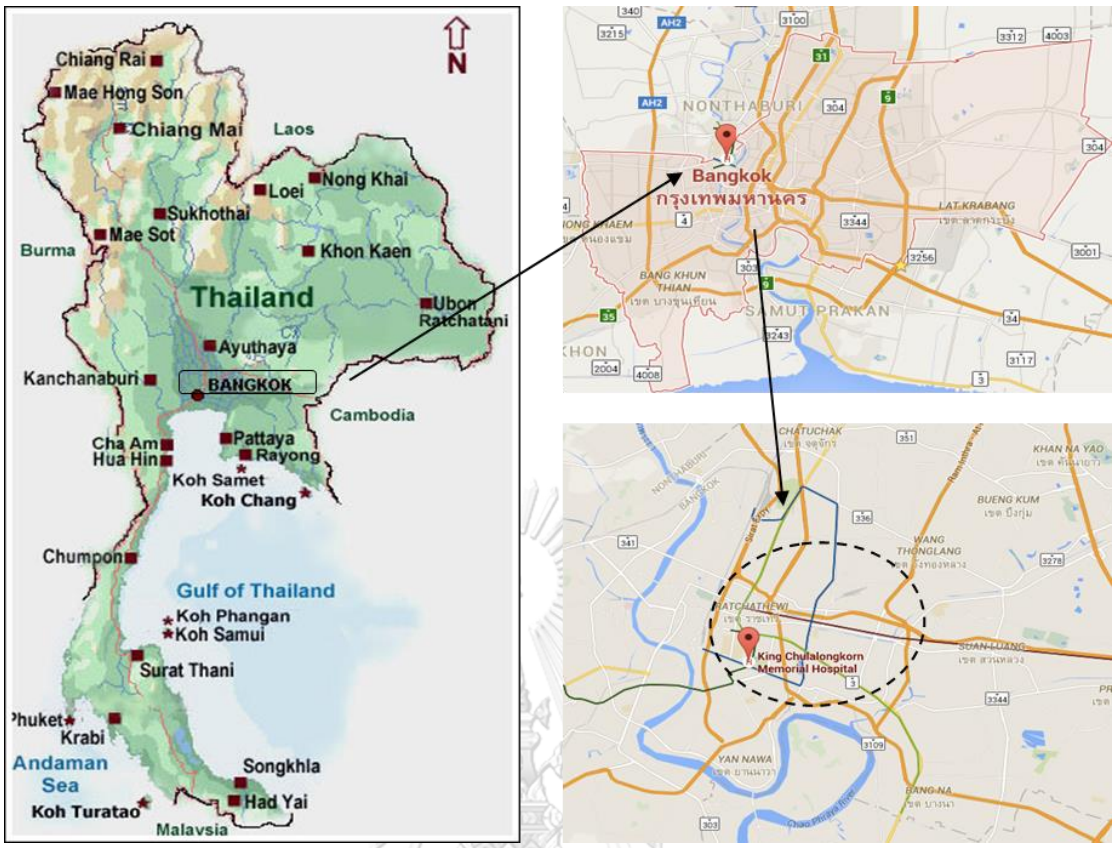


Figure 4 Map of King Chulalongkorn Memorial Hospital

Source: http://www.google.com/maps

3.3 Study population and sample group

Patients, who were referred for an overnight polysomnography and diagnosed with OSA, were enrolled from the Excellence Center for Sleep Disorders at King Chulalongkorn Memorial hospital, Bangkok, Thailand during the period of May to August 2016. The eligible criteria of selecting the participants was shown as the following:

3.3.1 Inclusion criteria

1) Male/female (aged 25 to 75 years)

2) Thai ethnic

3) Overnight polysomnography (PSG)

4) Newly diagnosed

5) Residence in Bangkok at least 1 year

6) Able to read, speak, and write in Thai

7) Willing to do an interview, and allow researcher to collect bedroom environmental condition (PM_{10}, temperature, and humidity) and urine with the provided equipment

3.3.2 Exclusion criteria

1) Co-morbidity: chronic respiratory failure, severe depression, severe anxiety, severe insomnia, N-stage of cancer, heart failure, and renal failure

2) Night shift working

3) Heavy smokers (≥15 cigarettes/day)

4) Pregnant woman

Personal characteristics and subjective sleep quality were obtained from a set of questions carried out by a face-to-face interview. All participants gave their written consent to participate and all research protocols were reviewed and approved by The Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University (RECCU No. 053/59), and the Faculty of Medicine Chulalongkorn University Institution Review Board (Med Chula IRB No. 038/59).

3.4 Sample size and sampling technique

The size of participant in this study was calculated by the equation of correlation, which was demonstrated at the below (*Eq. 1, Eq. 2*) to determine the relationship between independent variables and dependent variables (Hulley, Cummings, Browner, Grady, & Newman, 2007). A power of analysis was needed to be sufficient; thus, the researcher chose a power of 80% at the alpha level of 0.05. According to the previous study, it reported the correlation coefficient between pulse rate and particulate matter was 0.31, which the pulse rate could link to obstructive sleep apnea (Pope et al., 1999).

$$N = [(Z_{\alpha/2} + Z_{\beta})/C]^2 + 3$$

Equation 1 total number of subjects

And

$$C = 0.5 \ln [(1 + r)/(1 - r)]$$

Equation 2 correlation coefficient

When: N = Total number of subjects

$Z_{\alpha/2}$ = 1.96 (α = 0.05)

Z_{β} = 0.84 (β = 0.2 (power 80%))

r = expected correlation coefficient (0.31)

Thus; $C = 0.5 \ln[(1+0.31)/(1-0.31)]$

$= 0.3205$

$N = [(1.96+0.84)/0.3205]^2 + 3$

$= 79.3 \approx 80$ OSA patients

Add 10% for drop out = 80 + 8

= 88

Therefore, the overall sample in this study was supposed to be 80 participants from the calculation; however, the researcher added more 10 percent for drop out. So, the final number of participants was 88 OSA patients. Though, there was one group of participants, it had a variety of OSA severity. In addition, the sampling technique was a purposive sampling technique that recruited all participants who met the eligible criteria (**Figure 5**).

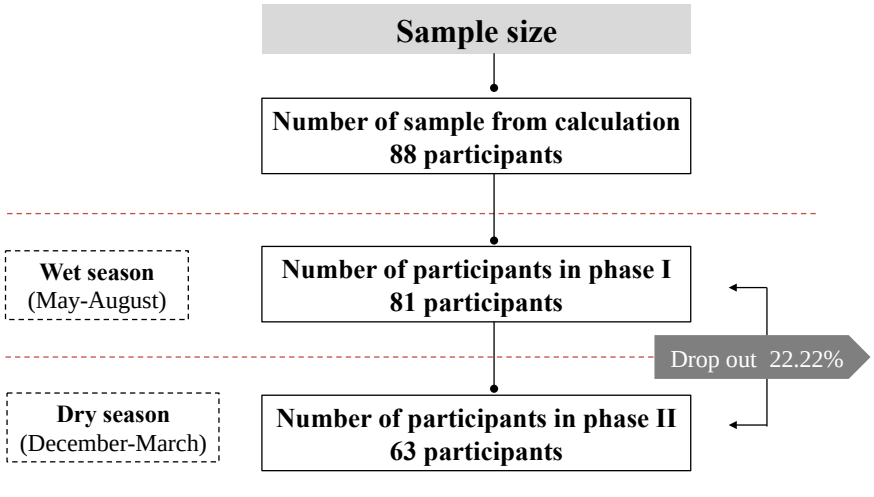


Figure 5 Number of participants in phase I and II

3.5 Measurement tools

3.5.1 Questionnaire

A set of questionnaires in this research was separated into two sets that were 1) a screening questionnaire, and 2) a principal questionnaire.

1. Screening questionnaire

The screening query contained three sections, which were 1) depression assessment, 2) anxiety screening, and 3) insomnia evaluation. This set of questionnaire took approximately 10 minutes to be done. It was used only in the first season (wet season) in order to exclude participants, who did not meet the eligible criteria of this study.

1.1 Depression assessment

This questionnaire was obtained from Patient Health Questionnaire-9 (PHQ-9) (Kroenke et.al, 2001). It is a standard query used for preliminary screening the severity of depression over the last two weeks. Moreover, this questionnaire was already translated into Thai version, and tested the reliability and the validity. For the reliability test, the Cronbach's alpha of total scale was 0.79 (Lotrakul et al., 2008). The test contains ten questions. Each of the items is scored "0" for "not at all", "1" for "several days", "2" for "more than half the days", and "3" for "nearly every day". However, the scores are counted from the items 1 to 9. Therefore, the scores are supposed to be ranged from 0 to 27 points by summing for each of the columns and then adding all columns to be a total score. The total score could indicate the level of depression as the contents below:

Total Score	Depression severity
1-4	None
5-9	Mild depression
10-14	Moderate depression
15-19	Moderately severe depression
20-27	Severe depression

1.2 Anxiety screening

This inquiry was obtained from Generalized Anxiety Disorder (GAD-7) (Spitzer et al., 2006). It is one of the most common questionnaires for screening anxiety and measuring the severity of anxiety symptoms over the last two weeks. This query was translated into Thai version. It consists of seven items, which each of the items is given the point "0" for "not at all", "1" for "several days", "2" for "more than half the days", and "3" for "nearly every day". The entire score is computed by adding the values for each item; hence, the total score is ranged from 0 to 21, and classified the level of anxiety severity as the following:

Total Score	Anxiety severity
0-4	None or minimal
5-9	Mild
10-14	Moderate
15-21	Severe anxiety

1.3 Insomnia evaluation

This questionnaire was obtained from Insomnia Severity Index (ISI) (Bastien, Vallières, & Morin, 2001; Morin, 1993). It is commonly applied to assessing insomnia and severity of insomnia in the last two weeks. It contains seven items that each item is rated into 5 scales ("0" = none, "4" = very severe problem). The entire score is calculated by adding the values of all items; hence, the total score is ranged from 0 to 28, and can be interpreted the level of insomnia as below:

Total Score	Severity of insomnia
0-7	No clinically significant insomnia
8-14	Sub-threshold insomnia
15-21	Clinical insomnia (moderate)
22-28	Clinical insomnia (severe)

2. Principal questionnaire

This set of principal questions was separated into two major sets that the first set was for the wet season, and the second set was for the dry season. Also, the first set (wet season) was divided into four parts, which were 1) socio-demographic characteristics, 2) psychological conditions, 3) residence and bedroom characteristics, and 4) sleep. To get done all questions of the first season (wet season) took approximately 20 minutes. For the second set (dry season) was divided into three parts, which were 1) OSA treatment, 2) change of bedroom environmental conditions, and 3) sleep (sleep quality (PSQI) and daytime sleepiness (ESS)). To finish all questions of the second season (dry season) took about 10 minutes.

The set of questionnaire for the wet season

2.1.1 Part 1: Socio-demographic characteristics

In this part of questionnaire was designed to carry out a survey of age, gender, weight, height, educational level, marital status, current address, telephone number, current occupation, monthly income, alcohol consumption, caffeine consumption, smoking status, secondhand smoke exposure, exercise, nap in daytime and general health information. As the above information, the researcher can know more detail about participants' background, which is helpful to investigate and consider a possible risk factor that affects to the interested outcomes.

2.1.2 Part 2: Psychological conditions

In this section, the questionnaire was revised based on literature review (Kayaba et al., 2014). It has 3 items for this section. It is about satisfaction in life, facing with stress, and how to cope with stress. Yield of this part is probably functional to assess and review its effects to the outcomes.

2.1.3 Part 3: Residence and bedroom characteristics

In this part, the questionnaire was adapted from Kayaba et al. (2014) (Kayaba et al., 2014) and developed based upon a former study. It contains 14 items, which question about environments of residence, particularly in the participants' bedroom, for example, type of residence, cooling device, window, room temperature setting, type of light, and color of light in bedroom. It also queries about cleaning behavior, such as, bedroom cleaning, and air conditioner cleaning. A validity of this enquiry was

tested and considered by expertise in the area of environmental health, sleep, and public health. After 3 experts proved all items of query, some items were revised following to their comments and advices. For the reliability coefficient test was done among 30 SDB patients, who had similar characteristics as a study group.

2.1.4 Part 4: Sleep

In this part, it can be subdivided into 4 parts: 1) sleep conditions, 2) Pittsburgh sleep quality index (PSQI), 3) excessive daytime sleepiness (ESS), and 4) chronotype of sleep disordered (CSM).

2.1.4.1 Sleep conditions

For the set of sleep conditions query was adapted and developed based on literature review. It comprises approximately 22 items, which enquired about environments in the bedroom, for example, the direction of head bed, bed size, type of mattress, fabric of bed sheets, pillowcases, duvets, material of pillow, pillow thickness, sleepwear, and so on. Also, it questioned about use of electronic media devices in bedroom. Professional experts in the field area of environmental health, sleep, and public health approved a validity of this questionnaire. Then, the researcher re-wrote and modified some items following by their suggestions. The reliability coefficient test was examined among 30 SDB patients, who had similar characteristics as a study group.

2.1.4.2 Pittsburgh sleep quality index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) was applied to evaluate subjective sleep quality (Buysse et al., 1989) and is a subjective standard questionnaire for estimating overall quality of sleep during the previous month. It contains 19 self-rated items that assess various components including sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, daytime dysfunction, and overall sleep quality. Each sleep component yields a score ranging from 0 to 3 (Buysse et al., 1989). Then, these sleep component scores are combined to yield a total score ranging from 0 to 21, called a “global score” indicating the participant’s sleep quality to be good or poor (Buysse et al., 1989). Based on former literature, participants with a score of 5 or lower were classified as good sleepers, and those with a score of 6 or greater were classified as poor sleepers. For sleep

quality component subscales, a dichotomous variable of optimal and suboptimal sleep quality was used. According to the original scale, sleep latency was subdivided into: <15 minutes, 16-30 minutes, 31-60 minutes, and >60 minutes. Those in the highest 3 groups of sleep latency (>15 minutes) were defined as experiencing long sleep latency. Additionally, sleep duration was evaluated using the PSQI questionnaire, which questioned participants on how many hours of actual sleep nightly they had during the past month. In accordance with the original scale, sleep duration was categorized: < 5 hours, 5.1-5.9 hours, 6-6.9 hours, and ≥ 7 hours. Those in the lowest 2 groups of sleep duration (< 6 hours) were classified as having short sleep duration. With regards to sleep efficiency, the original scale was grouped: >85%, 75-84%, 65-74%, and <65%. Those in the groups with 85% or less of sleep efficiency were defined as experiencing poor sleep efficiency.

Additionally, this questionnaire was translated into Thai version, and it was proved reliability and validity already. For the reliability test, the Cronbach's alpha of Thai-PSQI was 0.837 (Sitasuwan, Bussaratid, Ruttanaumpawan, & Chotinaiwattarakul, 2014).

Section	Score
1	Item 9 (very good (0), fairly good (1), fairly bad (2), very bad (3))
2	Item 2 (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + Item 5a (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)
3	Item 4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)
4	Item 4 (total of sleep hours) / Item 3 and 1(total of hours in bed) x 100, then [>85%=0, 75%-84%=1, 65%-74%=2, <65%=3]
5	Sum of scores item 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)
6	Item 6 (not during the past month (0), less than once a week (1), once/twice a week (2), three/more times a week (3)
7	Item 7 Score + Item 8 score, then [0=0; 1-2=1; 3-4=2; 5-6=3]

Then, add all these 7 section scores altogether = Global PSQI

Total Score	Subjective sleep quality
0-5	Good sleep
6-21	Poor sleep

2.1.4.3 Excessive daytime sleepiness (ESS)

This enquiry was drawn from Epworth Sleepiness Scale (ESS) (Johns, 1991). It is the most famous technique to assess the level of sleepiness in 8 general situations, which are 1) during sitting and reading 2) during watching television 3) during sitting in public places, such as, theater or meeting 4) during staying public bus over 1 hour continuously 5) during lying down to rest in the afternoon 6) during chatting or talking with other people 7) during sitting quietly after lunch break 8) during stuck in the traffic light about 2-3 minutes. The degree of dozing in each event can be scaled from 0 to 3. The entire score, thus, can be ranged from 0 to 24. After all, the result can be interpreted as the below. In addition, it was translated into Thai version, and tested validity and reliability. The value of Cronbach's alpha coefficients for standardized item was 0.87 (Banhiran, Assanasen, Nopmaneejumruslers, & Metheetrairut, 2011).

Total Score	Excessive daytime sleepiness
1-6	Getting enough sleep
7-8	Your score is average
9-above	Very sleepy and should seek medical advice

2.1.4.4 Chronotype of sleep disordered (CSM)

This set of survey was achieved from the Composite Scale of Morningness (CSM) (Smith, Reilly, & Midkiff, 1989). It is a common questionnaire for assessing characteristic of human circadian functioning individually. It contains 13 items with Likert-type responses that the content mentions about how easy for participants to get up in the morning, and so on. The entire scores can be ranged from 13 to 55. Also, the original cutoff points were set at the 10^{th} and 90^{th} percentiles and the result can be categorized into 3 groups as the below (Smith et al., 1989).

Additionally, this questionnaire was translated into Thai version and validity of this questionnaire was proven by professional experts in the field area of environmental health, sleep, and public health. After 3 experts checked all items of questions, some items were re-written and modified following by their comments and suggestions. A reliability coefficient was examined among 30 OSA patients, who had similar characteristics as a study group.

Furthermore, all set of query in Thai and English versions are shown in Appendix A.

CSM Score	Chronotype of sleep
Scores ≤ 22	Evening type
23 ≤ score ≤ 43	Intermediate type
Scores ≥ 44	Morning type

The set of questionnaire for the dry season

2.2.1 OSA treatment

In this part of questionnaire was designed to gain an information about treatment (receive/did not receive treatment) and type of OSA treatment. For this information, the researcher was able to know more detail of participants' situation. It was useful to be considered as a covariate factor in statistical analysis.

2.2.2 Change of bedroom environmental conditions

In this part, the question was planned to ask information about change of bedroom environmental conditions (color of light, curtain, or big cleaning bedroom) in the last 3 months before starting the second data collection in the dry season. This would be helpful for the researcher to know the change that might affect to the outcomes (sleep quality and PM_{10} concentration).

2.2.3 Sleep questionnaire

For the section of sleep, Pittsburgh sleep quality index (PSQI) and excessive daytime sleepiness (ESS) from the previous season were used to collect the data of sleep quality and daytime sleepiness of participants. Of which the research could compare differences between the seasons.

3.5.2 Polysomnography (PSG)

Overnight polysomnography is a gold-standard diagnostic test for obstructive sleep apnea. All participants underwent in-laboratory polysomnography at the beginning of study during the wet season (May to August 2016). The polysomnography system utilized in the study was Compumedics and its related software (Profusion 3) with standard techniques (**Figure 6**). The stages of sleep were scored in 30-sec intervals following the standard criteria from the AASM manual for the scoring of sleep and associated events (Iber, Ancoli-Israel, & Chesson, 2016). Apnea and hypopnea were defined using oral-nasal thermo-couple excursion and nasal pressure transducer excursion, respectively. Scoring apnea, hypopnea, and respiratory effort-related arousals (RERAs) was performed following the standard criteria from the AASM manual (Iber et al., 2016). Apnea was defined when dropping in peak signal excursions by ≥ 90% compared to pre-event baseline for ≥ 10 seconds. Hypopnea was defined when peak signal excursions drop by ≥ 30% of pre-event baseline for ≥ 10 seconds, and there was a ≥ 3% oxygen desaturation compared to pre-event baseline or the event was associated with an arousal (1A criteria). Respiratory effort-related arousals (RERAs) were defined when there was a sequence of breaths lasting ≥10 seconds characterized by increasing respiratory effort or by flattening of flow leading to arousal in which the event did not meet criteria for apnea or hypopnea. The apnea-hypopnea index was computed as the ratio of the count of all apneas and hypopneas to the total sleep time, expressed as events per hour. Respiratory disturbance index (RDI) was calculated as the ratio of the count of all respiratory events including RERAs to the total sleep time. Sleep efficiency was computed as the proportion of total sleep time over the total recording time in percent (Iber et al., 2016). Parameters of oxygenation, including absolute minimum SpO_2 during sleep and mean oxygen saturation during sleep, were measured by pulse oximetry. Based on the polysomnography results, OSA was diagnosed when AHI ≥5, and classified as mild when AHI was 5 to 14.9, moderate when AHI was 15 to 30, and severe when AHI > 30 (Ruehland et al., 2009).

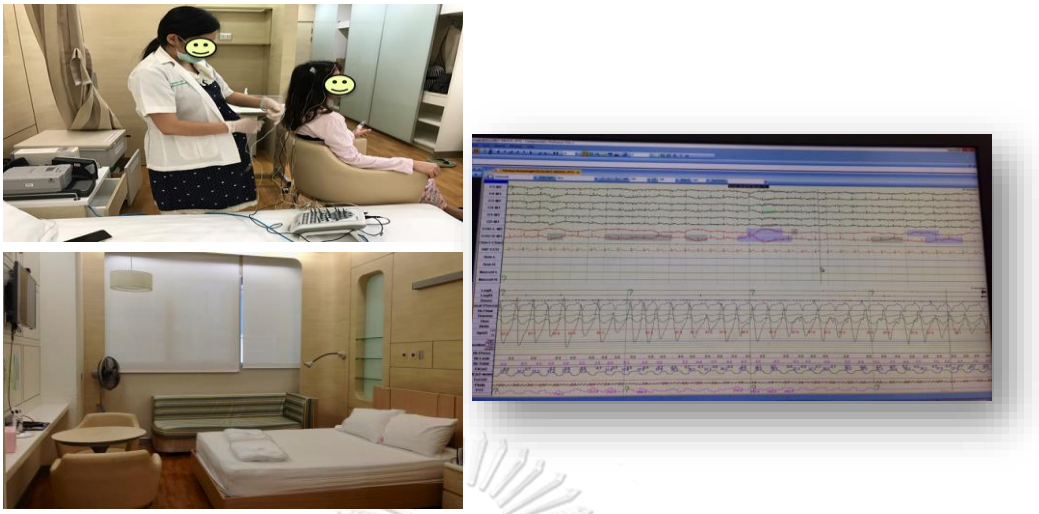


Figure 6 Polysomnography

3.5.3 Temperature, relative humidity, and absolute humidity

Ambient temperature and relative humidity were collected from participants' bedroom to detect an actual room temperature and relative humidity by using a HOBO® tempt/RH data logger (Onset devices, Pocasset, MA). This device can record and indicate a real time ambient temperature and relative humidity directly (**Figure 7**). Absolute humidity was calculated by temperature and relative humidity.

Figure 3.4

Figure 7 HOBO® tempt/RH data logger

3.5.4 Particulate matter diameter less than 10 micrometer (PM_{10})

A SKC personal sampling pump (model: 224-PCXR8), which is a portable and convenient device, was used to collect PM_{10} in this study. It is a well-known device that broadly uses to collect indoor particulate matter in person. This device consists

of personal air sampling pump, polyvinyl chloride filters with 5.0μm pore size (SKC Inc. USA), aluminum cyclone loaded with 37 mm. (CAT no. 225-01-02), support pad, and airflow calibrator (**Figure 8)**. The method of preparation, collection, and PM_{10} calculation followed the national institution's occupational safety and health code 0600 manual (NIOSH, 1998) (shown in **Figure 11, Figure 12, and** *Eq. 4*).

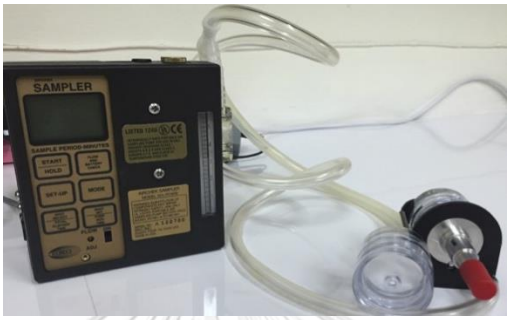
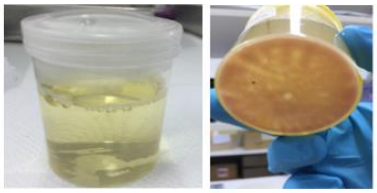


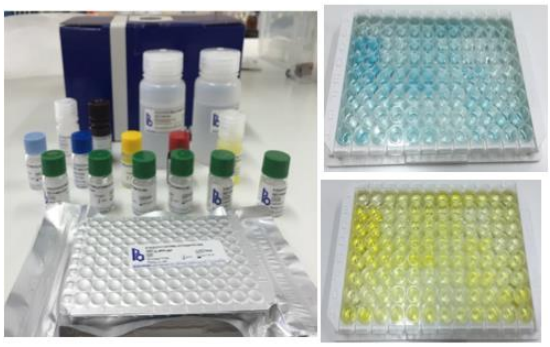
Figure 8 SKC personal sampling pump with cyclone and filter cassette

3.5.5 Urinary melatonin

Urinary melatonin (aMT6-s) was quantified by a commercial Bühlmann 6-sulfatoxymelatonin enzyme-linked immunosorbent assay (ELISA) kit, which manufactured by Bühlmann Laboratories AG, Schönenbuch, Switzerland (**Figure 9**). It is a non-invasive and the most feasible method of circadian phase assessment that enables researchers to measure the levels of melatonin in human urine directly (Peniston-Bird et al., 1996). Furthermore, it has been commonly used as an internal biological time biomarker in humans. After melatonin test, each urine sample was assayed for creatinine concentration with liquid reagents for enzymatic determination of creatinine in urine (Central lab). Results were expressed as aMT6s/creatinine (ng/mg).



Urine samples



Participants' urine were quantified by
6-SULFATOXYMELATONIN ELISA kit

Figure 9 Bühlmann 6-Sulfatoxymelatonin ELISA kit and urine samples

3.6 Data Collection

The data of bedroom environments (including PM_{10}, temperature, and relative humidity), subjective sleep quality (PSQI), excessive daytime sleepiness (ESS), and urinary melatonin were collected in two seasons, namely the wet season from late May to mid-August 2016, and the dry season that began in late December and continued into mid-March 2017. All mentioned environmental factors were collected in the participants' bedrooms for three consecutive nights in each season (Diette et al., 2007) in order to increase the validity of data, apart from subjective sleep quality, excessive daytime sleepiness, and urinary melatonin were collected only once in each season. After the polysomnography was performed and diagnosed by a sleep specialist, the first bedroom environmental conditions data was collected within one week for the wet season and the second data collection was conducted in the dry season. All sixty-three participants completed data collection of bedroom environmental conditions for both the wet and the dry seasons. All environmental measuring devices were delivered to participants' homes with a written instruction and a follow up phone call by the investigator.

In addition, all research assistants were trained how to collect data, interview by a face-to-face, and set up the environmental measuring devices at the beginning. The researcher also informed participants about the idea of the research in short to persuade them participating in this study. All participants gave their written consent to participate. The data collection chart is shown in **Figure 10**.

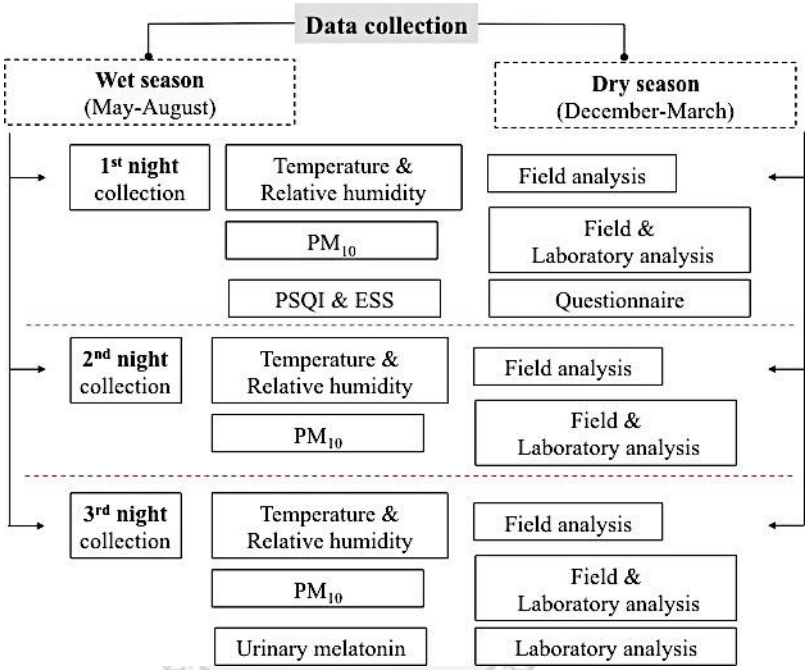


Figure 10 *Chart of data collection*

3.6.1 Temperature, relative humidity, and absolute humidity sampling

Temperature and relative humidity were continually detected and recorded by a HOBO® tempt/RH data logger (Onset devices, Pocasset, MA), calibrated and set before each sampling, every five minutes (Tunno et al., 2015). It was subsequently attached on the top of the insulated plastic box. Temperature and relative humidity during sleep time were drawn from the entire sampling period. The average of temperature and RH were reported. Absolute humidity was calculated using the following formula (1); where T is temperature in degree Celsius, rh is relative humidity in %, and e is natural logarithms (Mander, 2012). This device was delivered to participants' homes with a written instruction and a follow up phone call by the

investigator. The participants were instructed to place the device in their bedroom within 1 meter from the bed at the level of the nose while sleeping at night.

Equation 3 absolute humidity (grams/m^3) = $\frac{6.112 \times e^{[(17.67 \times T)/(T+243.5)]} \times rh \times 18.02}{(273.15+T) \times 100 \times 0.08314}$

3.6.2 Particulate matter diameter less than 10 micrometer (PM_{10}) sampling

PM_{10} samples were continuously monitored by a SKC personal sampling pump (model: 224-PCXR8) using 2.5-L/min aluminum cyclone loaded with 37 mm (CAT no. 225-01-02), 5.0 μm pore size, polyvinyl chloride filters (SKC Inc. USA) with a support pad. The filters were pre- and post- weighed in a temperature and relative humidity (RH) controlled environment following NIOSH guidelines (NIOSH, 1998). The personal air sampling was calibrated, and the start and the end period of data sampling were set. The device was placed in an insulated plastic box (cooler) and sound absorbing materials were inserted to reduce the noise of the device (Tsai et al., 2000). Therefore, the level of noise from the device was not over an annoyance level (approximately 45 decibels). The method of preparation and collection followed the national institution's occupational safety and health code 0600 manual (NIOSH, 1998) (shown in **Figure 11 and 12**). This device was delivered to participants' homes with a written instruction and a follow up phone call by the investigator. The participants were instructed to place the device in their bedroom within 1 meter from the bed at the level of the nose while sleeping at night.

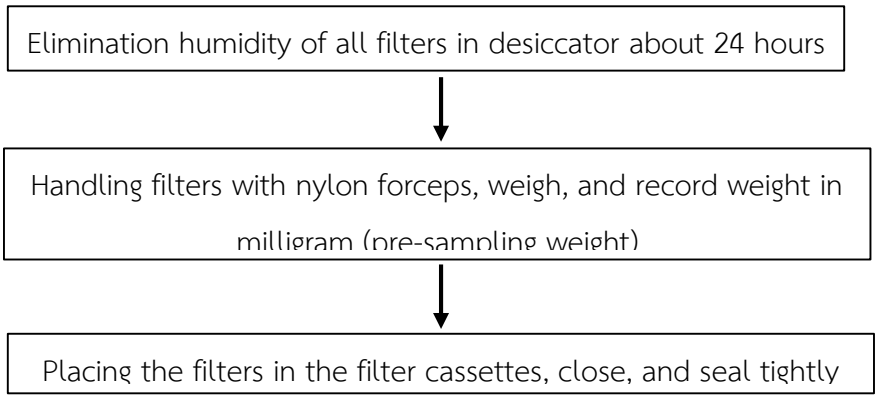


Figure 11 Sample preparation before sampling

Source: NIOSH-0600, 1998

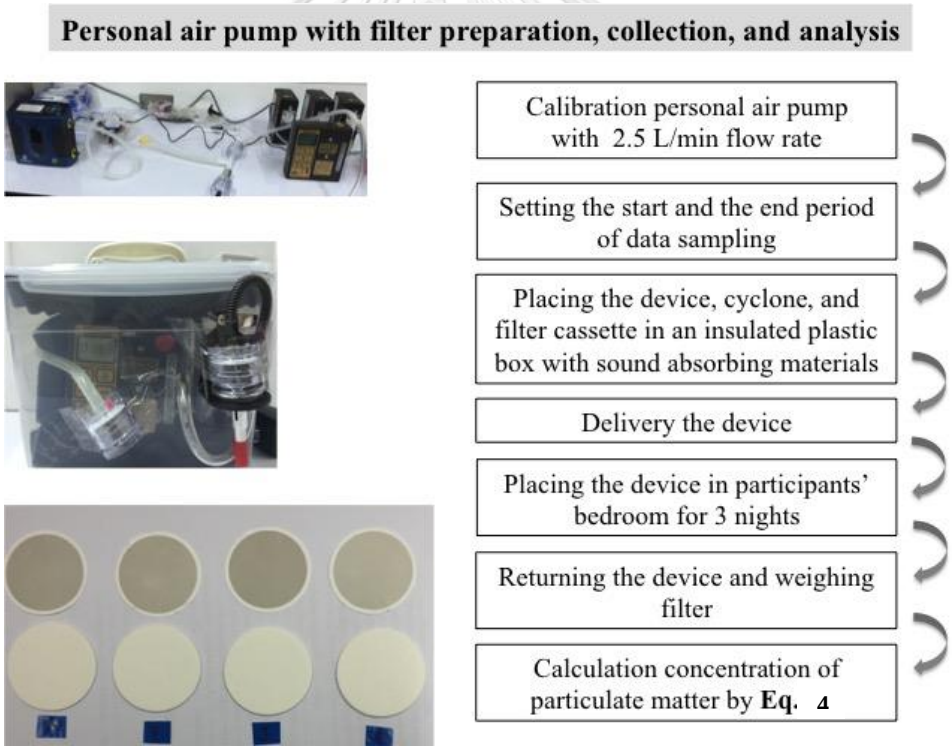


Figure 12 Personal air pump with filter preparation, collection, and analysis

Source: NIOSH-0600, 1998

3.6.3 Data collection of sleep questionnaire (PSQI and ESS)

All participants completed the set of sleep query by a face-to-face interview. This interview was conducted twice (the dry and wet season) but only once in each season.

3.6.4 Urinary melatonin sampling

Urine specimen was collected overnight, which meant all participants passed all urine in the provided bottle, since they started sleeping in the bedroom at night up until they woke up in the next morning. As it is possibly covered the entire of melatonin production at night. All participants were instructed to collect and keep the specimen with cool packs under the provided ice cooler. The urinary melatonin concentrations were assayed by the Bühlmann 6-sulfatoxymelatonin ELISA kit which assays were performed in duplicate. Furthermore, the known concentrations were used as standard and control in every ELISA kits in order to monitor the quality of the assay. In addition, the concentrations of urinary melatonin in this study were adjusted with urine creatinine in order to account for difference volume of urine, which may lead to various concentration of urinary melatonin, and to compare to other studies easily. This test was conducted two times (the wet and the dry seasons); however, it was collected only once in each season. The process of collecting and analyzing was demonstrated as the contents below:

1) Urine specimens were wrapped with aluminum foil and kept in ice cooler during transportation to the laboratory.

2) A 15 milliliters aliquot was frozen at -20°C until determination of urinary melatonin and creatinine.

3) Then, urine specimens were analyzed by commercial Bühlmann 6-sulfatoxymelatonin ELISA kit to measure the primary urinary metabolite of melatonin. The process of quantification with the ELISA kit was shown in the **Figure 13**.

4) The prepared urine specimens were packed in the ice cooler before delivering to the central lab to analyze creatinine.

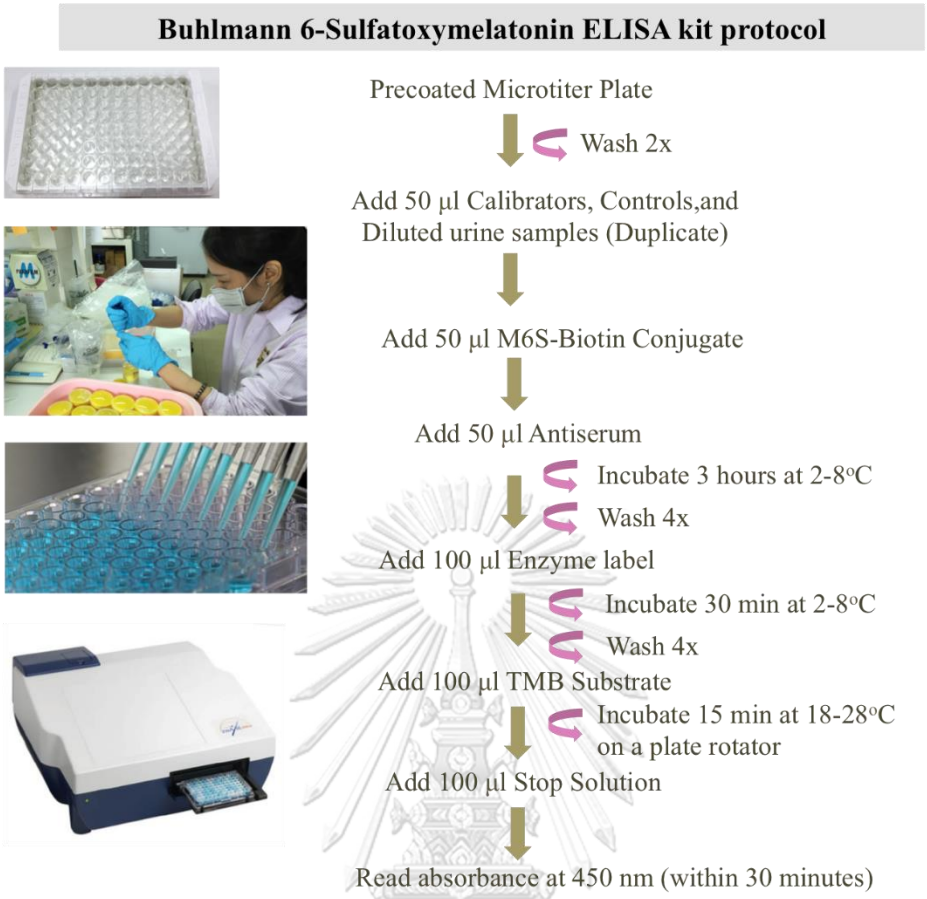


Figure 13 Protocol of Buhlmann 6-Sulfatoxymelatonin ELISA kit

3.7 Data Analysis

3.7.1 Statistical analysis

All analyses of this study were performed using SPSS Version 22.0, (IBM SPSS Version22, Chicago, IL,) which were illustrated as the following:

3.7.1.1 Descriptive statistics

Personal characteristics, psychological conditions (depression and anxiety), sleep (insomnia, sleep conditions, PSQI, ESS, CSM), polysomnography sleep variables, residence and bedroom characteristics, urinary melatonin concentration, and bedroom environmental conditions of participants, were assessed using means (± standard deviation) for continuous variables and counts and percentages for categorical variables. For non-normal distribution variables, a median (interquartile range) was provided.

3.7.1.2 Analytical statistics

3.7.1.2.1 Mann-Whitney U test was used to compare differences between two independent groups when the dependent variable is ordinal or continuous, but not normally distributed. It was applied to analyze differences of general characteristics (such as age, BMI, anxiety (GAD 7) and depression (PHQ 9)), sleep parameters (such as sleep latency, sleep duration, sleep quality and daytime sleepiness) and polysomnography variables (such as total sleep time, total wake time after sleep onset, sleep onset latency, stage 1 of sleep, slow-wave sleep, mean oxygen saturation, minimum oxygen saturation and arousal index) of participants between phase I (wet season) and phase II (dry season).

3.7.1.2.2 Independent t-test was performed to compare means between two unrelated groups on the same continuous variables with normal distribution. It was performed to analyze differences of sleep parameters (such as habitual sleep efficiency, insomnia and chronotype sleep (CSM)) and polysomnography variables (such as stage 2 of sleep, REM sleep, respiratory disturbance index (RDI) and apnea-

hypopnea index (AHI))) of participants between phase I (wet season) and phase II (dry season).

3.7.1.2.3 Paired t-test was applied to determine differences in the same individual's mean values of continuous variables with normal distribution (such as sleep quality, daytime sleepiness, urinary melatonin concentrations, PM_{10}, temperature, relative humidity, and absolute humidity) between seasons (wet and dry seasons).

3.7.1.2.4 Chi-square test was used to compare unrelated groups of categorical variables. Additionally, the chi-square test was performed to assess associations between two or more categorical variables. It was applied to test differences of general characteristics (such as gender, marital status, number of children, education, and so on), sleep parameters and polysomnography variables between phase I (wet season) and phase II (dry season). Furthermore, an association of bedroom characteristics and subjective sleep quality (PSQI) was tested by chi-square.

3.7.1.2.5 Fisher's exact test was an alternative selected when the assumption for using the chi-square test is not met (> 20% of the expected cell frequency < 5 in 2x2 tables).

3.7.1.2.6 Multiple linear regression models were applied to estimate an association between two or more independent variables and continuous dependent variables. It was also used to assess whether confounding exists as potential confounding variables, which had been included in the model. The associations of 1-year mean bedroom environmental conditions and seasonal variation (the dry and wet seasons) of bedroom environmental conditions with polysomnography sleep parameters (AHI and RDI), multiple linear regression models were applied and adjusted for age, gender, body mass index, alcohol consumption, smoking, and secondhand smoke.

3.7.1.2.7 Univariate analysis was used to evaluate odds ratio (OR) and 95% confidence interval (CI) for a single independent variable and dependent variable. The associations of subjective sleep quality (PSQI) and urinary melatonin concentrations with severity of obstructive sleep apnea (AHI), univariate analyses

were applied. Similarly, the association between subjective sleep quality (PSQI) and urinary melatonin concentrations was tested by univariate analysis. The good sleep quality (PSQI $\leq$ 5) and higher urinary melatonin concentrations **(**> 15**.**24 ng**/**mg**)** were used as the reference group in the analyses.

3.7.1.2.8 Multivariable-adjusted logistic regression models were utilized to estimate adjusted odds ratio (AOR) and 95% confidence interval (CI) for the associations of bedroom environmental conditions and subjective sleep quality parameters (PSQI) that were controlled for age, gender, body mass index, alcohol consumption, smoking, secondhand smoke, and AHI. The short sleep latency ($\leq$ 30 mins), longer sleep duration ($\geq$ 6 hours), good sleep efficiency ($\geq$ 85.00%), and good sleep quality (PSQI $\leq$ 5) were used as the reference group in the analyses. Moreover, the associations of bedroom environmental conditions and urinary melatonin concentrations were assessed by multivariable-adjusted logistic regression that were controlled by two types of adjusted models: 1) minimally adjusted model (age, gender, body mass index), and 2) fully adjusted model (age, gender, body mass index, alcohol consumption, active smoke, secondhand smoke, exercise, beta-blocker medicine use, sleeping pill use, and AHI).

3.7.2 Particulate matter concentration

The particulate matter concentration, especially respirable dust, will be calculated by equation (*Eq.4*) from NIOSH-0600 method (NIOSH, 1998). The equation is displayed as the following:

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V\ (m^3)} \times 1000\ (mg/m^3)$$

Equation 4 concentration of particulate matter

Where: C = concentration of particulate matter (mg/m^3)

W_1 = tare weight of filter before sampling (mg)

W_2 = post-sampling weight of sample-containing filter (mg)

B_1 = mean tare weight of blank filters (mg)

B_2 = mean post-sampling weight of blank filters (mg)

V = Air volume as sampled at flow (m^3)

3.8 Ethical Consideration

The Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University (RECCU No. 053/59), and the Faculty of Medicine Chulalongkorn University Institution Review Board (Med Chula IRB No. 038/59) gave an approval for all research protocols. The ethic consideration was considered by the three principal rules of ethical research involving human subjects that are 1) respect for person, 2) beneficence/ non-maleficence, and 3) justice. The researcher informed the purpose of study and entire process of study to participants before running the project. Also, participants were received the written consent form to give their permission for taking part in this study. All participants have an authority to reject or stop to join in this study as long as they would like to.

CHAPTER IV

RESULTS

Personal information, sleep quality and bedroom environmental characteristics of participants were obtained by a face-to-face interview. In the part of underlying diseases and polysomnography results, we were given permission from the Excellence Center for Sleep Disorders at King Chulalongkorn Memorial hospital to access and use the data from the medical record. Moreover, bedroom environmental conditions such as PM_{10}, temperature, and humidity were collected in two seasons (the wet and the dry season) for three consecutive nights. On the other hand, melatonin concentrations in urine of participants were collected only one night of each season. As this study had two phases with different numbers of participants; 1) The first phase was the wet season, which had 81 participants, and 2) The second phase was the dry season, which had 63 participants. Because of loss-to-follow-up influenced to the different numbers of participants.

4.1 General characteristics of participants in phase I and II

The phase I (the wet season), eighty-one participants recruited in this study were predominantly male (70.40%), a median of age 48.00 years. Their median BMI was 26.20 kg/m^2. Most of them got married (60.50%), but over half (55.6%) had no children. It seemed to be that less than half of participants graduated Master's degree or above (43.20%) and 43.20% of them earned monthly income greater than 50,000 baht. Almost one-fourth of participants (23.50%) reported active alcohol consumption, and very few (4.90%) and (8.60%) reported active smoking and current secondhand smoke exposure, respectively. Less than half of them (38.30%) had hypertension. Few participants used beta-blocker medicine (8.60%), as well as, sleeping pill (24.70%). A median concentration of urinary melatonin was 15.24 ng/mg **(Table 5)**.

In phase II (the dry season), of sixty-three participants completed both seasons were mostly male (73.00%) with a median age of 42.00 years. A median BMI of them was 26.20 kg/m^2. Approximately 22.20% reported active alcohol consumption, while 6.30% and 9.50% reported active smoking and current secondhand smoke exposure, respectively. Hypertension was reported by 34.90% of the participants. Few participants (6.30%) took beta-blocker medicine and a small number of them (20.60%) used sleep pill. An average melatonin concentration was 29.91 ng/mg (SD = 17.54) **(Table 5)**. Most of the values between phase I and phase II were fairly similar, but some were slightly different. Therefore, none of these variables showed any significant differences **(Table 5)**.

4.2 Sleep parameters of participants in phase I and II

The phase I (the wet season), according to the PSQI questionnaire, a median of sleep latency and sleep duration of participants was 20.00 minutes and 6.00 hours, respectively. A mean of habitual sleep efficiency was 87.76% (SD = 14.31). A majority of participants (69.10%) reached the criteria for poor sleep quality. According to insomnia, chronotype sleep, and daytime sleepiness questionnaires, approximately 3.70% reported severe insomnia, while 74.10% reported intermediate type. Approximately twenty-seven percent of them were suffered from daytime sleepiness problem (**Table 6**).

In phase II (the dry season), as the results from the PSQI questionnaire indicated the median of sleep latency and sleep duration of participants was 20.00 minutes and 6.00 hours, respectively, which was similar to the first phase. An average of habitual sleep efficiency was 89.21% (SD =14.2). A greater number of participants (68.30%) were classified as having poor sleep quality. As claimed by the results from insomnia, chronotype sleep, and daytime sleepiness questionnaires, very few participants (3.20%) were assumed severe insomnia, while 74.60% and 38.10% reported intermediate type, and daytime sleepiness problem, respectively (**Table 6**). Categorical data of sleep duration and chronotype sleep revealed significantly different between phase I and phase II **(Table 6)**.

Table 5 General characteristics of participants in phase I (N=81) and II (N=63)

Variables	Phase I: Wet season (N=81)	Phase II: Dry season (N=63)	P value
Age (years)	†48.00 (36.00-56.50)	†42.00 (35-57)	[a]0.627
BMI (kg/m^2)	†26.20 (22.99-31.96)	†26.20 (23.56-31.35)	[a]1.000
Gender, *n (%)*			
Male	57 (70.40)	46 (73.00)	[b]0.727
Female	24 (29.60)	17 (27.00)	
Marital status, *n (%)*			
Single	30 (37.00)	27 (42.90)	[b]0.730
Married	49 (60.50)	34 (54.00)	
Divorce	2 (2.50)	2 (3.20)	
Number of children, *n (%)*			
None	45 (55.60)	37 (58.70)	[b]0.849
≥ 1 child	36 (44.40)	26 (41.30)	
Education, *n (%)*			
< Master's degree	46 (56.80)	35 (55.60)	[b]0.882
> Master's degree	35 (43.20)	28 (44.40)	
Monthly income, *n (%)*			
≤ 50,000 baht	46 (56.80)	36 (57.10)	[b]0.966
> 50,000 baht	35 (43.20)	27 (42.90)	
Active alcohol consumption, *n (%)*	19 (23.50)	14 (22.20)	[b]0.861
Caffeine consumption, *n (%)*	60 (74.10)	46 (73.00)	[b]0.886
Glass of caffeine in daily, *n (%)*			
≤ 1 glass	39 (65.00)	31 (67.40)	[b]0.771
> 1 glass	21 (35.00)	15 (32.60)	
Active smoke, *n (%)*	4 (4.90)	4 (6.30)	¶1.000
Secondhand smoke exposure, *n (%)*	7 (8.60)	6 (9.50)	[b]0.855
Exercise (≥ 30 minutes), *n (%)*	43 (53.10)	31 (49.20)	[b]0.644
Subjective health satisfied, *n (%)*			
Very good and good	35 (43.20)	25 (39.70)	[b]0.670
Fair and poor	46 (56.80)	38 (60.30)	
Diabetes, *n (%)*	12 (14.8)	11 (17.50)	[b]0.667
Hypertension, *n (%)*	31 (38.3)	22 (34.90)	[b]0.679
Cardiovascular diseases, *n (%)*	6 (7.4)	5 (7.90)	¶1.000
Stroke, *n (%)*	2 (2.5)	2 (3.20)	¶1.000
Respiratory diseases, *n (%)*	20 (24.7)	17 (27.00)	[b]0.755
Beta-blocker medicine use, *n (%)*	7 (8.6)	4 (6.30)	¶0.756
Sleeping pill use, *n (%)*	20 (24.7)	13 (20.60)	[b]0.566
Anxiety (GAD 7)	†5.00 (1.00-8.00)	†5.00 (2.00-7.00)	[b]0.989
Depression (PHQ 9)	†6.00 (3.00-8.50)	†6.00 (3.00-9.00)	[b]0.910
Melatonin concentrations (ng/mg)	†15.24 (8.52-23.69)	§29.91 ± 17.54	Not test

† = Median (IQR); § = Mean ± SD; [a]= Mann-Whitney U test; [b] = Chi-square test; ¶ = Fisher's exact test

Table 6 Sleep parameters of participants in phase I (N=81) and II (N=63)

Variables	Phase I: Wet season (N=81)	Phase II: Dry season (N=63)	P value
Nap in daytime, *n (%)*	40 (49.40)	34 (54.00)	[b]0.585
Duration of napping, *n (%)*			
≤ 20 minutes	62 (76.50)	45 (71.40)	[b]0.486
> 20 minutes	19 (23.50)	18 (28.60)	
Sleep latency (min)	[†]20.00 (10.00-30.00)	[†]20.00 (10.00-30.00)	[a]0.933
≤ 15 min, *n (%)*	32 (39.50)	23 (36.50)	[b]0.713
> 15 min (long sleep latency), *n (%)*	49 (60.50)	40 (63.50)	
Sleep duration (hour)	[†]6.00 (6.00-7.00)	[†]6.00 (6.00-7.00)	[a]0.786
< 6 hours (short sleep duration), *n (%)*	17 (21.00)	32 (50.80)	[b]0.000***
≥ 6 hours, *n (%)*	64 (79.00)	31 (49.20)	
Habitual sleep efficiency (%)	[§] 87.76 ± 14.31	[§] 89.21 ± 14.16	[c]0.545
≥ 85%, *n (%)*	53 (65.40)	42 (68.30)	[b]0.722
< 85% (poor sleep efficiency), *n (%)*	28 (34.60)	20 (31.70)	
Sleep quality (PSQI)	[†]7.00 (5.00-9.50)	[†]7.00 (5.00-9.00)	[a]0.334
Good sleep, *n (%)*	25 (30.90)	20 (31.70)	[b]0.753
Poor sleep, *n (%)*	56 (69.10)	43 (68.30)	
Insomnia (ISI)	[§] 10.49 ± 5.58	[§]10.44 ± 5.59	[c]0.958
None, *n (%)*	29 (35.80)	23 (36.50)	[b]1.000
Mild, *n (%)*	32 (39.50)	25 (39.70)	
Moderate, *n (%)*	17 (21.00)	13 (20.60)	
Severe, *n (%)*	3 (3.70)	2 (3.20)	
Chronotype sleep (CSM)	[§] 35.84 ± 8.34	[§]35.33 ± 8.53	[c]0.721
Evening type, *n (%)*	4 (4.90)	12 (19.00)	[b]0.003**
Intermediate type, *n (%)*	60 (74.10)	47 (74.60)	
Morning type, *n (%)*	17 (21.00)	4 (6.30)	
Daytime sleepiness (ESS)	[†]8.00 (6.00-11.00)	[†]9.00 (6.00-11.00)	[a]0.793
Normal, *n (%)*	59 (72.80)	39 (61.90)	[b]0.163
Abnormal, *n (%)*	22 (27.20)	24 (38.10)	

[†] = *Median (IQR);* [§] = *Mean ± SD;* [a] = Mann-Whitney U test; [b] = Chi-square test; [c]= independent t-test

***P value ≤ 0.001; ** P value ≤ 0.01

4.3 Polysomnography variables of participants in phase I and II

In phase I (the wet season), based on polysomnography results, we found that median sleep efficiency was 85.50%. Average values of RDI and AHI in phase I were 44.97 events/hours (SD = 24.91), and 43.20 events/ hours (SD = 25.98), respectively. Approximately 68.00%, 16.00% and 16.00% met the criteria for severe, moderate and mild obstructive sleep apnea, respectively (**Table 7**).

In phase II (the dry season), according to polysomnography results, it indicated that median sleep efficiency of participants was 86.30%. Mean RDI and AHI in phase II were 47.66 events/hours (SD = 26.06), and 45.83 events/ hours (SD = 27.21), respectively. Over half (71.40%) was met the criteria for severe obstructive sleep apnea, and approximately 14.30% was met the criteria for moderate and mild sleep apnea (**Table 7**). Almost all of the values between phase I and phase II were fairly similar, but some were slightly different. Therefore, none of these variables demonstrated significant differences **(Table 7)**.

Table 7 Polysomnography variables of participants in phase I (N=81) and II (N=63)

Variables	Phase I: Wet season (N=81)	Phase II: Dry season (N=63)	P value
Total sleep time (min)	†311.50 (166.75-375.50)	†315.50 (168.50-377.50)	[a]0.928
Total wake time after sleep onset (min)	†31.00 (13.00-63.25)	†27.50 (10.50-58.00)	[a]0.480
Sleep onset latency (min)	†6.00 (3.00-13.25)	†9.50 (3.50-18.00)	[a]0.210
Sleep efficiency (%)	†85.50 (78.10-92.55)	†86.30 (79.80-93.30)	[a]0.476
Sleep architecture (%)			
Stage 1 sleep	†19.90 (12.15-30.40)	†20.50 (13.20-30.30)	[a]0.571
Stage 2 sleep	§46.59 ± 12.44	§46.31 ± 12.73	[c]0.893
Slow-wave sleep	†14.20 (5.25-23.90)	†16.20 (11.00-23.60)	[a]0.108
REM sleep	§14.64 ± 9.90	§14.94 ± 8.93	[c]0.847
Mean oxygen saturation (%)	†95.00 (93.00-96.00)	†95.00 (92.00-96.00)	[a]0.695
Minimum oxygen saturation (%)	†86.00 (75.00-90.00)	†84.00 (74.00-89.00)	[a]0.790
Arousal index (arousals/hour)	†34.90 (23.20-48.05)	†37.40 (23.10-49.70)	[a]0.987
Respiratory disturbance index , RDI (events/hour)	§44.97 ± 24.91	§47.66 ± 26.06	[a]0.529
Apnea-hypopnea index , AHI (events/hour)	§43.20 ± 25.98	§45.83 ± 27.21	[a]0.556
Mild OSA, *n (%)*	13 (16.00)	9 (14.30)	
Moderate OSA, *n (%)*	13 (16.00)	9 (14.30)	[b]0.901
Severe OSA, *n (%)*	55 (68.00)	45 (71.40)	

† = *Median (IQR);* § = *Mean ± SD;* [a] = Mann-Whitney U test; [b] = Chi-square test; [c]= independent t-test

4.4 An association of subjective sleep quality and severity of obstructive sleep apnea in phase I

The results of univariate analysis were shown in **Table 8**. It showed that factors of anxiety, depression, insomnia, chronotype sleep, and daytime sleepiness were significantly associated with subjective sleep quality. Multivariate analysis also indicated that insomnia and daytime sleepiness were significantly associated with subjective sleep quality. However, both analyses did not show any significant associations between subjective sleep quality and severity of obstructive sleep apnea.

4.5 An association of severity of obstructive sleep apnea (AHI) and urinary melatonin concentrations in phase I

As shown in **Table 9**, both univariate and multivariate analyses indicated that severity of obstructive sleep apnea was not associated with low level of melatonin concentrations (OR = 1.00, 95%CI; 0.98, 1.02), (AOR = 1.00, 95%CI; 0.98, 1.02). Additionally, our findings reported there was a significant association between PM_{10} and low level of melatonin concentrations in both univariate and multivariate analyses (OR = 1.06, 95%CI; 1.00, 1.11), (AOR = 1.06, 95%CI; 0.98, 1.13); however, other factors were not associated with low level of melatonin concentrations.

4.6 A relation of subjective sleep quality (PSQI) to urinary melatonin concentrations in phase I

According to univariate and multivariate analyses, these analyses did not reveal any significant association between subjective sleep quality and urinary melatonin concentrations. Moreover, none of these factors were found in associations with urinary melatonin concentrations (**Table 10**).

Table 8 Univariate and multivariate analysis relating subjective sleep quality (PSQI) to severity of obstructive sleep apnea (AHI) in phase I (N = 81)

Variables	Poor sleep quality (PSQI > 5)			
	Univariate analysis		Multivariate analysis	
	OR	95% CI	AOR	95% CI
Age	0.97	0.93, 1.01 (p=0.112)	1.05	0.96, 1.15 (p=0.291)
Gender (Male)	1.50	0.51, 4.40 (p=0.460)	1.14	0.16, 8.34 (p=0.894)
BMI	1.01	0.96, 1.07 (p=0.737)	1.07	0.93, 1.24 (p=0.365)
Alcohol (Have)	0.70	0.24, 2.07 (p=0.520)	0.27	0.03, 2.45 (p=0.245)
Smoke (Yes)	0.43	0.06, 3.21 (p=0.408)	0.49	0.02, 11.04 (p=0.655)
Secondhand smoke (Yes)	2.88	0.33, 25.28 (0.340)	8.41	0.12, 604.08 (p=0.329)
Exercise (No)	0.67	0.26, 1.74 (p=0.406)	2.01	0.35, 11.46 (p=0.430)
Anxiety (GAD 7)	1.42	1.18, 1.70 (p=0.000***)	1.10	0.81, 1.50 (p=0.527)
Depression (PHQ 9)	1.50	1.22, 1.85 (p=0.000***)	0.99	0.70, 1.41 (p=0.972)
Insomnia (ISI)	1.57	1.28, 1.94 (p=0.000***)	1.46	1.11, 1.93 (p=0.007**)
Chronotype sleep (CSM)	0.93	0.87, 0.99 (p=0.017*)	0.97	0.86, 1.09 (p=0.585)
Daytime sleepiness (ESS)	1.23	1.07, 1.46 (p=0.005**)	1.33	1.03, 1.71 (p=0.027*)
Severity of OSA (AHI)	1.00	0.97, 1.01 (p=0.311)	0.99	0.95, 1.03 (p=0.502)

***P value ≤ 0.001; ** P value ≤ 0.01; * P value < 0.05

Table 9 Univariate and multivariate relating severity of obstructive sleep apnea to urinary melatonin concentrations in phase I (N=81)

Variables	Urinary melatonin concentrations (≤ 15.24 ng/mg)			
	Univariate analysis		Multivariate analysis	
	OR	95% CI (P value)	AOR	95% CI (P value)
Age	0.99	0.95,1.02 (p=0.473)	0.98	0.94, 1.03 (p=0.439)
Gender (Male)	0.97	0.37, 2.51 (p=0.943)	1.03	0.34, 3.10 (p=0.957)
BMI	1.00	0.95, 1.05 (p=0.984)	1.02	0.95, 1.08 (p=0.637)
Alcohol (Have)	1.11	0.40, 3.11 (p=0.841)	0.87	0.26, 2.93 (p=0.818)
Smoke (Yes)	0.97	0.13, 7.27 (p=0.980)	1.14	0.13, 10.35 (p=0.907)
Secondhand smoke (Yes)	0.71	0.15,3.40 (p=0.669)	0.58	0.09, 3.88 (p=0.577)
Exercise (No)	1.56	0.65, 3.76 (p=0.321)	1.71	0.63, 4.65 (p=0.293)
Anxiety (GAD 7)	0.96	0.87, 1.06 (p=0.414)	1.00	0.82, 1.22 (p=0.777)
Depression (PHQ 9)	0.94	0.84, 1.04 (p=0.199)	0.92	0.76, 1.12 (p=0.389)
Beta-blocker use (Yes)	0.71	0.15, 3.40 (p=0.669)	1.26	0.21, 7.52 (p=0.799)
Sleeping pill use (Yes)	0.97	0.35, 2.66 (p=0.949)	1.49	0.43, 5.17 (p=0.530)
PM_{10}	1.06	1.00, 1.11 (p=0.049*)	1.06	1.00, 1.13 (p=0.043*)
Severity of OSA (AHI)	1.00	0.98, 1.02 (p=0.901)	0.991	0.97, 1.01 (p=0.430)

* P value < 0.05

Table 10 Univariate and multivariate analysis relating subjective sleep quality (PSQI) to urinary melatonin concentrations in phase I (N=81)

Variables	Urinary melatonin concentrations (≤ 15.24 ng/mg)			
	Univariate analysis		Multivariate analysis	
	OR	95% CI (P value)	AOR	95% CI (P value)
Age	0.99	0.95,1.02 (p=0.473)	0.98	0.94, 1.02 (p=0.237)
Gender (Male)	0.97	0.37, 2.51 (p=0.943)	1.45	0.50, 4.38 (p=0.473)
BMI	1.00	0.95, 1.05 (p=0.984)	0.99	0.94, 1.05 (p=0.811)
Alcohol (Have)	1.11	0.40, 3.11 (p=0.841)	1.03	0.32, 3.29 (p=0.966)
Smoke (Yes)	0.97	0.13, 7.27 (p=0.980)	0.70	0.08, 6.38 (p=0.751)
Secondhand smoke (Yes)	0.71	0.15,3.40 (p=0.669)	0.75	0.11, 5.11 (p=0.769)
Exercise (No)	1.56	0.65, 3.76 (p=0.321)	1.73	0.65, 4.60 (p=0.270)
Anxiety (GAD 7)	0.96	0.87, 1.06 (p=0.414)	1.06	0.88, 1.29 (p=0.533)
Depression (PHQ 9)	0.94	0.84, 1.04 (p=0.199)	0.92	0.76, 1.11 (p=0.383)
Beta-blocker use (Yes)	0.71	0.15, 3.40 (p=0.669)	1.06	0.18, 6.17 (p=0.953)
Sleeping pill use (Yes)	0.97	0.35, 2.66 (p=0.949)	2.19	0.54, 8.93 (p=0.273)
Sleep quality (PSQI)	0.91	0.80, 1.04 (p=0.170)	0.85	0.69, 1.05 (p=0.122)

4.7 Associations of bedroom characteristics and subjective sleep quality (PSQI) in phase I

As the **Table 11** shown bedroom characteristics between good sleepers and poor sleepers, we found that there was a significant association between electronic devices use before bedtime and subjective sleep quality (p value = 0.027). Also, the results showed a barely detectable statistically significant association of subjective sleep quality with hardness of pillow (p value = 0.065). None of participants who had

good sleep brought pets to their bedroom comparing to poor sleepers (p value = 0.099), although the statistical significance was not reached.

4.8 Participants' bedroom environmental conditions in phase I

Table 12 demonstrated bedroom environmental conditions of participants in phase I (the wet season). Average PM_{10} concentration in the wet season was 13.54 $\mu g/m^3$ (SD = 9.17). The maximum PM_{10} concentration was 40.99 $\mu g/m^3$. Mean temperature during sleep, relative humidity, and absolute humidity were 26.13°C (SD = 2.10), 63.85% (SD = 10.74), and 15.84 g/m^3 (SD = 3.64), respectively.

4.9 Associations of bedroom environmental conditions and urinary melatonin concentrations in phase I

In minimally adjusted model, an association between PM_{10} concentrations and low levels of urinary melatonin is significance (adjusted odds ratio (AOR) = 1.06, 95% CI; 1.00, 1.11; p value = 0.048). Temperature during sleep (AOR = 1.00, 95% CI; 0.81, 1.24; p value = 0.978), relative humidity (AOR = 1.03, 95% CI; 0.99, 1.24; p value = 0.134), and absolute humidity (AOR = 1.07, 95% CI; 0.95, 1.21; p value = 0.292) were not associated with urinary melatonin concentrations (**Table 13**).

In fully adjusted analyses, participants whose bedroom had an elevation of PM_{10} concentrations, it has a statistically significant 1.07-fold increased odds of low melatonin concentrations (≤ 15.24 ng/mg) (95% CI; 1.01-1.13; p value = 0.034). The associations between temperature, relative humidity, and absolute humidity and urinary melatonin concentrations were in similar directions as minimally adjusted model but none were statistically significant (**Table 13**).

Table 11 Associations of bedroom characteristics and subjective sleep quality (PSQI) in phase I (N=81)

Variables	Good sleep (PSQI ≤ 5) (N = 25)	Poor sleep (PSQI > 5) (N =56)	P value
Type of residence, *n (%)*			
Detached house	15 (60.00)	24 (42.90)	0.253
Condominium	5 (20.00)	19 (33.90)	
Others (townhome, apartment, etc.)	5 (20.00)	13 (23.20)	
Cool device, *n (%)*			
Air conditioner	11 (44.00)	29 (51.80)	0.517
Air conditioner and fan	14 (56.00)	27 (48.20)	
Noise at night, *n (%)*	17 (68.00)	37 (66.10)	0.859
Noise annoyance, *n (%)*	3 (12.00)	5 (8.90)	0.680¶
Type of light, *n (%)*			
Fluorescent	13 (52.00)	30 (53.60)	
Normal light	4 (16.00)	13 (23.20)	0.621
Others (LED and incandescent)	8 (32.00)	13 (23.20)	
Color of light, *n (%)*			
White	17 (68.00)	42 (75.00)	0.513
Others (orange and mixed)	8 (32.00)	14 (25.00)	
Have curtain in bedroom, *n (%)*	24 (96.00)	49 (87.50)	0.429
Type of curtain, *n (%)*			
UV block	18 (75.00)	32 (65.30)	
Blackout	4 (16.70)	11 (22.40)	0.685
Others (blind, mixed UV block and blackout)	2 (8.30)	6 (12.30)	
Have pets, *n (%)*	7 (28.00)	14 (25.00)	0.541
Bring pets to bed, *n (%)*	0 (100.00)	8 (14.30)	0.099¶
Direction of bed, *n (%)*			
North	9 (36.00)	13 (23.20)	
East	11 (44.00)	22 (39.30)	0.357
Others (west, south)	5 (20.00)	21 (37.50)	
Type of bed, *n (%)*			
Bed	21 (84.00)	44 (78.60)	0.765
Others (futon, duvet, mat or floor)	4 (16.00)	12 (21.40)	
Size of bed, *n (%)*			
King size	16 (64.00)	27 (48.20)	
Queen size	5 (20.00)	13 (23.20)	0.247
Others (single and twin)	4 (16.00)	16 (28.60)	

¶ = Fisher's exact test

* P value < 0.05

Table 11 Associations of bedroom characteristics and subjective sleep quality (PSQI) in phase I (N=81) (Continued)

Variables	Poor sleep (PSQI > 5) (N =56)	Good sleep (PSQI ≤ 5) (N = 25)	P value
Mattress, *n (%)*			
Latex	11 (44.00)	16 (28.60)	0.562
Spring	8 (32.00)	23 (41.00)	
Others (polyurethane foam, cotton, etc.)	6 (24.00)	17 (30.40)	
Bed sheet, *n (%)*			
Cotton	16 (64.00)	41 (73.20)	0.404
Others (linin, satin, silk, polyester, mixed)	9 (36.00)	15 (26.80)	
Blanket, *n (%)*			
Cotton	16 (64.00)	31 (55.40)	
Polyester	5 (20.00)	18 (32.10)	0.461
Others (downs, mixed)	4 (16.00)	7 (12.50)	
Pillow, *n (%)*			
Healthy pillow	6 (24.00)	19 (33.90)	
Polyester pillow	7 (28.00)	19 (33.90)	0.330
Others (cotton, latex, downs)	12 (48.00)	18 (32.10)	
Hardness of pillow, *n (%)*			
Soft	18 (72.00)	28 (50.00)	0.065
Others (medium and hard)	7 (28.00)	28 (50.00)	
Pajamas, *n (%)*			
Cotton	18 (72.00)	43 (76.80)	
Polyester	4 (16.00)	8 (14.30)	0.910
Others (linin, silk, mixed, naked)	3 (12.00)	5 (8.90)	
Frequency of bedclothes clean, *n (%)*			
< 2-3 time/month	13 (52.00)	25 (44.60)	0.431
≥ 2-3 time/month	12 (48.00)	31 (55.40)	
Types of bedroom clean, *n (%)*			
Vacuum	3 (12.00)	8 (14.30)	
Mop and sweep	4 (16.00)	5 (8.90)	0.715
Mixed	18 (72.00)	43 (76.80)	
Frequency of bedroom clean, *n (%)*			
≤ 2-3 times/month	4 (16.00)	12 (21.40)	
> 2-3 times/month	14 (56.00)	22 (39.30)	0.135
Everyday	7 (28.00)	22 (39.30)	
Electronic devices use before bedtime, *n (%)*	22 (88.00)	56 (100)	0.027*
Frequency of using electronic device before bedtime, *n (%)*			
≤ 5-6 times/week	12 (54.50)	24 (42.90)	0.351
Everyday	10 (45.50)	32 (57.10)	
Turn on electronic devices during sleep, *n (%)*	14 (63.60)	38 (67.90)	0.304

* P value < 0.05

Table 12 Participants' bedroom environmental conditions in phase I (N=81)

Variables	Phase I (N=81)
PM_{10} ($\mu g/m^3$)	
Mean ± SD	13.54 ± 9.17
Range (min-max)	0.78-40.99
Temperature during sleep (°C)	
Mean ± SD	26.13 ± 2.10
Range (min-max)	21.50-31.09
Relative humidity during sleep (%RH)	
Mean ± SD	63.86 ± 10.74
Range (min-max)	34.65-83.95
Absolute humidity (g/m^3)	
Mean ± SD	15.84 ± 3.64
Range (min-max)	7.45-22.71

Table 13 Minimally and fully adjusted odds ratios (AOR) relating bedroom environmental conditions to urinary melatonin concentrations in phase I (N=81)

Variables	Urinary melatonin concentrations (≤ 15.24 ng/mg)			
	Model I (minimally adjusted)		Model II (fully adjusted)	
	AOR	95%CI	AOR	95%CI
PM_{10}	1.06	1.00, 1.11 (p=0.048*)	1.07	1.01, 1.13 (p=0.034*)
Temperature during sleep	1.00	0.81, 1.24 (p=0.978)	1.00	0.80, 1.26 (p=0.989)
Relative humidity during sleep	1.03	0.99, 1.08 (p=0.134)	1.04	0.99, 1.09 (p=0.084)
Absolute humidity	1.07	0.95, 1.21 (p=0.292)	1.09	0.95, 1.24 (p=0.217)

Note: Model I were adjusted for age, gender, body mass index.

Model II were adjusted for age, gender, body mass index, alcohol consumption, active smoke, secondhand smoke, exercise, beta-blocker medicine use, sleeping pill use, and AHI.

* P value < 0.05

4.10 Comparisons of subjective sleep quality, daytime sleepiness, and urinary melatonin concentrations between wet and dry season in phase II

Table 14 reported subjective sleep quality, daytime sleepiness, and urinary melatonin concentrations of sixty-three participants in the dry and the wet seasons. A mean concentration of melatonin in the dry season (29.91 ng/mg) was significantly higher than in the wet season (15.50 ng/mg). The median of subjective sleep quality in wet season was 7.00, but mean subjective sleep quality in dry season was 6.95 (SD = 2.94). Means of daytime sleepiness both seasons were the same (9.00). No significant differences of subjective sleep quality and daytime sleepiness found between the seasons.

Table 14 Comparisons of subjective sleep quality (PSQI), daytime sleepiness (ESS), and urinary melatonin concentrations in phase II (N = 63)

Variables	Wet season	Dry season	P value (Wet and Dry)
Sleep quality (scores)			
Mean ± SD/ median (IQR)	7.00 (5.00-9.00)	6.95 ± 2.94	0.315
Range (min-max)	1.00-16.00	2.00-17.00	
Daytime sleepiness (scores)			
Median (IQR)	9.00 (6.00-11.00)	9.00 (5.00-11.00)	0.440
Range (min-max)	1.00-22.00	2.00-19.00	
Urinary melatonin concentrations (ng/mg)			
Mean ± SD	15.50 ± 9.05	29.91 ± 17.54	0.000***
Range (min-max)	0.13-37.42	3.00-96.84	

***P value ≤ 0.001

4.11 Comparison of bedroom environmental conditions between the wet and the dry season in phase II

The summary of bedroom environmental conditions between the dry and the wet season was shown in the **Table 15**. The mean of PM_{10} concentration in the dry season (19.71 µg/m^3) was significantly greater than the wet season (14.00 µg/m^3). The average temperature during sleep in the dry season and the wet season was fairly similar. The means of both relative humidity during sleep and absolute

humidity in the dry season (55.19 %RH and 13.62 g/m^3) were less than in the wet season (64.32 %RH and 15.93 g/m^3). However, there was no statistically significant difference of temperature between the seasons.

Table 15 Comparison of bedroom environmental conditions between the wet and the dry season in phase II (N = 63)

Variables	1-year mean	Wet season	Dry season	P value (Wet & Dry)
PM_{10} (µg/m^3)				
Mean ± SD	16.86 ± 6.45	14.00 ± 8.95	19.71 ± 9.74	0.001***
Range (min-max)	5.05-35.23	0.39-40.99	5.05-47.81	
Temperature during sleep (°C)				
Mean ± SD	26.12 ± 1.89	26.13 ± 2.04	26.11 ± 1.98	0.868
Range (min-max)	21.32-30.88	21.62-31.09	21.02-30.67	
Relative humidity during sleep (%RH)				
Mean ± SD	59.75 ± 9.51	64.32 ± 10.75	55.19 ± 10.44	0.000***
Range (min-max)	39.50-82.12	38.86-83.95	31.21-80.29	
Absolute humidity (g/m^3)				
Mean ± SD	14.78 ± 3.09	15.93 ± 3.54	13.62 ± 3.13	0.000***
Range (min-max)	9.01-21.78	9.14-22.71	7.21-21.06	

Definition of abbreviation: PM_{10} = particulate air matter less than 10 µm in aerodynamic diameter

***P value ≤ 0.001

4.12 Association of 1-year mean bedroom environmental conditions and subjective sleep quality parameters (PSQI) in phase II

The associations between the 1-year mean bedroom environmental conditions and subjective sleep quality, as evaluated by PSQI, were shown in **Table 16**. In the multivariable-adjusted model, participants whose bedroom had a higher temperature, it had a statistically significant 1.46-fold increased odds of poor sleep quality (95% CI; 1.01, 2.10; p value = 0.044). Absolute humidity tended to report long sleep latency (adjusted odds ratio (AOR) = 1.18, 95% CI 0.91-1.53; p value = 0.218), although statistical significance was not met. Moreover, there were no other

significant associations between bedroom environmental conditions and subjective sleep quality.

4.13 Association of 1-year mean bedroom environmental conditions and apnea-hypopnea index (AHI) and respiratory disturbance index (RDI) of participants in phase II

As shown in **Table 17**, multiple linear regression models reported that an elevation in PM_{10} concentration was significantly associated with an increase in AHI (Beta = 1.04, p value = 0.021). Temperature during sleep (Beta = 0.69, p value = 0.658), relative humidity (Beta = -0.51, p value = 0.145) and absolute humidity (Beta = -0.78, p value = 0.454) were not associated with AHI. An increment of PM_{10} concentration was also significantly associated with greater RDI (Beta =1.07, p value = 0.013). The associations between temperature, relative humidity, and absolute humidity and RDI were in similar directions as AHI but none were statistically significant.

Table 16 Association of 1-year mean bedroom environmental conditions and subjective sleep quality parameters (PSQI) in phase II (N = 63)

Outcome	PM_{10}		Temperature during sleep		Relative humidity during sleep		Absolute humidity	
	AOR	95%CI (P value)	AOR	95%CI (P value)	AOR	95%CI (P value)	AOR	95%CI (P value)
Long sleep latency (> 30 min)	0.99	0.86, 1.13 (p=0.880)	1.40	0.90, 2.18 (p=0.138)	1.10	0.99, 1.23 (p=0.089)	1.31	0.98, 1.76 (p=0.072)
Short sleep duration (< 6 hours)	1.03	0.94, 1.13 (p=0.542)	1.12	0.83, 1.50 (p=0.457)	1.01	0.94, 1.08 (p=0.831)	1.07	0.88, 1.31 (p=0.511)
Poor sleep efficiency (< 85.00%)	0.97	0.88, 1.07 (p=0.568)	1.02	0.75, 1.38 (p=0.909)	1.06	0.98, 1.14 (p=0.163)	1.12	0.90, 1.39 (p=0.306)
Poor sleep quality (PSQI >5)	1.01	0.91, 1.11 (p=0.921)	1.46	1.01, 2.10 (p=0.044*)	1.00	0.92, 1.08 (p=0.969)	1.18	0.91, 1.53 (p=0.218)

Note: all models were adjusted for age, gender, body mass index, alcohol consumption, smoke, secondhand smoke, and AHI.

"1-year mean" was calculated as an average of the data in the wet and the dry season.

* P value < 0.05

Table 17 Association of 1-year mean bedroom environmental conditions and apnea-hypopnea index (AHI) and respiratory disturbance index (RDI) of participants in phase II (N = 63)

Outcome	1-year mean exposure	Beta coefficients	95%CI	P value
AHI	PM_{10}	1.04	0.16, 1.91	0.021*
	Temperature during sleep	0.69	-2.42, 3.81	0.658
	Relative humidity	-0.51	-1.20, 0.18	0.145
	Absolute humidity	-0.78	-2.86, 1.30	0.454
RDI	PM_{10}	1.07	0.24, 1.91	0.013*
	Temperature during sleep	0.92	-2.08, 3.93	0.540
	Relative humidity	-0.47	-1.14, 0.19	0.161
	Absolute humidity	-0.63	-2.63, 1.38	0.533

Note: all models were adjusted for age, gender, body mass index, alcohol consumption, smoke, and secondhand smoke.

"1-year mean" was calculated as an average of the data in the wet and the dry season.

* P value < 0.05

4.14 Association of bedroom environmental conditions and apnea-hypopnea index (AHI) and respiratory disturbance index (RDI) of participants classified by seasons in phase II

The associations between bedroom environmental conditions and obstructive sleep apnea severity stratified by seasons were shown in the **Figure 14**. It demonstrated a trend towards significant association between PM_{10} concentration and AHI during the dry season (Beta = 0.56, 95% CI; -0.02, 1.14, p value = 0.059) but not the wet season (Beta = 0.40, 95% CI; -0.25, 1.05 p value = 0.220). No differences were found in other associations between other bedroom environmental conditions and AHI in the dry and the wet seasons.

A differentiation of the association between bedroom environment conditions (the wet and the dry season) and RDI was revealed in the **Figure 15**. It showed a strong association of PM_{10} concentration and RDI in the dry season (Beta =0.59, 95% CI; 0.03, 1.15, p value = 0.040) but not the wet season (Beta =0.39, 95% CI; -0.23, 1.01, p value = 0.215). No differences were found in other associations between other bedroom environmental conditions and RDI in the dry and wet seasons

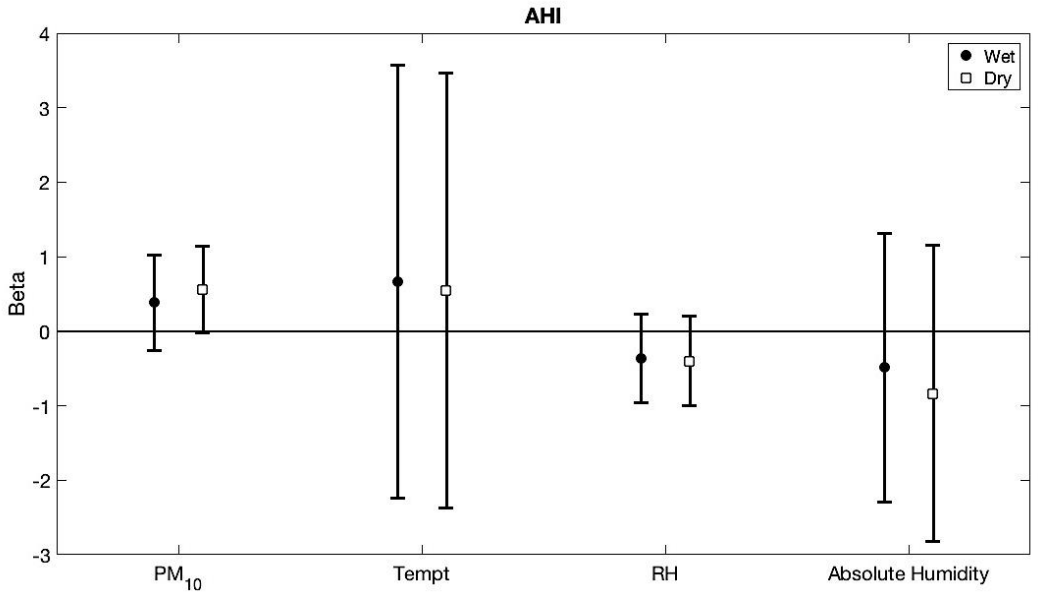


Figure 14 Beta coefficients with 95% CI for the association of bedroom environmental conditions (stratified by seasons) and AHI

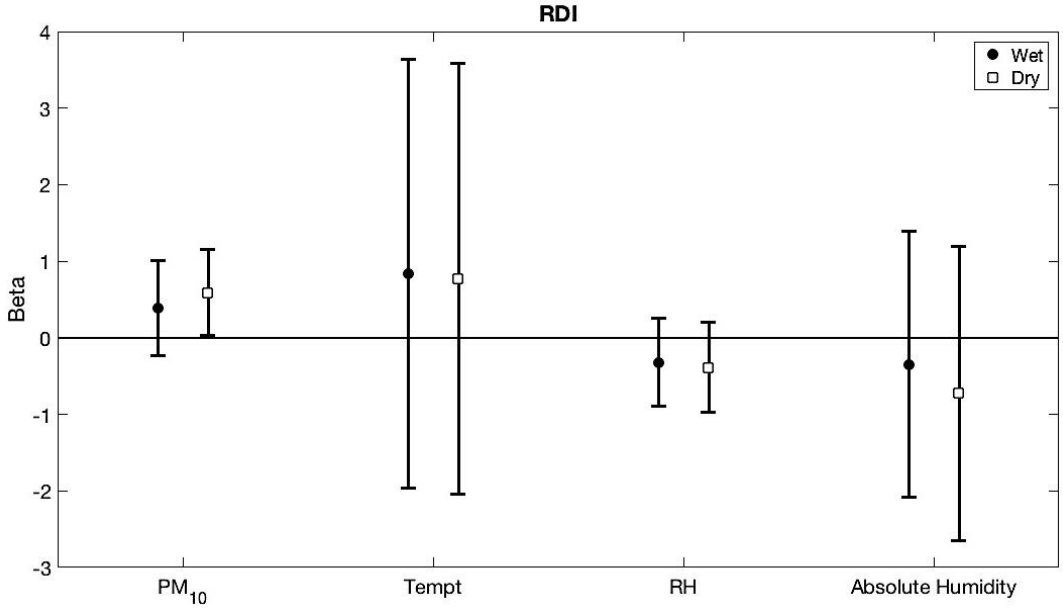


Figure 15 Beta coefficients with 95% CI for the association of bedroom environmental conditions (stratified by seasons) and RDI

CHAPTER V

DISCUSSION

This study demonstrated that bedroom environmental conditions, particularly PM_{10} concentration, had an impact on severity of OSA. Elevation of AHI and RDI were significantly associated with an increase in PM_{10} concentration; however, the associations were particularly shown in the dry season. We also observed an association between an increment of bedroom temperature during sleep and poorer sleep quality. In addition, electronic devices use before bedtime showed a significant association with subjective sleep quality. Our results also reported that an increase of PM_{10} concentration was significantly associated with low melatonin concentrations.

5.1 General information

5.1.1 General characteristics of participants

Our findings in two phases illustrated the disparity in number of participants because some participants from the first phase denied continuing. As our study focused on OSA, which can occur at all age, usually presents in ages over 40 years (Duran et al., 2001) and male individuals have more chance to develop OSA (Block et al., 1979). Furthermore, gaining weight or obesity among middle-aged adults have been noticeable in one crucial risk factors of OSA (Peppard, Young, Palta, Dempsey, & Skatrud, 2000). Previous studies reported an average age of male Korean participants, which was a majority in this study, was 49.6 years with a mean BMI 26.5 kg/m^2 (J. Kim et al., 2004). Moreover, Neruntarat *et al*. reported the mean age of study population was 37.2 years with a mean BMI 24.7 kg/m^2 and the proportion of male was slightly greater than female (Neruntarat & Chantapant, 2011).

As mentioned in above which was similar to our study population. Of our study participants in two phases were largely male that accounted for 70.40% to 73.00% who were middle-aged adults (median age 42 to 48 years), with the median

BMI 26.20 kg/m^2. It would appear that these basic characteristics (age, gender, and BMI) were likely to be significant characteristics of OSA. Although very few participants in this study were active smoking, the secondhand smoke exposure reported a higher proportion. Therefore, the secondhand smoke exposure appeared to play an important role in the prevalence of OSA in this study. In addition, alcohol consumption is one known risk factor of OSA. Approximately twenty-two percent of participants in this study reported active alcohol consumption. This might pose a possible risk of OSA as well. Besides, the concentration of urinary melatonin was shown a slightly different level among participants in these two phases. It might be influenced by beta-blocker medicine, sleeping pill use, mental problems or behavior before sleep.

5.1.2 Sleep parameters of participants

Based on sleep questionnaires that utilized in this study such as sleep quality (PSQI), insomnia (ISI), chronotype sleep (CSM), and daytime sleepiness (ESS). On the one hand, our results presented a median of sleep latency and sleep duration of participants in two phases were 20.00 minutes and 6.00 hours, respectively. On the other hand, Kalcina *et al.* reported a mean sleep latency and sleep duration of Croatians OSA were in the range of 16.00 to 30.00 minutes and 6.00 to 7.00 hours orderly, and Sitasuwan *et al.* also showed a mean sleep latency and sleep duration of Thais OSA were in the range of 16.00 to 60.00 minutes and 5.00 to 7.00 hours, respectively. Moreover, our results illustrated averages of habitual sleep efficiency in two phases were 87.76% (SD = 14.31) and 89.21% (SD =14.2) that showed a slightly different value between two phases. In accordance with Kalcina *et al.* and Sitasuwan *et al.* revealed habitual sleep efficiency of Croatians and Thais OSA were in the range of 75% to 85% and above. A large number of our participants in two phases of this study (69.10% and 68.30%) achieved the criteria for poor sleep quality (PSQI > 5), which the median score of global PSQI was 7.00 for both. On the contrary, Kalcina *et al.* and Sitasuwan indicated a greater value of mean global PSQI among Croatians and Thais OSA (8.62 and 9.54, respectively).

Means insomnia scores (ISI score) of this two phases study were 10.49 and 10.44, whereas Glidewell and colleagues found an average score of ISI among Duke OSA was 12.00 (SD = 6.7) that showed a higher mean ISI scores, compared with our results. Moreover, Glidewell *et al.* claimed that ISI score was possibly to predict sign of OSA in their study as well. Besides, our study reported that a greater number of two phases participants were intermediate type of chronotype sleep, which accounted for 74.10% to 74.60%, and means CSM scores of two phases were 35.84 (SD = 8.34) and 35.33 (SD = 8.53). In contrast to earlier finding (Reutrakul et al., 2015), mean of CSM scores seemed to be greater than this study (44.15, SD = 5.46); the reason of dissimilarity might be age difference. However, both participants of the prior study (Reutrakul et al., 2015) and this study appeared to have morning preference.

In this study also revealed median scores of ESS in two phases were 8.00 to 9.00 that was similar to the study of Sitasuwan and colleagues displayed the median value of Thai ESS among OSA patients was 8.00. Nevertheless, Kalcina *et al.* and Glidewell *et al.* showed the mean values of Croatians and Duke ESS was 9.42 (SD = 5.57) and 10.90 (SD = 4.20), respectively.

5.1.3 Polysomnography variables of participants

According to polysomnography results for two phases, which revealed medians sleep efficiency among OSA patients were 85.50% and 86.30%. Contrary to the polysomnography result of Reddy *et al.* reported a mean sleep efficiency of Indian OSA was 80.10% (SD = 13.50) (Reddy et al., 2009). Our study also presented medians sleep onset latency of participants were 6.00 and 9.50 minutes. Conversely, Reddy and colleagues showed a median sleep onset latency of Indian OSA was 11.90 minutes (Reddy et al., 2009). In addition, Neruntarat and colleagues published a paper illustrating that mean sleep onset latency of Thai OSA was 23.40 minutes (SD = 5.30) (Neruntarat & Chantapant, 2011). Both previous studies demonstrated higher results of sleep onset latency. Furthermore, our results share similarities with Neruntarat *et al.*'s and Reddy *et al.*'s findings that the stage 2 of sleep stages shows

the greatest proportion of total time sleep (Neruntarat & Chantapant, 2011; Reddy et al., 2009).

The earlier study (Reddy et al., 2009) established a median AHI of Indian OSA was 21.70 events/hour. However, this study found means AHI of Thai OSA for two phases were 43.20 events/ hours (SD = 25.98) and 45.83 events/ hours (SD = 27.21). Additionally, our arousal index results showed higher values than the prior studies (Neruntarat & Chantapant, 2011; Reddy et al., 2009). It seems to be that most of our participants got much worse severity than the previous studies.

5.2 An association of subjective sleep quality and severity of obstructive sleep apnea

Prior studies (Palagini et al., 2016) stated that individuals with insomnia, anxiety, or depression mostly have poorer subjective sleep quality compared to healthy participants. As anxiety and depressive symptoms, which are a sort of psychological problem, were possibly to predict the situation of insomnia. Of which insomnia is likely to have an impact on good subjective sleep quality (Palagini et al., 2016). Moreover, one study reported that there is an association between daytime sleepiness and subjective sleep quality even though it is just a weak correlation (Mondal et al., 2013). This study showed some similarity in the way earlier studies claimed. We found significant associations of anxiety, depression, insomnia, chronotype sleep, and daytime sleepiness with subjective sleep quality in the univariate analysis. We also utilized multivariate analysis that reported significant associations of insomnia and daytime sleepiness with subjective sleep quality.

Nonetheless, our findings did not reveal any significant associations between subjective sleep quality and severity of obstructive sleep apnea. Similarly, Macey and colleagues addressed that there is no correlation of OSA severity (AHI) with subjective sleep quality and daytime sleepiness. Additionally, this earlier study (Macey et al., 2010) provided a potential reason for this existence that number and extent of arousals are more likely to link with poor sleep quality and daytime

sleepiness than AHI. Moreover, blood oxygen desaturation is considered as a better choice to predict daytime sleepiness (Macey et al., 2010).

5.3 An association of severity of obstructive sleep apnea (AHI) and urinary melatonin concentrations

On the one hand, prior studies noted that individuals with OSA symptom have a normal range of melatonin in saliva and plasma (Redline et al., 2010). Besides, one study claimed that treatment of OSA seems not having an influence on levels of melatonin (Wikner et al., 1997). On the other hand, Reutrakul and colleagues reported that patients who affected by mild to severe OSA significantly tends to have lower levels of nocturnal urinary melatonin (Reutrakul et al., 2017). Accordingly, our univariate and multivariate analyses showed a trend of OSA severity was put into a list for one possible risk factor of poorer melatonin concentrations, though statistical significance was not reached.

The study of Reutrakul gave adequate explanations of OSA severity and nocturnal urinary melatonin (Reutrakul et al., 2017). Beginning with melatonin production has a difficulty to synthesize among OSA patients because of hypothalamic pituitary adrenal activities interference. Also, individuals with OSA are predominantly suffered from sleep disruption that seems to affect circadian rhythm and melatonin synthesis. Eventually, geolocation is one plausible reason to describe a link between severity of OSA and nocturnal melatonin secretion.

5.4 A relation of subjective sleep quality (PSQI) to urinary melatonin concentrations

Several studies have reported nocturnal melatonin secretion implies as a key factor for controlling the proper function of sleep-wake cycle (Mahlberg et al., 2006) and the Pittsburgh Sleep Quality Index (PSQI) has been used as a primary measurement to assess subjective good or poor sleep quality (Buysse et al., 1989) . Previous studies found that a higher total nocturnal melatonin concentration was correlated with sleep (Morris et al. 1990) and a lower urinary melatonin

concentration was significantly correlated to the worse sleep efficiency (Haimov et al., 1994). Moreover, an earlier study demonstrated sleep efficiency and sleep latency among unhealthy elderly insomniacs was improved after receiving melatonin treatment, but the treatment had no impact on total sleep time (Garfinkel et al. 1995). On the contrary, the latter research pointed that whether sleep quality or sleep duration in elder with age-related sleep maintenance problems did not improve after treating with melatonin (Baskett et al., 2003).

Contrary to expectations, we did not find a significant association between subjective sleep quality and urinary melatonin concentrations in both univariate and multivariate analyses in this study. It is consistent with a study of Lushington *et al.* and Saksvik-Lehouillier *et al.*, which reported there was no an association of urinary melatonin concentration with subjective sleep quality as well (Lushington et al. 1999; Saksvik-Lehouillier et al. 2015). In addition, both good and poor sleepers did not show any difference in melatonin excretion (Haimov et al., 1994); nevertheless, another showed a significantly positive correlation between sleep quality and nocturnal urinary melatonin concentration among good sleepers (Lushington et al., 1998). As our findings were inadequate to support the hypothesis and there is plenty of contradiction between melatonin and sleep parameters; thus, we hope that further studies will take it into consideration in order to address a potential pathway of this association.

5.5 Associations of bedroom characteristics and subjective sleep quality (PSQI)

A favorable environment of residence appears to be essential to promote good sleep quality, particularly in bedroom (Grigsby-Toussaint et al., 2015). Moreover, a large number of studies about sleep environment and sleep quality have been published (Kim et al., 2010). In this present study, we collected data of bedroom characteristics, electronic devices use before sleep time, and subjective sleep quality in order to explore associations among these. A prior study (Kayaba et al., 2014) showed that there were no associations of type of residence, direction of bed, type of bed, curtain in bedroom, type of light, and color of light with sleep quality, which

was similar to our results. Despite that the aforementioned study showed significant associations of light bulb use, air conditioner, and noise at night with poor sleep quality that seemed inconsistent with our findings. These differences can be explained by participants' bedroom characteristics that both good and poor sleepers use air condition as usual, also our participants may be familiar with noise at night and were consequently unable to influence their sleep.

Several studies assumed that a texture of sleepwear, a size of sleepwear, and a fabric of bed sheet greatly affect the exchange of heat and moisture between body and bedclothes (Dickson 1984; Libert et al., 1988; Okamoto et al., 2005), which it may lead to sleep disturbance in addition to poor sleep quality. Unfortunately, our results were below expectations to illustrate associations of texture and size of sleepwear, and a fabric of bed sheet with subjective sleep quality. Although our study could not provide any associations, we still believe that it is worth to investigate in the future. Since there is no standard for selecting bedding, and some evidences claimed that type and hardness of pillow is possibly to influence whether good or poor sleep quality (Suckling et al., 1957; Bader and Engdal, 2000). In this present study found that hardness of pillow tends to be associated with subjective sleep quality that are in the line with the previous studies.

Furthermore, our study reported that all of poor sleepers use electronic gadgets before sleep, and it also showed a significant association between subjective sleep quality and using electronic devices before bedtime. Of which confirms with the study of Munezawa *et al.* noted that use of mobile phone after turning off the lights is associated with sleep disturbances (short sleep duration, subjective poor sleep quality, excessive daytime sleepiness, and insomnia symptoms) (Munezawa et al., 2011). Another studies also mentioned that using of electronic media, such as television, personal computers (surfing internet), and computer games, is associated with sleep disorders (Higuchi et al., 2005; Paavonen et al., 2006). These may be justified by the study of Van den Bulck, which assumed that the specific wavelength of light emission from electronic devices after light off, it can induce difficulty to fall asleep, and also may stimulate the brain to be active that result in suppressing production of hormone melatonin (Van den Bulck, 2010).

5.6 Associations of bedroom environmental conditions and urinary melatonin concentrations

To our knowledge, the effects of bedroom environmental conditions such as PM_{10}, temperature, and humidity on melatonin concentrations among OSA patients have not been formerly investigated. In the present study, we found novel evidence of particulate matter effect on low levels of urinary melatonin. Our findings show statistically significant associations between PM_{10} concentrations and low levels of urinary melatonin both in minimally and fully adjusted analyses.

None of literature supports pathways of low melatonin level affected by PM_{10}; however, there are several possible explanations for this outcome. A prior study mentioned that PM_{10} is recognized as a potential factor that leads to inflammation of respiratory system in individuals who is regularly exposed to it (Kang et al., 2015). Since the size of PM_{10} is small so that it can easily get into the airway and reach to the alveoli. This may activate signal transmission pathways and results in oxidative stress (Amato et al., 2010). In addition, PM_{10} has been connected with an increase risk of SDB and a reduction in sleep quality (Zanobetti et al., 2010). This may have an impact on impaired melatonin production, resulting in low level of melatonin concentration among OSA patients.

5.7 Comparisons of subjective sleep quality, daytime sleepiness, and urinary melatonin concentrations between the wet and the dry season

Our research reported the median of subjective sleep quality in the wet season was 7.00, but the mean subjective sleep quality in the dry season was 6.95 (SD = 2.94). Additionally, averages daytime sleepiness were similarities between these two seasons (9.00). It seems that there were no significant differences of subjective sleep quality and daytime sleepiness between the seasons in our study, which was in disagreement with our hypothesis. The reason for this rather contradictory result can be attributed to bedroom characteristics, and bedroom environmental conditions of participants. Moreover, it can be explained by the study of Kume *et al.*, which

pointed that it is hardly to see differences in the sleep-wake cycle according to season (Kume et al., 2017).

Although we did not find any differences in sleep quality and daytime sleepiness by seasonal variations, our results revealed a significant difference in melatonin concentrations. In the present study, we found that the concentrations of melatonin were greater in the dry season comparing with the wet season. According to the theory of melatonin secretion, several studies mentioned that it is higher at the nighttime or under the dark condition (Arendt & Middleton, 2017). Besides, conditions of light in nature are influenced by season and weather; hence, one study assumed that seasonal changes have an impact on secretion of melatonin (Wehr, 1997). The study mentioned that secretion of melatonin is greater in winter than summer (Wehr, 1997). Wahnschaffe *et al.* gave several explanations about seasonal variations and circadian rhythms, which were circadian rhythms of hormones, mood, and activity according to seasonal alterations mostly find in northern latitudes with variable length of daylight, differences of season and weather in daily activity and behavior before bedtimes also may affect to circadian rhythms, and indoor evening light on short days may have an effect on circadian rhythms as well (Wahnschaffe et al., 2017). In contradiction with earlier findings (Wehr, 1997), we found melatonin concentrations were greater in the dry season than the wet season. It would seem that OSA treatment might have a greater impact on melatonin concentrations than seasonal variations among OSA patients.

5.8 Comparison of bedroom environmental conditions between the wet and the dry season in phase II

The results of bedroom environmental conditions in our study showed that the mean 1-year PM_{10} concentration was 16.86 μg/m^3, which was well below the National Ambient Air Quality Standards (NAAQSs) of outdoor air in Thailand (50 μg/m^3) (PCD, 2017) and the World Health Organization (WHO) (20 μg/m^3) (WHO, 2015). However, even such low levels might have a negative impact on the respiratory health of susceptible individuals, since there is no threshold limit for pollutants to

trigger respiratory problems (WHO, 2015) or OSA (Zanobetti et al., 2010). The average bedroom PM_{10} concentrations in the dry and the wet season were 19.71 μg/m^3 and 14.00 μg/m^3, respectively. Overall, seasonal trends indicated significantly higher PM_{10} concentrations in the dry season compared to the wet season. Srithawirat *et al.* and Jinsart *et al*. reported similar results (Srithawirat et al., 2014; Jinsart et al., 2012). Moreover, the data of outdoor PM_{10} concentrations from the Pollution Control Department of Thailand found higher concentrations in the dry season compared with the wet season in Bangkok (PCD, 2017).

5.9 Association of 1-year mean bedroom environmental conditions and subjective sleep quality parameters (PSQI) in phase II

Our study found a statistically significant association between poorer sleep quality and elevation in bedroom temperatures. A former study claimed that the best range of air temperature for good sleep using objective measures of sleep quality is 24 to 26°C at 50%RH and the upper limit for the best sleep quality is 28.1°C at 50%RH (Kim & Kum, 2006). It appears then, that suitable room temperature, and humidity during sleep can play an essential role in influencing good sleep, especially in OSA patients. In order to ensure good sleep quality among varied levels of severity of OSA patients, further study should investigate appropriate room temperature, RH, and absolute humidity.

However, our study did not demonstrate association of PM_{10}, and other subjective sleep parameters. A previous study proved that a decrease in sleep efficiency is related to short-term elevations in PM_{10} in a cross-sectional study using objective measures of sleep (Zanobetti et al., 2010). Elder *et al.* and Wang *et al.* reported that particles move from the nose up the olfactory nerve into the striatum frontal cortex, and cerebellum (Elder et al., 2006; B. Wang et al., 2007). This is likely to induce brain inflammation (Campbell et al., 2005), and a change in neurotransmitter levels (Coogan et al., 2012; Tin Tin Win et al., 2008), which would then influence sleep quality. Further evidence of particle deposition in the brain has been linked to neural inflammation (Gerlofs-Nijland et al., 2010; Levesque et al.,

2011), which may disrupt sleep-wake cycles (Bertini et al., 2010; Pan et al., 2013). However, similar to our finding, a study conducted by Fang SC, et al did not observe an association between long-term black carbon exposures and any sleep parameters in their overall studied participants (Fang et al., 2014). The inconsistent results could be due to the heterogeneity of the study population.

5.10 Association of 1-year mean bedroom environmental conditions and apnea-hypopnea index (AHI) and respiratory disturbance index (RDI) of participants in phase II

In agreement with our results, Zanobetti *et al.* reported that an interquartile increase in short-term PM_{10} levels was associated with a 12.9% increase in RDI (95% CI; 2.77, 24.09) during summer time, using the data from Sleep Heart Health Study (SHHS), a U.S. multicenter cohort study (Zanobetti et al., 2010). In this study, the outdoor PM_{10} data was retrieved using information from U.S. EPA Air Quality System Technology Transfer Network. Another study by Glaser MS also supported the link between outdoor pollution exposure and OSA (Glaser et al., 2014). This aforementioned study reported that 81% of at-risk World Trade Center (WTC)-exposed rescue/recovery workers were diagnosed with OSA. Severe OSA was associated with WTC exposure on September 11, 2001 with odds ratio of 1.91 (95% CI; 1.15, 3.17). However, not all studies were in support of such associations, as the population-based cohort study using outdoor environmental data conducted by Weinreich *et al.* reported no association between PM_{10} and AHI (Weinreich et al., 2015). There are several potential explanations for inconsistent results of the associations between air pollution and OSA. All previous studies, unlike our study, were conducted using outdoor data, which might not reflect the amount of pollution exposure during sleep.

There is no clear literature supporting the persistence of the changes in the brain or upper airway system caused by the environmental factors linking to OSA. However, environmental factors had been shown to have cumulative adverse effects, which over longer periods of time result in the development of chronic

diseases (Coogan et al., 2012). Air pollution, especially particulate matter, potentially affects sleep through the central nervous system and the upper airways (Dockery & Pope, 1994; Kleinman et al., 2008). Pollutants may directly increase nasal or pharyngeal inflammatory responses, which increase upper airway resistance and reduce airway patency (DeMeo et al., 2004; Mehra & Redline, 2008). These mechanisms possibly alter ventilation and perfusion, resulting in exacerbation of hypoxia associated with OSA.

Our study did not demonstrate associations between humidity level and AHI. Theoretically, drying of upper airway mucosa during the night, through increasing surface tension forces, can contribute to increasing severity of OSA (Miki et al., 1992). High ambient humidity, which moistens the upper airway mucosa might then improve OSA. However; similar to our findings, a previous study did not report association between humidity level and AHI (Jokic et al., 1999). Contrary to a positive finding of topical phosphocholinamin, a long-acting tissue lubricating agent, application to upper airway mucosa in reducing AHI (Jokic et al., 1999), addition of liquid to the airway surface may prove to be less important.

Weinreich G, et al demonstrated significant association between temperature and AHI (Weinreich et al., 2015). Upper airway dilator muscle activity, measured by genioglossus electromyograms, has been shown to be greater during cold air breathing compared to warm air breathing. Therefore, reduction in upper airway muscle activity may result in higher AHI in a warmer environment (Dempsey et al., 2010). However, our study did not demonstrate association between temperature and AHI. The discrepancy of the results of the studies may be from difference in observed temperature (mean temperature of 13.1 ± 6.2 ^{o}C in Weinreich G, et al study compared to 26.12 ± 1.89 ^{o}C in our study).

5.11 Association of bedroom environmental conditions and apnea-hypopnea index (AHI) and respiratory disturbance index (RDI) of participants classified by seasons in phase II

Seasonal variations may also play a role as the study by Zanobetti A, et al observed an association between PM_{10} and RDI exclusively during summer time (Zanobetti et al., 2010). During summer compared with other seasons, windows are often kept open during the night so the level of outdoor PM_{10} may better reflect indoor levels during summer compared to other seasons, when the windows may be kept closed. It is possible that in-bedroom and outdoor environment might have different impacts on OSA severity, which might explain some differences in the findings of various studies. Though PM_{10} levels, temperature, and humidity of bedroom were controlled during the night by the air conditioner, our results reported the significant difference of PM_{10} and humidity levels between the wet and the dry season.

Several studies have demonstrated that levels of particulate matter in Asian countries are mainly affected by seasonal variations (Begum et al., 2006; Wang et al., 2008). It appears to be possible that weather precipitation or dispersion may influence the levels of particulate matter. The higher level of PM_{10} observed during dry season may explain stronger association of PM_{10} concentration and RDI in the dry season compared to wet season. This observation proposes that the levels of PM_{10} concentration when decreases below a certain amount do not affect the AHI or RDI.

CHAPTER VI

CONCLUSIONS

6.1 Conclusions

Our findings suggest that bedroom environmental conditions can be linked to OSA severity. Although environmental factors might not be a direct cause of OSA, they may play a role in exacerbating the severity of OSA. Moreover, we found a significant association between PM_{10} concentrations and low levels of urinary melatonin among OSA patients. In spite of an increase in public awareness of OSA, a majority of those affected still remain undiagnosed and untreated. Along with treatment, these new findings suggest that reduction in exposure to particulate matter might lessen the severity of OSA and increase or maintain melatonin level.

All of participants in this study were OSA patients and predominantly were men. Medians age of them were 42-48 years old and their median BMI was 26.20 kg/m^2. More than half of them got married, graduated Master's or higher degree, and earned money less than or equal 50,000 baht; however, less than half of them had children. Few participants took beta-blocker medicine and a small number of them used sleep pill. Based on the PSQI questionnaire, in the first phase, a majority of participants (69.10%) reached the criteria for poor sleep quality. Approximately 3.70% reported severe insomnia, while 27.20 percent of them were suffered from daytime sleepiness problem. In the second phase, a greater number of participants (68.30%) were classified as having poor sleep quality. Very few participants (3.20%) were assumed severe insomnia, while 38.10% reported daytime sleepiness problem.

Polysomnography results in the first phase, we found that average values of RDI and AHI in phase I were 44.97 events/hours (SD = 24.91), and 43.20 events/ hours (SD = 25.98), respectively. Approximately 68.00%, 16.00% and 16.00% met the criteria for severe, moderate and mild obstructive sleep apnea, respectively. In the second phase, mean RDI and AHI in phase II were 47.66 events/hours (SD = 26.06),

and 45.83 events/ hours (SD = 27.21), respectively. Over half (71.40%) was met the criteria for severe obstructive sleep apnea, and approximately 14.30% was met the criteria for moderate and mild obstructive sleep apnea.

Anxiety, depression, insomnia, chronotype sleep, and daytime sleepiness were significantly associated with subjective sleep quality in univariate analysis. On the other hand, only insomnia and daytime sleepiness were significantly associated with subjective sleep quality in multivariate analysis. However, both analyses did not show any significant associations between subjective sleep quality and severity of obstructive sleep apnea.

The severity of obstructive sleep apnea was not associated with low melatonin concentrations (OR = 1.00, 95%CI; 0.98, 1.02), (AOR = 1.00, 95%CI; 0.98, 1.02) in both univariate and multivariate analyses. Moreover, there was no any significant association between subjective sleep quality and urinary melatonin in this study.

A significant association between use of electronic devices before bedtime and subjective sleep quality (p value = 0.027) was found. Furthermore, an association of subjective sleep quality with hardness of pillow was barely detectable statistically significant (p value = 0.065) in this study.

An average PM_{10} concentration in the wet season was 13.54 μg/m^3 (SD = 9.17). The maximum PM_{10} concentration was 40.99 μg/m^3. A mean temperature during sleep, relative humidity, and absolute humidity were 26.13°C (SD = 2.10), 63.85% (SD = 10.74), and 15.84 g/m^3 (SD = 3.64), respectively. In minimally adjusted model, a significant association between PM_{10} concentrations and low levels of urinary melatonin was found (AOR = 1.06, 95% CI; 1.00, 1.11; p value = 0.048) and in fully adjusted analyses, participants whose bedroom had an elevation of PM_{10} concentrations, it has a statistically significant 1.07-fold increased odds of low melatonin concentrations (≤ 15.24 ng/mg) (95% CI; 1.01-1.13; p value = 0.034).

An average concentration of melatonin in the dry season (29.91 ng/mg) was significantly higher than in the wet season (15.50 ng/mg). The median of subjective sleep quality in wet season was 7.00, but mean subjective sleep quality in dry season was 6.95 (SD = 2.94). Means of daytime sleepiness both seasons were the

same (9.00). No significant differences of subjective sleep quality and daytime sleepiness found between the seasons.

A mean of PM_{10} concentration in the dry season (19.71 μg/m^3) was significantly greater than the wet season (14.00 μg/m^3). An average temperature during sleep in the dry season and the wet season was fairly similar. Means of both relative humidity during sleep and absolute humidity in the dry season (55.19 %RH and 13.62 g/m^3) were less than in the wet season (64.32 %RH and 15.93 g/m^3). However, there was no statistically significant difference of temperature between the seasons.

In the multivariable-adjusted model, participants whose bedroom had a higher temperature, it had a statistically significant 1.46-fold increased odds of poor sleep quality (95% CI; 1.01, 2.10; p value = 0.044). Absolute humidity tended to report long sleep latency (AOR = 1.18, 95% CI 0.91-1.53; p value = 0.218), although statistical significance was not met. Moreover, there were no other significant associations between bedroom environmental conditions and subjective sleep quality.

An elevation in PM_{10} concentration was significantly associated with an increase in AHI (Beta = 1.04, p value = 0.021). Temperature during sleep (Beta = 0.69, p value = 0.658), relative humidity (Beta = -0.51, p value = 0.145) and absolute humidity (Beta = -0.78, p value = 0.454) were not associated with AHI. A higher PM_{10} concentration was also significantly associated with greater RDI (Beta =1.07, p value = 0.013). The associations between temperature, relative humidity, and absolute humidity and RDI were in similar directions as AHI but none were statistically significant.

Our findings found a trend towards significant association between PM_{10} concentration and AHI during the dry season (Beta = 0.56, 95% CI; -0.02, 1.14, p value = 0.059) but not the wet season (Beta = 0.40, 95% CI; -0.25, 1.05 p value = 0.220). It also showed a strong association of PM_{10} concentration and RDI in the dry season (Beta =0.59, 95% CI; 0.03, 1.15, p value = 0.040) but not the wet season (Beta =0.39, 95% CI; -0.23, 1.01, p value = 0.215).

6.2 Benefits of this study

1. Associations model of OSA severity with sleep quality and urinary melatonin can be applied to other OSA patients in order to improve their sleep quality and melatonin level.
2. Meditation and relaxation (listening to natural sounds, aroma therapy, or having warm milk) before bedtime can calm and soothe mental stress (anxiety and depression). These may help to have a good sleep.
3. Reduction in electronic gadgets use before bedtime, and wash bed clothes and clean bedroom frequently are likely to increase sleep quality.
4. Keeping bedroom clean and creating good bedroom environmental conditions (temperature and relative humidity should be 24 to 26°C at 50%RH) for sleep may be possible to raise quality of sleep and promote a good sleep.
5. Pillow should not be too soft (head sinks into the pillow), especially in OSA patients; it tends to have an effect on a good quality of sleep.
6. Bedroom environmental conditions may deliver the evidence needed for developing preventive and therapeutic strategies designed to alleviate the burden of both severity and sleep quality in patients with OSA.
7. Our findings on an indoor air exposure (bedroom environmental conditions) can be used to modify and adapt as a guideline to control and manage the level of exposure in the future.

6.3 Limitations of the study

1. The sample size of this study is relatively small.
2. We used a cross-sectional study design, which makes it difficult to draw conclusions regarding causation since we cannot be certain if the exposure preceded the outcomes.
3. Half of our participants had severe OSA, which may have limited the generalizability of our study findings to a broader general population. Besides, patients in this study had polysomnography performed only in the wet season.

However, the significant association between PM_{10} concentration and RDI was observed only in the dry season when polysomnography was not performed.

4. The patients' weight data that may have an effect on the associations of OSA with other parameters in the dry season were not collected after the initial measurement.
5. We used self-reported sleep quality (PSQI) to measure sleep quality scores. Actigraphy recordings would be more appropriate for retrieving accurate sleep quality.
6. The noise of the personal air sampling device may have disrupted the patient's sleep quality during the data collection at night.
7. We collected only PM_{10} in this study, whereas $PM_{2.5}$ is smaller and more harmful to health than PM_{10}, and it could have some effects on OSA severity.
8. Our 1-year mean PM_{10} concentrations are based on an average concentration of three samplings from two seasons (the wet and the dry season) in the participants' bedrooms; hence, they may not accurately indicate the annual average of indoor PM_{10} concentrations.
9. Uncontrolled confounding appears to be a potential source for bias in melatonin level.

6.4 Recommendations for further study

1. To raise an adequate power in detecting some significant relationships; a number of sample sizes should increase in the further study.

2. Further study should be concerned about the prospective cohort studies in which environmental conditions and stage of OSA development are recorded in the general population would allow us to clarify the understanding of environmental impact on OSA severity.

3. Control group should be taken in to consideration in the further study.

4. $PM_{2.5}$ and other pollutants in bedroom should explore in the further study.

5. More frequent samplings should be considered to obtain a better representative of annual mean indoor PM_{10} concentrations.

6. Further studies may explore the effect of PM_{10} on OSA severity in OSA patients under a certain bedroom environmental condition (with/without air conditioner usage) to study other factors such as therapeutic conditions that may influence the severity. For example, the effect of PM_{10} on OSA patients who regularly use continuous positive airway pressure (CPAP) devices may be different from those who do not use CPAP.

APPENDICES

APPENDIX A

Questionnaire (English)

Wet season

Screening Questionnaires [Sleep environments and sleep-disordered breathing in Bangkok, Thailand: A repeated cross-sectional study]

Part 1: General information

1) Do you have any diseases following to the content below?

( ) Asthma ( ) Stroke ( ) Chronic pain

( ) Heart failure ( ) Chronic renal failure ( ) N-stage of cancer

2) Do you work night shift? ( ) Yes ( ) No

3) Do you smoke 15-25 cigarettes per day? ( ) Yes ( ) No

4) Do you take sleep medicine? ( ) Yes ( ) No

5) Are you pregnant? ( ) Yes ( ) No

Part 2: Standard depression assessment (PHQ-9) Obtained from Kroenke et.al, 2001: Lotrakul et.al, 2008

Over the last 2 weeks, how often have you been bothered by any of the following problems?

	Not at all	Several day	More than	Nearly everyday
1) Little interest or pleasure in doing things	0	1	2	3
2) Feeling down, depressed, or hopeless	0	1	2	3
3) Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4) Feeling tired or having little energy	0	1	2	3
5) Poor appetite or overeating	0	1	2	3
6) Feeling bad about yourself - or that you are a failure or have let yourself or your family down	0	1	2	3
7) Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8) Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9) Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3
10) If you have been bothered by any of the problems. How difficult have these problems made it for you to do your work, take care of things at home, take care of	Not difficult at all	Some what difficult	Very difficult	Extremely difficult
Add columns				
Total				

Principal Questionnaires [Sleep environments and sleep-disordered breathing in Bangkok, Thailand: A repeated cross-sectional study]

Part 1 Socio-demographic characteristic

1. Age ..... Years

2. Sex [ ] 1. Female [ ] 2. Male

3. Weight ..... Kilograms

4. Height ..... Centrimeters

5. Educational Level [ ] 1. Illiteracy [ ] 2. Primary school [ ] 3.Secondary school
[ ] 4. Bacherlor's degree [ ] 5. Master's degree or Higher

6. Marital status [ ] 1. Single
[ ] 2. Married (How many children do you have?.....)
[ ] 3. Divorced/Widowed

7. Current address Street.....District.....Sub-district.....Postal code.....

8. Telephone number 1).....2).....

9. Current occupation [ ] 1. Officer [ ] 2. Government officer [ ] 3. Housewife [ ] 4. Business owner
[ ] 5. Unemployed [ ] 6.Others..... (Please specific)

10. Monthly income ..... Baht

11. How many family members in home.....persons

12. Do you currently drink alcohol? [ ] 1. No
[ ] 2. Yes (How many glasses/bottles per day?.....Please specific)

13. What kind of alcohol do you usually drink?

[ ] 1. Beer [ ] 2. Wine [ ] 3. Liquor [ ] 4. Others.....(Please specific)

14. Do you currently drink caffeine beverage?

[ ] 1. No [ ] 2. Yes (How many cups/bottles per day?.....Please specific)

15. What kind of caffeine beverage do you usually take?

[ ] 1. Coffee [ ] 2. Tea [ ] 3. Cocoa [ ] 4. Energy drink [ ] 5. Coke

[ ] 6. Others .....(Please specific)

16. Do you currently smoke cigarettes?

[ ] 1. No [ ] 2. Yes (How many rolls per day?.....Please specific)

17. Is there any smoker in your house (apart from you)? [ ] 1. No [ ] 2. Yes

18. What kind of fruit do you normally consume? (Please choose only one)

[ ] 1. Banana [ ] 2. Orange [ ] 3. Ripe mango [ ] 4. Pineapple [ ] 5. Others.....(Please specific)

19. Do you usually do exercise at least 30 minutes per time?

[ ] 1. No [ ] 2. Yes (How many times per week?.....Please specific)

20. Do you usually take a nap during daytime?

[ ] 1. No [ ] 2. Yes (How long do you take a nap for once?.....Minutes/Hours)

(How many times do you take a nap per day?.....Times)

21. Does doctor, nurse, or health professional inform you that you have any health problems?

[ ] 1. No [ ] 2. Obese [ ] 3. Hypertension [ ] 4. Heart diseases

[ ] 5. Diabetes [ ] 6. Respiratory problems [ ] 7. Others..... (Please specific)

22. How would you rate your health in general?

[ ] 1. Very good [ ] 2. Good [ ] 3. Poor [ ] 4. Fair [ ] 5. Don't know

Part 2 Psychological conditions

1. Are you satisfied with your life at this moment

[ ] 1. Very satisfied [ ] 2. Satisfied [ ] 3. Moderately satisfied [ ] 4. Dissatisfied

2. Do you think you face with stress in currently?

[ ] 1. No [ ] 2. Yes (How often do you face with?.....Times/week)

3. Are you able to cope with stress?

[ ] 1. Very well [ ] 2. Good [ ] 3. Pretty good [ ] 4. Worse

Normally, how do you handle with stress?

[ ] 1. Meditation [ ] 2. Hangout

[ ] 3. Listen to music [ ] 4. Others.....(Please specific)

Part 3 Residence and Bedroom conditions

1. What is the type of your residence?

[ ] 1. Detached house [ ] 2. Town house [ ] 3. Condominium

[ ] 4. Flat [ ] 5. Apartment [ ] 6. Others.....(Please specific)

2. How far from your residence to the main road? (Please give a detail roughly)

[ ] 1. 0.5 kilometer [ ] 2. 1 kilometer [ ] 3. 2 kilometer [ ] 4. Others..... kilometer (Please specific)

3. Do you have any cooling devices in your bedroom?

[ ] 1. Air conditioner [ ] 2. Fan [ ] 3. Nothing [ ] 4. Others.....(Please specific)

4. In case using air conditioner, how many times do you clean air conditioner filter by yourself?

[ ] 1. Morethan 2-3 times/month [ ] 2. 2-3 times/month

[ ] 3. Once a month [ ] 4. Less than once a month [ ] 5. Never

5. In case using air conditioner, how many times do you hire somebody to clean air conditioner?

[ ] 1. 2-3 times/year [ ] 2. Once a year [ ] 3. Less than once a year [ ] 4. Never

6. Is there any window in your bedroom? [ ] 1. No [ ] 2. Yes

How often do you open window

[ ] 1. everyday [ ] 2. 2-3 days a week [ ] 3. Once a week

[ ] 4. Never [ ] 5. Don't know

If you open window (How long do you usually open it?.....Hours/time) (Please specific)

7. What is the temperature that you usually set in your bedroom in case turning on air conditioner?.....°C

8. Do you usually hear any noise at night?

[ ] 1. No [ ] 2. Yes (If answer "yes" please answer the following question)

What kind of noise do you usually hear?

[ ] 1. Traffic noise [ ] 2. Children noise [ ] 3. Neighbor noise

[ ] 4. Sky train noise [ ] 5. Train noise [ ] 6. Others.....(Please specific)

How do you feel about this noise? [ ] 1. Annoyance [ ] 2. Familiar with it

9. What kind of lighting equipment (normal lighting) do you use in bedroom?

[ ] 1. Normal light bulb [ ] 2. Fluorescent

[ ] 3. Light-emitting diode lamp (LED) [ ] 4. Others..... (Please specific)

10. What is the color of lighting in bedroom? [ ] 1. White [ ] 2. Orange

11. Do you turn on the light while you are sleeping?

[ ] 1. No [ ] 2. Yes ( ) White ( ) Orange

12. Is there any carpet or rug in your bedroom? [ ] 1. No [ ] 2. Yes

In case there is carpet or rag in bedroom, how do you clean it? [ ] 1. Wash [ ] 2. Vacuum

And how often do you clean your carpet or rug?

[ ] 1. More than 2-3 times/month [ ] 2. 2-3times/month

[ ] 3.Once a month [ ] 4. Less than once a month

13. Is there any curtains or blinds in your bedroom? [ ] 1. No [ ] 2. Yes

In case there is curtains or blinds, please specific type of fabric

[ ] 1. Blackout (100-80% UV block) [ ] 2. Dim-out (50% UV block)

[ ] 3. Wood blind [ ] 4. Aluminum blind

How do you clean your curtains or blinds? [ ] 1. Wash [ ] 2. Vacuum

How often do you clean it? [ ] 1. 2-3 times/year [ ] 2. Once a year [ ] 3. Less than once a year

14. Do you usually bring your pets to your bedroom?

[ ] 1. Never [ ] 2. Rarely [ ] 3. Sometimes [ ] 4. Always

Part 4 Sleep

4.1) Sleep environments

1. Where is the direction of the head bed?

[ ] 1. North [ ] 2. East [ ] 3. West [ ] 4. South

2. What is the type of your bed?

[ ] 1. Bed [ ] 2. Futon [ ] 3. Others.....(Please specific)

3. What is your bed size?

[ ] 1. King 72''x 78'' (inches) / 182 x 198 (centimeters)

[ ] 2. Queen 60''x 78'' (inches) / 152 x 198 (centimeters)

[ ] 3. Single 36''x 78'' (inches) / 91 x 198 (centimeters)

[ ] 4. Twin-XL 42''x 78''(inches) / 107 x 198 (centimeters)

[ ] 5. Super King 76''x 78'' (inches) / 193 x 198 (centimeters)

4. What kind of mattress do you use?

[ ] 1. Foam [ ] 2. Latex [ ] 3. Spring [ ] 4. Others..... (Please specific)

5. What kind of bed sheets and pillowcases fabric do you use?

[ ] 1. Linen [ ] 2. Cotton [ ] 3. Satin

[ ] 4. Silk [ ] 5. Polyester [ ] 6. Others.....(Please specific)

6. What kind of duvet fabric do you always use?

[ ] 1.Cotton [ ] 2. Synthetic fabric [ ] 3. Nano

[ ] 4. Polyester [ ] 5. Downs [ ] 6. Others.....(Please specific)

7. What type of pillow do you always use?

[ ] 1.Polyester [ ] 2. Memory foam [ ] 3. Downs

[ ] 4. Feathers [ ] 5. Others..... (Please specific)

8. What kind of pillow thickness do you use?

[ ] 1. Soft [ ] 2. Firm [ ] 3. Others..... (Please specific)

9. What kind of sleep garment do you usually wear?

[ ] 1. Silk [ ] 2. Linen

[ ] 3. Cotton [ ] 4. Others.....(Please specific)

10. Do you have sleep partner? [ ] 1. No [ ] 2. Yes ( ) Male ( ) Female ( ) Both

11. Do you have air purifier in your bedroom? [ ] 1. No [ ] 2. Yes

In case there is air purifier, how often do you turn it on?

[ ] 1. Everyday [ ] 2. 2-3 days a week [ ] 3. Once a week

[ ] 4. Never [ ] 5. Don't know

12. How often do you wash your bedclothes (bed sheets, pillow sheets, duvets)?

[ ] 1. More than 2-3 times/month [ ] 2. 2-3times/month

[ ] 3.Once a month [ ] 4. Less than once a month

13. How do you clean your bedroom? [ ] 1. Vacuum [ ] 2. Sweeping [ ] 3. Mopping

14. How often do you clean your bedroom?

[ ] 1. More than 2-3 times/month [ ] 2. 2-3times/month

[ ] 3.Once a month [ ] 4. Less than once a month

15. What kind of electronic media use do you have in bedroom? (Answer more than one)

[ ] 1. TV [ ] 2. Computer/laptop [ ] 3. Music player [ ] 4. Game console

[ ] 5. Tablets [ ] 6. Smart phone [ ] 7. All [ ] 8. Others..... (Please specific)

16. How many of the listed electronic media devices above do you use the last hour before going to sleep?

[ ] 1. 1 [ ] 2. 2 [ ] 3. 3 [ ] 4. More than 3

17. How often do you use electronic media devices before sleep?

[ ] 1. Once in a week [ ] 2. 2-3 times a week [ ] 3. Almost everyday [ ] 4. Everyday

18. What time do you start using electronic media devices at above in the evening?.....

19. What time do you switch off electronic media devices at above in the evening?.....

20. What kind of electronic media devices do you usually use before sleep? (Please identified it only one)

[ ] 1. TV [ ] 2. Computer/laptop [ ] 3. Music player [ ] 4. Game console

[ ] 5. Tablets [ ] 6. Smart phone [ ] 7. Others.....(Please specific)

21. What do you usually do by using electronic media devices before sleep? (Answer more than one)

[ ] 1. Watching movies or tv series by [ ] TV [ ] Tablets [ ] Mobile [ ] Laptop/computer

[ ] 2. Surfing internet or reading with [ ] Laptop/computer [ ] Tablets [ ] Mobile [ ] TV internet

[ ] 3. Surfing social network (facebook, intagram) with [ ] Laptop/computer [ ] Tablets

[ ] Mobile [ ] TV internet

[ ] 4. Playing online or offline game via [ ] Laptop/computer [ ] Tablets [ ] Mobile [ ] TV internet

[ ] 5. Chatting or texting by [ ] laptop/computer [ ] tablets [ ] Mobile

[ ] 6. Talking or calling by [ ] laptop/computer [ ] tablets [ ] Mobile

[ ] 7. Others..... (Please specific)

22. Do you usually turn on electronic media devices while you are sleeping?

[ ] 1. No [ ] 2. Yes ( ) TV ( ) Music player ( ) Mobile ( ) Tablet

4.2) Sleep quality assessment

(The Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale (ESS))

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed?.....24hr.)

2. How long (in minutes) has it taken you to fall asleep each night? .....

3. When have you usually gotten up in the morning? .....

4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) .....

	Not during the past month	Less than once a week	Once/ twice a week	Three /more times week
5.During the past month, how often have you had trouble sleeping because you....	0	1	2	3
a) Cannot get to sleep within 30 minutes	0	1	2	3
b) Wake up in the middle of the night or early	0	1	2	3
c) Have to get up to use the bathroom	0	1	2	3
d) Cannot breathe comfortably	0	1	2	3
e) Cough or snore loudly	0	1	2	3
f) Feel too cold	0	1	2	3
g) Feel too cold	0	1	2	3
h) Have bad dreams	0	1	2	3
i) Have pain	0	1	2	3
j) Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):	0	1	2	3
6. During the past month, how often have you taken medicine (prescribed / "over the counter" to help	Not during the past month	Less than once a	Once/twice a week	Three/more times
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	Not during the past month 0	Less than once a week	Once/twice a week 2	Three/more times a week
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get thing done?	No problem at all 0	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how would you rate your sleep quality overall?	Very good 0	Fairly good 1	Fairly bad 2	Very bad 3

10. Do you have a bed partner or roommate?

[ ] No bed partner or roommate [ ] Partner/roommate in other room

[ ] Partner in same room, but not same bed [ ] Partner in same bed

If you have a roommate or bed partner, ask him/her how often in the past month you have had....

	Not during the past month	Less than once a week	Once/ twice a week	Three /more times week
10.1) Loud snoring	0	1	2	3
10.2) Long pauses between breaths while sleep	0	1	2	3
10.3) Leg twitching or jerking while you sleep	0	1	2	3

4.3) Excessive daytime sleepiness (ESS) assessment

Instructions: Use the following scale to choose the most appropriate number for each situation:

0 = would never doze

1 = Slight chance of dozing

2 = Moderate chance of dozing

3 = High chance of dozing

Situation	Chance of dozing
1. Sitting and reading	.....
2. Watching TV	.....
3. Sitting, inactive in a public place (eg. a theater or a meeting)	.....
4. As a passenger in a car for an hour without a break	.....
5. Lying down to rest in the afternoon when circumstances permit	.....
6. Sitting and talking to someone	.....
7. Sitting quietly after lunch without alcohol	.....
8. In a car, while stopped for about 2-3 minutes in the traffic	.....

4.4) Composite scale of morningness assessment (CSM) (Smith et al., 1989)

1. Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan you day?

[5] Before 06.30 a.m. [4] 06.30 - 07.45 a.m. [3] 07.45 - 09.45 a.m.

[2] 09.45 - 11.00 a.m. [1] After 11.00 a.m.

2. Considering your only "feeling best" rhythm, at what time would you go to bed if you were entirely free to plan your evening?

[5] Before 9.00 p.m. [4] 9.00 – 10.15 p.m. [3] 10.15 p.m. – 12.30 a.m.

[2] 12.30 a.m. – 01.45 a.m. [1] After 01.45 a.m.

3. Assuming normal circumstance, how easy do you find getting up in the morning?

[1] Not at all easy [2] Slight easy

[3] Fairly easy [4] Very easy

4. How alert do you feel during the first half hour after having awakened in the morning?

[1] Not at all alert [2] Slightly alert

[3] Fairly alert [4] Very alert

5. During the first half hour after having awakened in the morning, how tired do you feel?

[1] Very tired [2] Fairly tired

[3] Fairly refreshed [4] Very refreshed

6. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is 7:00-8:00 a.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?

[4] Would be in good form [3] Would be in a reasonable form

[2] Would find it difficult [1] Would find it very difficult

7. At what time in the evening do you feel tired and, as a result, in need of sleep?

[5] Before 9.00 p.m. [4] 9.00 – 10.15 p.m. [3] 10.15 p.m. – 12.30 a.m.

[2] 12.30 a.m. – 1.45 a.m. [1] After 01.45 a.m.

8. You wish to be at your peak performance for a test which you know is going to be mentally exhasting and lasting for two hours. You are entirely free to plan your day, and considering only you own "feeling best" rhythm, which ONE of the four testing times would you choose?

[4] 08.00 - 10.00 a.m. [3] 11.00 a.m. – 1.00 p.m.

[2] 3.00 - 5.00 p.m. [1] 7.00 – 9.00 p.m.

9. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

[4] Definitively a morning type

[3] More a morning than an evening type

[2] More an evening than a morning type

[1] Definitively an evening type

10. When would you prefer to rise (provided you have a full day's work - 8 hours) if you were totally free to arrange your time?

[4] Before 06.30 a.m. [3] 06.30 - 07.30 a.m.

[2] 07.30 - 08.30 a.m. [1] Before 08.30 a.m.

11. If you always had to rise at 6:00 a.m., what do you think it would be like?

[1] Very difficult and unpleasant

[2] Rather difficult and unpleasant

[3] A little unpleasant but no great problem

[4] Easy and not unpleasant

12. How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?

[4] 0-10 minutes [3] 11-20 minutes

[2] 21-40 minutes [1] more than 40 minutes

13. Please indicate to what extent you are a morning or evening active individual.

[4] Pronounced morning active (morning alert and evening tired)

[3] To some extent, morning active

[2] To some extent, evening active

[1] Pronounced evening active (morning alert and evening tired)

APPENDIX B

Questionnaire (English)

Dry season

Questionnaires [Sleep environments and sleep-disordered breathing in Bangkok, Thailand: A repeated cross-sectional study]

OSA treatment

1. Do you receive treatment for OSA?

( ) No ( ) Yes ( ) 1. Behavior change (eg. weight reduction)

( ) 2. CPAP use

( ) 3. Oral devices

( ) 4. Surgery

Bedroom environmental conditions

2. Did you change any bedroom environmental conditions in the last 3 months (eg. color of the light in bedroom, curtain, etc.)

( ) No ( ) Yes .....

Epworth Sleepiness Scale (ESS) questionnaire

3. Epworth Sleepiness Scale (ESS) assessments

Instructions: Use the following scale to choose the most appropriate number for each situation:

0 = would never doze

1 = Slight chance of dozing

2 = Moderate chance of dozing

3 = High chance of dozing

Situation	Chance of dozing
1. Sitting and reading	.....
2. Watching TV	.....
3. Sitting, inactive in a public place (eg. a theater or a meeting)	.....
4. As a passenger in a car for an hour without a break	.....
5. Lying down to rest in the afternoon when circumstances permit	.....
6. Sitting and talking to someone	.....
7. Sitting quietly after lunch without alcohol	.....
8. In a car, while stopped for about 2-3 minutes in the traffic	.....

The Pittsburgh Sleep Quality Index (PSQI) questionnaire

4. The Pittsburgh Sleep Quality Index (PSQI) assessment

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed?.....24hr.)

2. How long (in minutes) has it taken you to fall asleep each night? .....

3. When have you usually gotten up in the morning? .....

4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) .....

	Not during the past month	Less than once a week	Once/ twice a week	Three /more times week
5.During the past month, how often have you had trouble sleeping because you....	0	1	2	3
a) Cannot get to sleep within 30 minutes	0	1	2	3
b) Wake up in the middle of the night or early	0	1	2	3
c) Have to get up to use the bathroom	0	1	2	3
d) Cannot breathe comfortably	0	1	2	3
e) Cough or snore loudly	0	1	2	3
f) Feel too cold	0	1	2	3
g) Feel too cold	0	1	2	3
h) Have bad dreams	0	1	2	3
i) Have pain	0	1	2	3
j) Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):	0	1	2	3
6. During the past month, how often have you taken medicine (prescribed / "over the counter" to help	Not during the past month	Less than once a	Once/twice a week	Three/more times
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	Not during the past month 0	Less than once a week	Once/twice a week 2	Three/more times a week
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get thing done?	No problem at all 0	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how would you rate your sleep quality overall?	Very good 0	Fairly good 1	Fairly bad 2	Very bad 3

10. Do you have a bed partner or roommate?

[ ] No bed partner or roommate [ ] Partner/roommate in other room

[ ] Partner in same room, but not same bed[ ] Partner in same bed

If you have a roommate or bed partner, ask him/her how often in the past month you have had....

	Not during the past month	Less than once a week	Once/ twice a week	Three /more times week
10.1) Loud snoring	0	1	2	3
10.2) Long pauses between breaths while sleep	0	1	2	3
10.3) Leg twitching or jerking while you sleep	0	1	2	3

APPENDIX C

Questionnaire (Thai)

Wet season

แบบสอบถามคัดกรอง [สภาพแวดล้อมในการนอนหลับและภาวะการหยุดหายใจในขณะนอนหลับในกรุงเทพ,ประเทศไทย: การศึกษาแบบสำรวจซ้ำ] **กรุณาทำเครื่องหมายถูก (✓) หน้าข้อที่ท่านเลือก**

ตอนที่ 1: แบบสอบถามคัดกรองข้อมูลทั่วไป

1) ท่านมีประวัติโรค ดังนี้หรือไม่

( ) หอบหืด ( ) เส้นเลือดในสมองตีบตัน ( ) มีอาการปวดเรื้อรัง ( ) มีภาวะหัวใจล้มเหลว

( ) ผู้ที่มีการฟอกไต ( ) ผู้ที่เป็นมะเร็งตั้งแต่ขั้นที่ลุกลามไปยังต่อมน้ำเหลืองจนลุกลามไปยังอวัยวะอื่นๆ

2) ท่านงานผลัดกลางคืนใช่หรือไม่ ( ) ใช่ ( ) ไม่ใช่

3) ท่านสูบบุหรี่ประมาณ 15-25 มวนต่อวัน ( ) ใช่ ( ) ไม่ใช่

4) ท่านกินยานอนหลับ ( ) ใช่ ( ) ไม่ใช่

5) ท่านกำลังตั้งครรภ์อยู่ ( ) ใช่ ( ) ไม่ใช่

ตอนที่ 2: แบบประเมินมาตรฐานคัดกรองภาวะซึมเศร้า (PHQ-9) พัฒนาโดย Drs. Robert L. Spitzer, Janet B.W. Williams, Kurt Kroenke **ในช่วง 2 สัปดาห์ที่ผ่านมา**, ท่านถูกรบกวนด้วยปัญหาต่อไปนี้บ่อยเพียงใด

	ไม่เลย	มีบางวันไม่บ่อย	มีค่อนข้างบ่อย	เกือบทุกวัน
1) ไม่ค่อยอยากทำ หรือไม่รู้สึกสนุกที่จะทำอะไร	0	1	2	3
2) รู้สึกเศร้า หดหู่ หรือสิ้นหวัง	0	1	2	3
3) มีปัญหานอนไม่หลับหรือนอนหลับไม่สนิทตลอดคืน หรือนอนมากเกินไป	0	1	2	3
4) รู้สึกเหนื่อยหรือไม่ค่อยมีแรง	0	1	2	3
5) ไม่ค่อยอยากกินอะไร หรือกินมากเกินไป	0	1	2	3
6) รู้สึกแย่กับตนเองหรือรู้สึกว่าตนเองเป็นคนล้มเหลว หรือทำให้ตนเองหรือครอบครัวผิดหวัง	0	1	2	3
7) ไม่ค่อยมีสมาธิกับสิ่งต่างๆ เช่น การอ่านหนังสือพิมพ์ หรือ ดูโทรทัศน์	0	1	2	3
8) เคลื่อนไหวช้า หรือพูดช้าจนคนอื่นสามารถสังเกตเห็นได้หรือในทางตรงข้ามคืออยู่ไม่นิ่งกระสับกระส่ายจนเคลื่อนไหวบ่อยกว่าปกติมาก	0	1	2	3
9) มีความคิดว่าคงจะดีกว่าหากตายไปเสียได้ หรือ คิดทำร้ายตนเองด้วยวิธีใดวิธีหนึ่ง	0	1	2	3
10) หากท่านตอบว่าถูกรบกวนด้วยปัญหา ข้อใดๆ ข้างต้น ปัญหาเหล่านี้ก่อให้เกิดความยุ่งยากแก่ท่านมากน้อยเพียงใดในการทำงาน การดูแลเรื่องต่างๆที่บ้าน หรือการมีสัมพันธ์ที่ดีกับผู้อื่น	ไม่ยุ่งยากเลย	ยุ่งยากเล็กน้อย	ยุ่งยากมาก	ยุ่งยากมากที่สุด
รวมคะแนนในคอลัมน์				
รวมทั้งหมด				

ตอนที่ 3: แบบประเมินมาตรฐานคัดกรองภาวะวิตกกังวล (GAD-7) พัฒนาโดย Drs. Robert L. Spitzer, Janet B.W. Williams, Kurt Kroenke

ในช่วง 2 สัปดาห์ที่ผ่านมา, ท่านถูกรบกวนด้วยปัญหาต่อไปนี้บ่อยเพียงใด **กรุณาทำเครื่องหมายถูก (✓) หน้าข้อที่ท่านเลือก**

	ไม่เลย	มีบางวัน ไม่บ่อย	มีค่อนข้าง บ่อย	เกือบ ทุกวัน
1) รู้สึกกระวนกระวายใจ วิตกกังวล หรือ ตึงเครียดมาก	0	1	2	3
2) ไม่สามารถหยุด หรือ ควบคุมตัวเองไม่ให้วิตกกังวลได้	0	1	2	3
3) วิตกกังวลมากเกินไปในเรื่องต่างๆกัน	0	1	2	3
4) ทำตัวให้ผ่อนคลายได้ยาก	0	1	2	3
5) กระสับกระส่ายมากจนแทบนั่งไม่ติด	0	1	2	3
6) กลายเป็นคนรำคาญง่าย หรือ อารมณ์เสียง่าย	0	1	2	3
7) รู้สึกกลัวเหมือนกับว่าอาจจะมีเรื่องเลวร้ายเกิดขึ้น	0	1	2	3
รวมคะแนนในคอลัมน์				
รวมทั้งหมด				

ตอนที่ 4: แบบประเมินมาตรฐานคัดกรองภาวะนอนหลับยาก (ISI) ได้ทำรับอนุญาติและแปลจาก Charles M. Morin
กรุณาเลือกคำตอบในแต่ละข้อที่ตรงกับท่านมากที่สุดในช่วง 2 สัปดาห์ที่ผ่านมา

กรุณาทำเครื่องหมายถูก (✓) หน้าข้อที่ท่านเลือก

	ไม่เลย	เล็กน้อย	พอสมควร	ค่อนข้างมาก	มากที่สุด
1) คุณรู้สึกนอนหลับยาก	0	1	2	3	4
2) คุณรู้สึกนอนหลับไม่สนิท	0	1	2	3	4
3) คุณมีปัญหาตื่นนอนเช้าเกินไป	0	1	2	3	4
4) คุณพอใจกับวงจรการนอนหลับ (การนอนหลับและการตื่น) ของคุณในขณะนี้หรือไม่	พอใจมากที่สุด 0	พอใจ 1	ค่อนข้างพอใจ 2	ไม่พอใจ 3	ไม่พอใจมากที่สุด 4
5) คุณคิดว่าคนรอบตัวสังเกตเห็นว่าคุณภาพชีวิต (การทำงาน และความสุข) ของคุณแย่ลงเนื่องมาจากปัญหาการนอนหลับของคุณบ้างหรือไม่	ไม่เลย 0	มีบ้าง 1	ค่อนข้างมี 2	เป็นที่สังเกตุมาก 3	เป็นที่สังเกตุมากที่สุด 4
6) คุณรู้สึกกังวลกับปัญหาการนอนหลับในปัจจุบันบ้างหรือไม่	ไม่วิตกกังวล 0	วิตกกังวลบ้าง 1	ค่อนข้างวิตกกังวล 2	วิตกกังวลมาก 3	วิตกกังวลมากที่สุด 4
7) คุณคิดว่าปัญหาการนอนหลับในปัจจุบันของคุณส่งผลต่อการดำเนินชีวิตประจำวัน (เช่น ความเหนื่อยล้าในเวลากลางวันความสามารถในการทำงานหรือกิจกรรมต่างๆ ความสนใจในสิ่งต่างๆ ความจำ หรือ อารมณ์ เป็นต้น)	ไม่รบกวนเลย 0	รบกวนบ้าง 1	ค่อนข้างรบกวน 2	รบกวนมาก 3	รบกวนมากที่สุด 4
รวมคะแนนในคอลัมน์					
รวมคะแนนทั้งหมด					

แบบสอบถามหลัก [สภาพแวดล้อมในการนอนหลับและภาวะการหยุดหายใจในขณะนอนหลับในกรุงเทพ, ประเทศไทย: การศึกษาแบบสำรวจซ้ำ] **กรุณาทำเครื่องหมายถูก (✓) หน้าข้อที่ท่านเลือก และเติมคำตอบในช่องว่าง**

ส่วนที่ 1 ข้อมูลทั่วไป

1. อายุ ..... ปี
2. เพศ [ ] 1. หญิง [ ] 2. ชาย
3. น้ำหนัก ..... กิโลกรัม
4. ส่วนสูง ..... เซนติเมตร
5. ระดับการศึกษา [ ] 1. ไม่ได้ศึกษา [ ] 2. ระดับประถมศึกษา [ ] 3.ระดับมัธยมศึกษา
   [ ] 4. ปริญญาตรี [ ] 5. ปริญญาโท หรือ สูงกว่า
6. สถานะการสมรส [ ] 1. โสด
   [ ] 2. แต่งงานแล้ว (ท่านมีบุตรทั้งหมดกี่คน?.....)
   [ ] 3. หย่าร้าง/หม้าย
7. อาชีพปัจจุบัน [ ] 1. พนักงานออฟิศ [ ] 2. รัฐวิสาหกิจ [ ] 3. แม่บ้าน
   [ ] 4. ธุรกิจส่วนตัว [ ] 5. ว่างงาน [ ] 6. อื่นๆ..... (โปรดระบุ)
8. รายได้ต่อเดือน ..... บาท
9. จำนวนสมาชิกทั้งหมดในบ้านที่อยู่ปัจจุบัน .....
10. ปัจจุบันท่านดื่มแอลกอฮอล์หรือไม่
    [ ] 1. ไม่ (โปรดข้ามไป**ข้อที่ 14**) [ ] 2. ใช่ (จำนวน **แก้ว/ขวด** ที่ท่านดื่มต่อวัน.....(โปรดระบุ)
11. หากท่านดื่มเครื่องดื่มที่มีส่วนผสมของแอลกอฮอล์ โดยส่วนใหญ่ท่านดื่มแอลกอฮอล์ชนิดใด
    [ ] 1. เบียร์ [ ] 2. ไวน์ [ ] 3. เหล้า [ ] 4. อื่นๆ.....(โปรดระบุ)
12. ปัจจุบันท่านดื่มเครื่องดื่มที่มีส่วนผสมคาเฟอีนหรือไม่
    [ ] 1. ไม่ (โปรดข้ามไป**ข้อที่ 17**) [ ] 2. ใช่ (ท่านดื่มกี่ **ขวด** ต่อวัน.....โปรดระบุ)

*หากเปรียบปริมาณการดื่มจากแก้วหรือขวดให้เทียบเท่ากับขนาดของขวดน้ำดื่มสิงห์ หรือ เนสเล่ (0.6 ลิตร)

13. หากท่านดื่มเครื่องดื่มที่มีส่วนผสมของคาเฟอีน โดยส่วนใหญ่ท่านดื่มเครื่องดื่มชนิดใด
    [ ] 1. กาแฟ [ ] 2. ชา [ ] 3. โกโก้ [ ] 4. เครื่องดื่มชูกำลัง
    [ ] 5. โค้ก [ ] 6. อื่นๆ .....(โปรดระบุ)
14. หากท่านดื่มเครื่องดื่มที่มีส่วนผสมของคาเฟอีน โดยส่วนใหญ่ท่านดื่มครั้งสุดท้ายในเวลาใดของวันที่ดื่ม
    .....(โปรดระบุ)
15. ปัจจุบันท่านสูบบุหรี่หรือไม่
    [ ] 1. ไม่ (โปรดข้ามไป**ข้อที่ 19**) [ ] 2. ใช่ (ท่านสูบบุหรี่กี่**มวน**ต่อวัน.....โปรดระบุ)
16. นอกจากท่าน มีบุคคลใดในบ้านที่สูบบุหรี่หรือไม่ [ ] 1. ไม่มี [ ] 2. มี
17. ภายใน 1 สัปดาห์ที่ผ่านมา ท่านรับประทานผลไม้ชนิดใด**บ่อยที่สุด**
    [ ] 1. กล้วย [ ] 2. ส้ม [ ] 3. มะม่วงสุก
    [ ] 4. สับปะรด [ ] 5. ฝรั่ง [ ] 6. อื่นๆ.....(โปรดระบุ)

18. โดยส่วนใหญ่ท่านออกกำลังกายอย่างน้อย 30 นาทีต่อครั้งหรือไม่

[ ] 1. ไม่ [ ] 2. ใช่ (ท่านออกกำลังกายกี่**ครั้งต่อสัปดาห์**.....โปรดระบุ)

19. โดยปกติท่านได้งีบหลับในช่วงกลางวันหรือไม่

[ ] 1. ไม่ [ ] 2. ใช่ (ท่านงีบหลับนานเท่าใดต่อครั้ง.....**นาที/ชั่วโมง**)

(ท่านงีบหลับกี่ครั้งต่อวัน.....**ครั้ง**)

20. ไม่ทราบว่ามีแพทย์, พยาบาล, หรือ ผู้เชี่ยวชาญทางด้านสุขภาพได้แจ้งว่าท่านมีปัญหาสุขภาพใดหรือไม่ (ตอบได้**มากกว่า 1 ข้อ**)

[ ] 1. ไม่มี [ ] 2. โรคอ้วน [ ] 3. โรคความดันโลหิต [ ] 4. โรคหัวใจ

[ ] 5. โรคเบาหวาน [ ] 6. ปัญหาระบบหายใจ [ ] 7. อื่นๆ..... (โปรดระบุ)

21. หากให้ท่านประเมินระดับสุขภาพของท่าน ท่านจะประเมินระดับใด

[ ] 1. ดีมาก [ ] 2. ค่อนข้างดี [ ] 3. ค่อนข้างแย่ [ ] 4. เฉยๆ [ ] 5. ไม่ทราบ

ส่วนที่ 2 สภาวะทางจิตใจ

2.1) สภาวะทางจิตใจ

1. ท่านพอใจกับชีวิตของท่านในตอนนี้หรือไม่

[ ] 1. พอใจมากที่สุด [ ] 2. พอใจ [ ] 3. ค่อนข้างพอใจ [ ] 4. ไม่พอใจเลย

2. ท่านเผชิญกับความเครียดบ้างหรือไม่ในขณะนี้

[ ] 1. ไม่ [ ] 2. ใช่ (บ่อยครั้งแค่ไหนที่ท่านเผชิญกับความเครียด.....**ครั้ง/สัปดาห์**)

3. ท่านสามารถรับมือกับความเครียดได้หรือไม่

[ ] 1. ทำได้อย่างดีที่สุด [ ] 2. ทำได้ดี [ ] 3. ค่อนข้างทำได้ดี [ ] 4. ค่อนข้างแย่

โดยปกติท่านจัดการกับความเครียดอย่างไร

[ ] 1. ทำสมาธิ [ ] 2. ออกไปเที่ยว [ ] 3. ฟังเพลง [ ] 4. อื่นๆ.....(โปรดระบุ)

ส่วนที่ 3 ที่พักและสภาวะในห้องนอน

1. ที่พักอาศัยของท่านเป็นแบบใด

[ ] 1. บ้านเดี่ยว [ ] 2. ทาวน์โฮม [ ] 3. คอนโดมิเนียม [ ] 4. แฟลต

[ ] 5. อพาร์ทเม้นต์ [ ] 6. ตึกแถว [ ] 7. อื่นๆ.....(โปรดระบุ)

2. ท่านมีเครื่องทำความเย็นชนิดใดในห้องนอนของท่าน (ตอบได้**มากกว่า 1 ข้อ**)

[ ] 1. เครื่องปรับอากาศ [ ] 2. พัดลม

[ ] 3. ไม่มีเลย [ ] 4. อื่นๆ.....(โปรดระบุ)

3. ในกรณีที่ท่านมีพัดลมในห้องนอน, บ่อยครั้งแค่ไหนที่ท่านล้างทำความสะอาดตัวกรอง

[ ] 1. มากกว่า 2-3 ครั้ง/เดือน [ ] 2. 2-3ครั้ง/เดือน [ ] 3. 1 ครั้ง/เดือน

[ ] 4. น้อยกว่า 1 ครั้ง/เดือน [ ] 5. ไม่เคย

4. ในกรณีที่ท่านมีเครื่องปรับอากาศในห้องนอน, บ่อยครั้งแค่ไหนที่ท่านล้างทำความสะอาดตัวกรอง

[ ] 1. มากกว่า 2-3 ครั้ง/เดือน [ ] 2. 2-3ครั้ง/เดือน [ ] 3. 1 ครั้ง/เดือน

[ ] 4. น้อยกว่า 1 ครั้ง/เดือน [ ] 5. ไม่เคย

5. ในกรณีที่ท่านมีเครื่องปรับอากาศ, บ่อยครั้งแค่ไหนที่ท่านจ้างคนมาทำความสะอาดเครื่องปรับอากาศ

[ ] 1. 2-3ครั้ง/ปี [ ] 2. 1 ครั้ง/ปี [ ] 3. น้อยกว่า 1 ครั้ง/ปี [ ] 4. ไม่เคย

6. ในห้องนอนของท่านมีหน้าต่าง หรือประตูระเบียงหรือไม่ [ ] 1. ไม่มี [ ] 2. มี

บ่อยครั้งแค่ไหนที่ท่านเปิดหน้าต่าง

[ ] 1. ทุกวัน [ ] 2. 2-3 วัน/สัปดาห์ [ ] 3. 1 ครั้ง/สัปดาห์ [ ] 4. ไม่เคย [ ] 5. ไม่ทราบ

หากท่านเปิดหน้าต่าง (นานแค่ไหนที่ท่านเปิดหน้าต่าง.....**ชั่วโมง/ครั้ง**)(โปรดระบุ)

7. ในกรณีที่ท่านเปิดเครื่องปรับอากาศในห้องนอน ส่วนใหญ่ท่านกำหนดอุณหภูมิเท่าไร.....องศาเซลเซียส

8. โดยปกติท่านได้ยินเสียงใดๆบ้างหรือไม่ในตอนกลางคืน

[ ] 1. ไม่ [ ] 2. ได้ยิน (ถ้าท่านตอบว่า**ได้ยิน** กรุณา**ตอบคำถามด้านล่าง**)

โดยปกติท่านได้ยินเสียงชนิดใด

[ ] 1. เสียงจราจรบนท้องถนน [ ] 2. เสียงเด็กร้องไห้ [ ] 3. เสียงข้างบ้าน

[ ] 4. เสียงรถไฟฟ้า [ ] 5. เสียงรถไฟ [ ] 6. เสียงเครื่องปรับอากาศ

[ ] 7. อื่นๆ.....(โปรดระบุ)

ท่านรู้สึกอย่างไรกับเสียงเหล่านี้ [ ] 1. รำคาญ [ ] 2. คุ้นชิน

9. ท่านใช้หลอดไฟฟ้าชนิดใดในห้องนอนของท่าน

[ ] 1. หลอดไฟธรรมดา (หลอดไส้) [ ] 2. หลอดไฟฟลูออเรสเซนต์

[ ] 3. หลอดไฟแบบ LED [ ] 4. อื่นๆ.....(โปรดระบุ)

10. สีของหลอดไฟที่ท่านใช้ในห้องนอน [ ] 1. สีขาว [ ] 2. สีส้ม

11. ท่านเปิดไฟขณะที่ท่านหลับหรือไม่ [ ] 1. ไม่ [ ] 2. ใช่ ( ) ไฟสีขาว ( ) ไฟสีส้ม

12. ในห้องนอนของท่านมีพรมหรือไม่ [ ] 1. ไม่มี (โปรดข้ามไป**ข้อที่ 12**) [ ] 2. มี

ในกรณีที่ห้องนอนของท่านมีพรม, ท่านมีวิธีการทำความสะอาดอย่างไร

[ ] 1. ซักล้าง [ ] 2. ดูดฝุ่น [ ] 3. อื่น.....(โปรดระบุ)

และบ่อยครั้งแค่ไหนที่ท่านทำความสะอาดพรม

[ ] 1. มากกว่า 2-3 ครั้ง/เดือน [ ] 2. 2-3 ครั้ง/เดือน

[ ] 3. 1 ครั้ง/เดือน [ ] 4. น้อยกว่า 1 ครั้ง/เดือน

13. ในห้องนอนของท่านมีผ้าม่านหรือมู่ลี่หรือไม่ [ ] 1. ไม่มี (โปรดข้ามไป**ข้อที่ 13**) [ ] 2. มี

ในกรณีที่ห้องนอนมีผ้าม่านหรือมู่ลี่ กรุณาระบุชนิดของผ้าม่านหรือมู่ลี่

[ ] 1. ผ้าม่านทึบแสง (แสงเข้ามาไม่ได้เลย) [ ] 2. ผ้าม่านกันแสง (แสงเข้ามาได้บ้าง)

[ ] 3. มู่ลี่ไม้ [ ] 4. มู่ลี่อะลูมิเนียม

ท่านทำความสะอาดผ้าม่านหรือมู่ลี่อย่างไร [ ] 1. ซักล้าง [ ] 2. ดูดฝุ่น [ ] 3. ปัดฝุ่น

บ่อยครั้งแค่ไหนที่ท่านทำความสะอาดผ้าม่านหรือมู่ลี่

[ ] 1. 2-3 ครั้ง/ปี [ ] 2. 1 ครั้ง/ปี [ ] 3. น้อยกว่า 1 ครั้ง/ปี

14. ท่านมีสัตว์เลี้ยงหรือไม่ [ ] 1. ไม่มี (โปรดข้ามไป**ส่วนที่ 4**) [ ] 2. มี คือ .....

ในกรณีที่ท่านมีสัตว์เลี้ยง บ่อยครั้งแค่ไหนที่ท่านนำสัตว์เลี้ยงเข้าในห้องนอน

[ ] 1. ไม่เคย [ ] 2. แทบจะไม่ [ ] 3. บางครั้ง [ ] 4. บ่อยครั้ง

ส่วนที่ 4 การนอนหลับ

4.1) สภาพแวดล้อมการนอนหลับ

1. หัวเตียงของท่านตั้งอยู่ทางทิศใด [ ] 1. ทิศเหนือ [ ] 2. ทิศตะวันออก [ ] 3. ทิศตะวันตก
[ ] 4. ทิศใต้ [ ] 5. ไม่แน่ใจ/ไม่แน่ใจ

2. ที่นอนของท่านเป็นแบบใด [ ] 1. เตียงนอน [ ] 2. ฟูกนอน (เบาะ) [ ] 3. เสื่อ
[ ] 4. อื่นๆ.....(โปรดระบุ)

3. เตียงนอนของท่านมีขนาดเตียงเท่าใด

[ ] 1. คิงส์ไซส์ (ขนาด 6 หรือ 6.5 ฟุต) [ ] 2. ควีนส์ไซส์ (ขนาด 5 ฟุต)

[ ] 3. เตียงคู่ (ขนาด 4.5 ฟุต) [ ] 4. เตียงเดี่ยว (ขนาด 3.5 ฟุต)

4. ที่นอนของท่านผลิตจากวัสดุชนิดใด

[ ] 1. ที่นอนฟองน้ำอัด [ ] 2. ที่นอนยางพารา [ ] 3. ที่นอนสปริง

[ ] 4. ที่นอนใยมะพร้าว [ ] 5. ที่นอนเมมโมรี่โฟม [ ] 6. อื่นๆ.....(โปรดระบุ)

5. ผ้าปูที่นอนและปลอกหมอนที่ท่านใช้ผลิตจากวัสดุชนิดใด

[ ] 1. ผ้าลินิน [ ] 2. ผ้าค้อตตอน (ผ้าฝ้าย) [ ] 3. ผ้าซาติน

[ ] 4. ผ้าไหม [ ] 5. ผ้าโพลีเอสเตอร์ [ ] 6. อื่นๆ.....(โปรดระบุ)

6. ผ้าห่มที่ท่านใช้ผลิตจากวัสดุชนิดใด

[ ] 1.ผ้าค้อตตอน (ผ้าฝ้าย) [ ] 2. ผ้าใยสังเคราะห์ (ผ้าโพลีเอสเตอร์) [ ] 3. ผ้าห่มนาโน

[ ] 4. ผ้าห่มขนเป็ด [ ] 5. อื่นๆ.....(โปรดระบุ)

7. หมอนที่ท่านใช้ผลิตจากวัสดุชนิดใด

[ ] 1.โพลีเอสเตอร์ [ ] 2. เมมโมรี่โฟม [ ] 3. ขนเป็ด

[ ] 4. นุ่น [ ] 5. หมอนเพื่อสุขภาพ [ ] 6. อื่นๆ.....(โปรดระบุ)

8. ปกติท่านหนุนหมอนแบบใด [ ] 1. นุ่ม [ ] 2. แน่น (แข็ง)
[ ] 3. อื่นๆ.....(โปรดระบุ)

9. ชุดนอนของท่านผลิตจากวัสดุชนิดใด

[ ] 1. ผ้าไหม [ ] 2. ผ้าลินิน [ ] 3. ผ้าค้อตตอน (ผ้าฝ้าย)

[ ] 4. ผ้าใยสังเคราะห์ [ ] 5. อื่นๆ .....(โปรดระบุ)

10. ท่านมีคนนอนกับท่านหรือไม่ [ ] 1. ไม่มี [ ] 2. มี( ) เพศชาย ( ) เพศหญิง ( ) ทั้งสองเพศ

11. ในห้องนอนของท่านมีเครื่องฟอกอากาศหรือไม่ [ ] 1. ไม่มี [ ] 2. มี

หากท่านมีเครื่องฟอกอากาศในห้องนอน บ่อยครั้งแค่ไหนที่ท่านเปิดใช้

[ ] 1. ทุกวัน [ ] 2. 2-3 วัน/สัปดาห์ [ ] 3. 1 ครั้ง/สัปดาห์ [ ] 4. ไม่เคยเปิด[ ] 5. ไม่ทราบ

ในกรณีที่ท่านมีเครื่องฟอกอากาศ, บ่อยครั้งแค่ไหนท่านทำความสะอาดเครื่องฟอกอากาศด้วยตัวของท่าน

[ ] 1. ทุกวัน [ ] 2. ทุกสัปดาห์ [ ] 3. 1ครั้ง/สัปดาห์ [ ] 4. ทุกเดือน [ ] 5. 1 ครั้ง/ปี

12. บ่อยครั้งแค่ไหนที่ท่านทำความสะอาดชุดเครื่องนอนของท่าน (ผ้าปูเตียง, ปลอกหมอน, ผ้าห่ม)

[ ] 1. มากกว่า 2-3 ครั้ง/เดือน [ ] 2. 2-3 ครั้ง/เดือน [ ] 3. 1 ครั้ง/เดือน [ ] 4. น้อยกว่า 1 ครั้ง/เดือน

13. ท่านทำความสะอาดห้องนอนอย่างไร (เลือกได้**มากกว่า 1 ข้อ)**

[ ] 1. ดูดฝุ่น [ ] 2. กวาดพื้น [ ] 3. ถูพื้น [ ] 5. อื่นๆ.....

14. บ่อยครั้งแค่ไหนที่ท่านทำความสะอาดห้องนอน

[ ] 1. ทุกวัน [ ] 2. มากกว่า 2-3 ครั้ง/เดือน [ ] 3. 2-3 ครั้ง/เดือน

[ ] 4. 1 ครั้ง/เดือน [ ] 5. น้อยกว่า 1 ครั้ง/เดือน

15. ในห้องนอนของท่านมีอุปกรณ์อิเล็กโทนิคชนิดใดบ้าง (ตอบได้**มากกว่า 1 ข้อ**)

[ ] 1. โทรทัศน์ [ ] 2. คอมพิวเตอร์/โน้ตบุ๊ค [ ] 3. เครื่องเล่นเพลง

[ ] 4. เกมส์ [ ] 5. แท็บเล็ต [ ] 6. สมาร์ทโฟน

[ ] 7. มีทั้งหมดที่กล่าว [ ] 8. อื่นๆ.....(โปรดระบุ)

16. จากรายการอุปกรณ์อิเล็กโทรนิคข้างต้น ท่านใช้อุปกรณ์เหล่านั้นกี่ชิ้นก่อนเข้านอน

[ ] 1. 1 [ ] 2. 2 [ ] 3. 3 [ ] 4. มากกว่า 3

17. บ่อยครั้งแค่ไหนที่ท่านใช้อุปกรณ์อิเล็กโทรนิคก่อนนอน

[ ] 1. 1 ครั้ง/สัปดาห์ [ ] 2. 2-3 ครั้ง/สัปดาห์ [ ] 3. เกือบทุกวัน [ ] 4. ทุกวัน

18. ท่าน**เริ่มใช้**งานอุปกรณ์อิเล็กโทรนิคดังกล่าวกี่โมงในเวลากลางคืน.....

19. ท่าน**หยุด**การ**ใช้**งานอุปกรณ์อิเล็กโทรนิคดังกล่าวกี่โมงในเวลากลางคืน.....

20. โดยปกติอุปกรณ์อิเล็กโทรนิคชนิดใดที่ท่านใช้ก่อนเข้านอน (ตอบได้**มากกว่า 1 ข้อ**)

[ ] 1. โทรทัศน์ [ ] 2. คอมพิวเตอร์/โน้ตบุ๊ค [ ] 3. เครื่องเล่นเพลง [ ] 4. เกมส์

[ ] 5. แท็บเล็ต [ ] 6. สมาร์ทโฟน [ ] 7. อื่นๆ.....(โปรดระบุ)

21. โดยปกติแล้วท่านใช้อุปกรณ์อิเล็กโทรนิคเหล่านี้ทำอะไรก่อนเข้านอน (ตอบได้มากกว่า 1 ข้อ)

[ ] 1. ดูข่าว, หนัง, สารคดี, ทีวี หรือ ซีรีย์ [ ] โทรทัศน์ [ ] แท็บเล็ต [ ] โทรศัพท์ [ ] โน้ตบุ๊ค/คอมพิวเตอร์

[ ] 2. ท่องอินเตอร์เน็ตหรืออ่าน [ ] โน้ตบุ๊ค/คอมพิวเตอร์ [ ] แท็บเล็ต [ ] โทรศัพท์ [ ] โทรทัศน์อินเตอร์เน็ต

[ ] 3. ท่องสังคมออนไลน์ (เฟสบุ๊ค,อินสตราแกรม)

[ ] โน้ตบุ๊ค/คอมพิวเตอร์ [ ] แท็บเล็ต [ ] โทรศัพท์ [ ] โทรทัศน์อินเตอร์เน็ต

[ ] 4. เล่นเกมส์ออนไลน์หรืออ๊อฟไลน์

[ ] โน้ตบุ๊ค/คอมพิวเตอร์ [ ] แท็บเล็ต [ ] โทรศัพท์ [ ] โทรทัศน์อินเตอร์เน็ต

[ ] 5. แชทหรือส่งข้อความ [ ] โน้ตบุ๊ค/คอมพิวเตอร์ [ ] แท็บเล็ต [ ] โทรศัพท์

[ ] 6. พูดคุยหรือโทรศัพท์ [ ] โน้ตบุ๊ค/คอมพิวเตอร์ [ ] แท็บเล็ต [ ] โทรศัพท์

[ ] 7. อื่นๆ..... (โปรดระบุ)

22. โดยปกติแล้วท่านเปิดอุปกรณ์อิเล็กโทรนิคขณะท่านหลับหรือไม่

[ ] 1. ไม่เปิด [ ] 2. เปิด ( ) โทรทัศน์ ( ) เครื่องเล่นเพลง ( ) โทรศัพท์ ( ) แท็บเล็ต

หากท่านเปิดอุปกรณ์อิเล็กโทรนิคดังกล่าว รบกวนท่านขณะท่านหลับหรือไม่

[ ] 1. รบกวน [ ] 2. ไม่รบกวน

4.2) แบบประเมินคุณภาพการนอนหลับ (PSQI) จาก Buysse et al., 1989: Sitasuwan et al., 2014

คำแนะนำในการตอบแบบสอบถาม: คำถามต่อไปนี้เกี่ยวข้องกับพฤติกรรมการนอนของท่านในช่วงระยะเวลา 1 เดือนที่ผ่านมา คำตอบของท่านควรบ่งบอกสิ่งที่ใกล้เคียงความเป็นจริงมากที่สุดและเป็นสิ่งที่เกิดขึ้นกับตัวท่านเป็นส่วนใหญ่ทั้งในเวลากลางวันและ กลางคืน โปรดตอบทุกคำถามในช่วงระยะเวลา 1 เดือนที่ผ่านมา,

1. ส่วนใหญ่ท่านมักเข้านอนกี่โมง.....24 ชั่วโมง)

2. ส่วนใหญ่ท่านต้องใช้เวลานานเท่าไร (นาที) จึงจะนอนหลับ .....

3. ส่วนใหญ่ท่านตื่นนอนตอนเช้ากี่โมง .....

4. ท่านนอนหลับได้จริงเป็นเวลากี่ชั่วโมงต่อคืน(คำตอบอาจแตกต่างจากระยะเวลารวมทั้งหมดตั้งแต่เริ่มเข้านอนจนถึงตื่นนอน) .....

	ไม่เคยเลยใน ช่วงระยะเวลา 1 เดือนที่ผ่านมา	น้อยกว่า 1 ครั้ง/ สัปดาห์	1-2 ครั้ง/ สัปดาห์	3 ครั้ง/สัปดาห์ ขึ้นไป
5.ในช่วงระยะเวลา 1 เดือนที่ผ่านมาท่านมีปัญหาการนอนหลับเนื่องจากเหตุผลดังต่อไปนี้บ่อยเพียงใด....				
ก) นอนไม่หลับหลังจากเข้านอนไปแล้วกว่า 30 นาที	0	1	2	3
ข) รู้สึกตัวตื่นขึ้นระหว่างนอนหลับกลางดึก หรือ ตื่นเช้ากว่าเวลาที่ตั้งใจไว้	0	1	2	3
ค) ตื่นไปเพื่อเข้าห้องน้ำ	0	1	2	3
ง) หายใจไม่สะดวก	0	1	2	3
จ) ไอ หรือ กรนเสียงดัง	0	1	2	3
	ไม่เคยเลยใน ช่วงระยะเวลา 1 เดือนที่ผ่านมา	น้อยกว่า 1 ครั้ง/ สัปดาห์	1-2 ครั้ง/ สัปดาห์	3 ครั้ง/สัปดาห์ ขึ้นไป
ฉ) รู้สึกหนาวเกินไป	0	1	2	3
ช) รู้สึกร้อนเกินไป	0	1	2	3
ช) ฝันร้าย	0	1	2	3
ฌ) รู้สึกปวด (ตัวอย่าง ปวดตัว, ปวดคอ, ปวดหลัง, อื่นๆ)	0	1	2	3
ญ) เหตุผลอื่น ถ้ามีกรุณาระบุ..... รวมทั้งบ่อยครั้งแค่ไหนที่ท่านมีปัญหาการนอนหลับเนื่องจากเหตุผลนี้	0	1	2	3
6. ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านใช้ยาเพื่อช่วยในการนอนหลับบ่อยเพียงใด (ไม่ว่าตามใบสั่งแพทย์ หรือหาซื้อเอง)	ไม่เคยเลยใน 1 เดือนที่ผ่านมา 0	น้อยกว่า 1 ครั้ง/ สัปดาห์ 1	1-2 ครั้ง/ สัปดาห์ 2	3 ครั้ง/ สัปดาห์ขึ้น ไป 3

7. ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านมีปัญหาเกี่ยวกับความกระตือรือร้นในการทำงานให้สำเร็จมากน้อยเพียงใด	ไม่มีปัญหาเลย 0	มีปัญหาเพียงเล็กน้อย 1	ค่อนข้างที่จะเป็นปัญหา 2	เป็นปัญหาอย่างมาก 3
8. ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านมีปัญหาง่วงนอน หรือเผลอหลับ ขณะขับขี่ยานพาหนะ, ขณะรับประทาน หรือขณะเข้าร่วมกิจกรรมทางสังคมต่างๆ บ่อยเพียงใด	ไม่เคยเลยใน 1 เดือนที่ผ่านมา 0	น้อยกว่า 1 ครั้ง/สัปดาห์ 1	1-2 ครั้ง/สัปดาห์ 2	3 ครั้ง/สัปดาห์ขึ้นไป 3
9. ในช่วงระยะเวลา 1 เดือนที่ผ่านมาท่านคิดว่าคุณภาพการนอนหลับโดยรวมของท่านเป็นอย่างไร	ดีมาก 0	ค่อนข้างดี 1	ค่อนข้างแย่ 2	แย่มาก 3

10. ท่านมีคู่นอน, เพื่อนร่วมห้องหรือผู้อาศัยอยู่ในบ้านหลังเดียวกันหรือไม่

[ ] ไม่มีเลย [ ] มี แต่นอนคนละห้อง

[ ] มี และนอนในห้องเดียวกัน แต่คนละเตียง [ ] มี และนอนเตียงเดียวกัน

หากท่านตอบว่ามี กรุณาสอบถามจากบุคคลข้างต้นว่า ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านได้เคยมีอาการดังนี้หรือไม่

	ไม่เคยเลยในช่วงระยะเวลา 1 เดือนที่ผ่านมา	น้อยกว่า 1 ครั้ง/สัปดาห์	1-2 ครั้ง/สัปดาห์	3 ครั้ง/สัปดาห์ขึ้นไป
10.1) กรนเสียงดัง	0	1	2	3
10.2) มีช่วงหยุดหายใจเป็นระยะเวลานานขณะหลับ	0	1	2	3
10.3) ขาเกร็งหรือกระตุกขณะหลับ	0	1	2	3

4.3) แบบทดสอบระดับความง่วงนอน เอ็บเวิร์ธ (ESS) จาก John, 1991: Banhiran et al., 2010

คำแนะนำในการทำแบบสอบถาม: ให้ลองนึกว่าสถานการณ์ข้างล่างนี้ จะมีผลต่อคุณอย่างไร กรุณาใช้เกณฑ์ การให้คะแนนข้างล่าง เพื่อเลือกคะแนนที่เหมาะสมที่สุดสำหรับแต่ละสถานการณ์

0 หมายถึง ไม่มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ

1 หมายถึง มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ เล็กน้อย (นานๆครั้ง)

2 หมายถึง มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ ปานกลาง

3 หมายถึง มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ สูง (เป็นประจำ)

สถานการณ์	ความเป็นไปได้ที่จะง่วงจนงีบหรือเผลอหลับ
1. ขณะกำลังนั่งและอ่านหนังสือ	.....
2. ขณะกำลังดูโทรทัศน์	.....
3. ขณะกำลังนั่งเฉยๆในที่สาธารณะ เช่น ในโรงภาพยนตร์ หรือที่ประชุมสัมมนา	.....
4. ขณะกำลังนั่งเป็นผู้โดยสารในรถนานกว่า 1 ชั่วโมงอย่างต่อเนื่อง	.....
5. ขณะกำลังนอนเอนหลังเพื่อพักผ่อนในตอนบ่ายถ้ามีโอกาส	.....
6. ขณะกำลังนั่งและพูดคุยกับผู้อื่น	.....
7. ขณะกำลังนั่งเงียบๆหลังอาหารกลางวันโดยที่ไม่ได้ดื่มแอลกอฮอล์	.....
8. ขณะกำลังขับรถแต่หยุดรถเพื่อรอสัญญาณจราจร นาน 2-3 นาที	.....

4.4) แบบทดสอบประเภทเวลาของนาฬิกาชีวิต (วงจรเซอร์คาเดียน) (CSM) จาก Smith et al., 1989

1. หากท่านเลือกเวลาตื่นได้อย่างอิสระ ท่านจะเลือกตื่นช่วงเวลาที่ทำให้ท่านรู้สึกดีที่สุด

[5] ก่อน 06.30 น. [4] 06.30 - 07.45 น. [3] 07.45 - 09.45 น.

[2] 09.45 - 11.00 น. [1] หลัง 11.00 น.

2. หากท่านเลือกเวลาเข้านอนได้อย่างอิสระ ท่านจะเลือกเข้านอนช่วงเวลาที่ทำให้ท่านรู้สึกดีที่สุด

[5] ก่อน 21.00 น. [4] 21.00 - 22.15 น. [3] 22.15 - 00.30 น.

[2] 00.30 - 01.45 น. [1] หลัง 01.45 น.

3. ท่านคิดว่าการตื่นเช้าง่ายเพียงใดสำหรับท่าน

[1] ไม่ง่ายเลย [2] ค่อนข้างง่าย [3] ง่ายพอสมควร [4] ง่ายมาก

4. ภายในเวลาครึ่งชั่วโมงหลังตื่นนอนตอนเช้า ท่านรู้สึกกระปรี้กระเปร่าเพียงใด

[1] ไม่กระปรี้กระเปร่าเลย [2] ค่อนข้างกระปรี้กระเปร่า

[3] กระปรี้กระเปร่าพอสมควร [4] กระปรี้กระเปร่ามาก

5. ภายในเวลาครึ่งชั่วโมงหลังตื่นนอนตอนเช้า ท่านรู้สึกอ่อนเพลียเพียงใด

[1] อ่อนเพลียมาก [2] อ่อนเพลียพอสมควร [3] สดชื่นพอสมควร [4] สดชื่นมาก

6. หากเพื่อนของท่านแนะนำให้ท่านออกกำลังกายสัปดาห์ละ 2 ครั้ง โดยครั้งละ 1 ชั่วโมง ช่วงเวลา 07.00 - 08.00 น. ท่านจะทำได้ดีเพียงใดในช่วงเวลาดังกล่าว

[4] ทำได้ดี [3] ทำได้ดีพอสมควร [2] ยากที่จะทำ [1] ยากมากที่จะทำ

7. เวลาใดตอนกลางคืนที่ท่านรู้สึกอ่อนล้าและต้องการนอน

[5] ก่อน 21.00 น. [4] 21.00 - 22.15 น. [3] 22.15 - 00.30 น.

[2] 00.30 - 01.45 น. [1] หลัง 01.45 น.

8. หากท่านต้องทำงานซึ่งใช้สมองเป็นอย่างมากเป็นเวลา 2 ชั่วโมง ช่วงเวลาใดที่ท่านคิดว่าท่านสามารถทำงานได้เป็นอย่างดี

[4] 08.00 - 10.00 น. [3] 11.00 - 13.00 น. [2] 15.00 - 17.00 น. [1] 19.00 - 21.00 น.

9. ท่านคิดว่าท่านเป็นบุคคลประเภทใด ระหว่าง (1) ตื่นเช้าและเข้านอนเร็ว หรือ (2) ตื่นสายและนอนดึก

[4] เป็นประเภทแรกแน่ๆ [3] เป็นประเภทแรกมากกว่าประเภทหลัง

[2] เป็นประเภทหลังมากกว่าประเภทแรก [1] เป็นประเภทหลังแน่ๆ

10. หากท่านต้องทำงานวันละ 8 ชั่วโมง โดยท่านสามารถเลือกเวลาตื่นเวลาได้อย่างอิสระท่านจะเลือกตื่นเวลาใด

[4] ก่อน 06.30 น. [3] 06.30 - 07.30 น. [2] 07.30 - 08.30 น. [1] หลัง 08.30 น.

11. ท่านรู้สึกอย่างไร หากท่านต้องตื่นนอน 6 โมงเช้าเป็นประจำ

[1] ยากมากและเป็นทุกข์ [2] ค่อนข้างยากและเป็นทุกข์

[3] เป็นทุกข์เล็กน้อยแต่ไม่มีปัญหาอะไรมาก [4] ง่ายและไม่เป็นทุกข์

12. ท่านใช้เวลานานเท่าใดกว่าจะรู้สึกตื่นเต็มที่หลังจากตื่นนอนในตอนเช้า

[4] 0-10นาที [3] 11-20นาที [2] 21-40นาที [1] มากกว่า 40 นาที

13. ท่านรู้สึกกระฉับกระเฉงตอนเช้า หรือกลางคืน

[4] กระฉับกระเฉงในตอนเช้าอย่างเด่นชัด (ตื่นตัวในตอนเช้าและอ่อนเพลียในตอนเย็น)

[3] ค่อนไปทางกระฉับกระเฉงในตอนเช้า

[2] ค่อนไปทางกระฉับกระเฉงในตอนกลางคืน

[1] กระฉับกระเฉงในตอนกลางคืนอย่างเด่นชัด (อ่อนเพลียในตอนเช้าและตื่นตัวในตอนเย็น)

APPENDIX D

Questionnaire (Thai)

Dry season

1) แบบสอบถามเกี่ยวกับการรับการรักษาจากภาวะการหยุดหายใจขณะนอนหลับ

1.1 ท่านได้รับการรักษาจากภาวะการหยุดหายใจขณะนอนหลับหรือไม่

( ) ไม่ ( ) ใช่ แบบใด ( ) 1. ปรับเปลี่ยนพฤติกรรมเสี่ยง (อาทิเช่น การลดน้ำหนัก, เลี่ยงเครื่องดื่มแอลกอฮอล์ก่อนนอน)

( ) 2. ใช้เครื่องช่วยสร้างแรงดันบวกในทางเดินหายใจ CPAP

( ) 3. การใช้อุปกรณ์ทางทันตกรรม หรือ ช่องปาก

( ) 4. การผ่าตัด

2) แบบสอบถามเกี่ยวกับสภาพแวดล้อมในห้องนอน

2.1 ภายใน 3 เดือนที่ผ่านมา ท่านได้ทำการปรับเปลี่ยนสภาพแวดล้อมในห้องนอนบ้างหรือไม่ (อาทิเช่น เปลี่ยนสีไฟภายในห้องนอน, ผ้าม่าน,อื่นๆ)

( ) ไม่ ( ) ใช่ คือ.....

3) แบบประเมินคุณภาพการนอนหลับ (PSQI) จาก Buysse et al., 1989: Sitasuwan et al., 2014

คำแนะนำในการตอบแบบสอบถาม: คำถามต่อไปนี้เกี่ยวข้องกับพฤติกรรมการนอนของท่านในช่วงระยะเวลา 1 เดือนที่ผ่านมา คำตอบของท่านควรบ่งบอกสิ่งที่ใกล้เคียงความเป็นจริงมากที่สุดและเป็นสิ่งที่เกิดขึ้นกับตัวท่านเป็นส่วนใหญ่ทั้งในเวลากลางวันและ กลางคืน โปรดตอบทุกคำถาม ในช่วงระยะเวลา 1 เดือนที่ผ่านมา,

1. ส่วนใหญ่ท่านมักเข้านอนกี่โมง.....24 ชั่วโมง)

2. ส่วนใหญ่ท่านต้องใช้เวลานานเท่าไร (นาที) จึงจะนอนหลับ .....

3. ส่วนใหญ่ท่านตื่นนอนตอนเช้ากี่โมง .....

4. ท่านนอนหลับได้จริงเป็นเวลากี่ชั่วโมงต่อคืน(คำตอบอาจแตกต่างจากระยะเวลารวมทั้งหมดตั้งแต่เริ่มเข้านอนจนถึงตื่นนอน) .....

	ไม่เคยเลยใน ช่วงระยะเวลา 1 เดือนที่ผ่านมา	น้อยกว่า 1 ครั้ง/ สัปดาห์	1-2 ครั้ง/ สัปดาห์	3 ครั้ง/สัปดาห์ ขึ้นไป
5.ในช่วงระยะเวลา 1 เดือนที่ผ่านมาท่านมีปัญหาการนอนหลับเนื่องจากเหตุผลดังต่อไปนี้บ่อยเพียงใด....				
ก) นอนไม่หลับหลังจากเข้านอนไปแล้วกว่า 30 นาที	0	1	2	3
ข) รู้สึกตัวตื่นขึ้นระหว่างนอนหลับกลางดึก หรือ ตื่นเช้ากว่าเวลาที่ตั้งใจไว้	0	1	2	3
ค) ตื่นไปเพื่อเข้าห้องน้ำ	0	1	2	3
ง) หายใจไม่สะดวก	0	1	2	3
จ) ไอ หรือ กรนเสียงดัง	0	1	2	3
	ไม่เคยเลยใน ช่วงระยะเวลา 1 เดือนที่ผ่านมา	น้อยกว่า 1 ครั้ง/ สัปดาห์	1-2 ครั้ง/ สัปดาห์	3 ครั้ง/สัปดาห์ ขึ้นไป
ฉ) รู้สึกหนาวเกินไป	0	1	2	3
ช) รู้สึกร้อนเกินไป	0	1	2	3
ซ) ฝันร้าย	0	1	2	3
ฌ) รู้สึกปวด (ตัวอย่าง ปวดตัว, ปวดคอ, ปวดหลัง, อื่นๆ)	0	1	2	3
ญ) เหตุผลอื่น ถ้ามีกรุณาระบุ..... รวมทั้งบ่อยครั้งแค่ไหนที่ท่านมีปัญหาการนอนหลับเนื่องจากเหตุผลนี้	0	1	2	3
6. ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านใช้ยาเพื่อช่วยในการนอนหลับบ่อยเพียงใด (ไม่ว่าตามใบสั่งแพทย์ หรือหาซื้อเอง)	ไม่เคยเลยใน 1 เดือนที่ผ่านมา 0	น้อยกว่า 1 ครั้ง/ สัปดาห์ 1	1-2 ครั้ง/ สัปดาห์ 2	3 ครั้ง/ สัปดาห์ขึ้น ไป 3
7. ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านมีปัญหาเกี่ยวกับความกระตือรือร้นในการทำงานให้สำเร็จมากน้อยเพียงใด	ไม่มีปัญหาเลย 0	มีปัญหาเพียงเล็กน้อย 1	ค่อนข้างที่จะเป็นปัญหา 2	เป็นปัญหาอย่างมาก 3
8. ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านมีปัญหาง่วงนอน หรือเผลอหลับ ขณะขับขี่ยานพาหนะ, ขณะรับประทาน หรือขณะเข้าร่วมกิจกรรมทางสังคมต่างๆ บ่อยเพียงใด	ไม่เคยเลยใน 1 เดือนที่ผ่านมา 0	น้อยกว่า 1 ครั้ง/สัปดาห์ 1	1-2 ครั้ง/ สัปดาห์ 2	3 ครั้ง/ สัปดาห์ขึ้นไป 3
9. ในช่วงระยะเวลา 1 เดือนที่ผ่านมาท่านคิดว่าคุณภาพการนอนหลับโดยรวมของท่านเป็นอย่างไร	ดีมาก 0	ค่อนข้างดี 1	ค่อนข้างแย่ 2	แย่มาก 3

10. ท่านมีคู่นอน, เพื่อนร่วมห้องหรือผู้อาศัยอยู่ในบ้านหลังเดียวกันหรือไม่

[ ] ไม่มีเลย [ ] มี แต่นอนคนละห้อง

[ ] มี และนอนในห้องเดียวกัน แต่คนละเตียง [ ] มี และนอนเตียงเดียวกัน

หากท่านตอบว่ามี กรุณาสอบถามจากบุคคลข้างต้นว่า ในช่วงระยะเวลา 1 เดือนที่ผ่านมา ท่านได้เคยมีอาการดังนี้หรือไม่

	ไม่เคยเลยในช่วงระยะเวลา 1 เดือนที่ผ่านมา	น้อยกว่า 1 ครั้ง/สัปดาห์	1-2 ครั้ง/สัปดาห์	3 ครั้ง/สัปดาห์ขึ้นไป
10.1) กรนเสียงดัง	0	1	2	3
10.2) มีช่วงหยุดหายใจเป็นระยะเวลานานขณะหลับ	0	1	2	3
10.3) ขาเกร็งหรือกระตุกขณะหลับ	0	1	2	3

4) แบบทดสอบระดับความง่วงนอน เอ็บเวิร์ธ (ESS) จาก John, 1991: Banhiran et al., 2010

คำแนะนำในการทำแบบสอบถาม: ให้ลองนึกว่าสถานการณ์ข้างล่างนี้ จะมีผลต่อคุณอย่างไร กรุณาใช้เกณฑ์ การให้คะแนนข้างล่างเพื่อเลือกคะแนนที่เหมาะสมที่สุดสำหรับแต่ละสถานการณ์

0 หมายถึง ไม่มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ

1 หมายถึง มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ เล็กน้อย (นานๆครั้ง)

2 หมายถึง มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ ปานกลาง

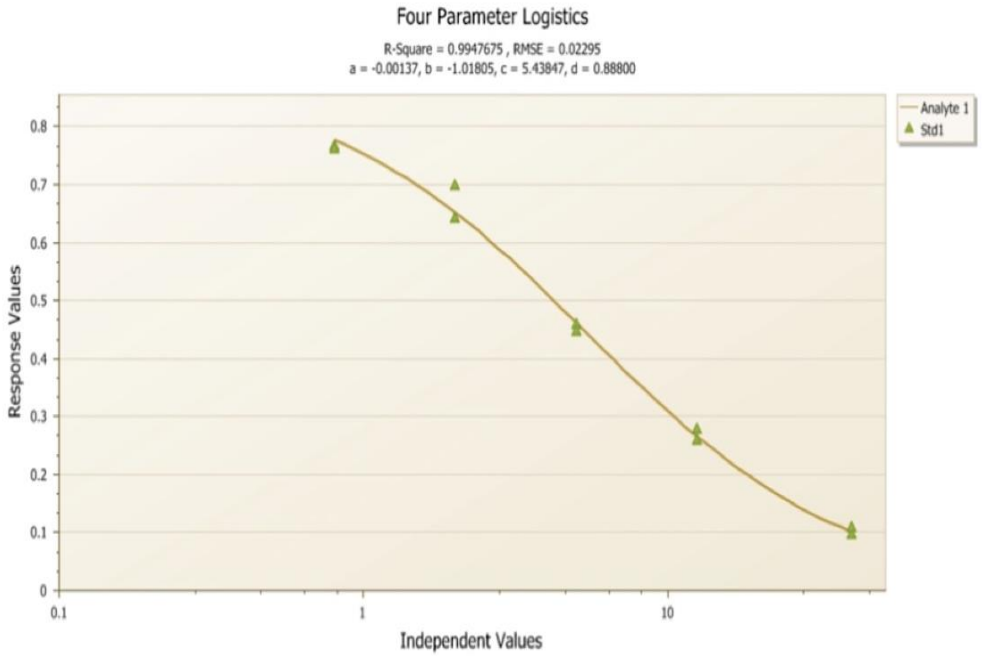
3 หมายถึง มีความเป็นไปได้ที่จะงีบหรือเผลอหลับ สูง (เป็นประจำ)

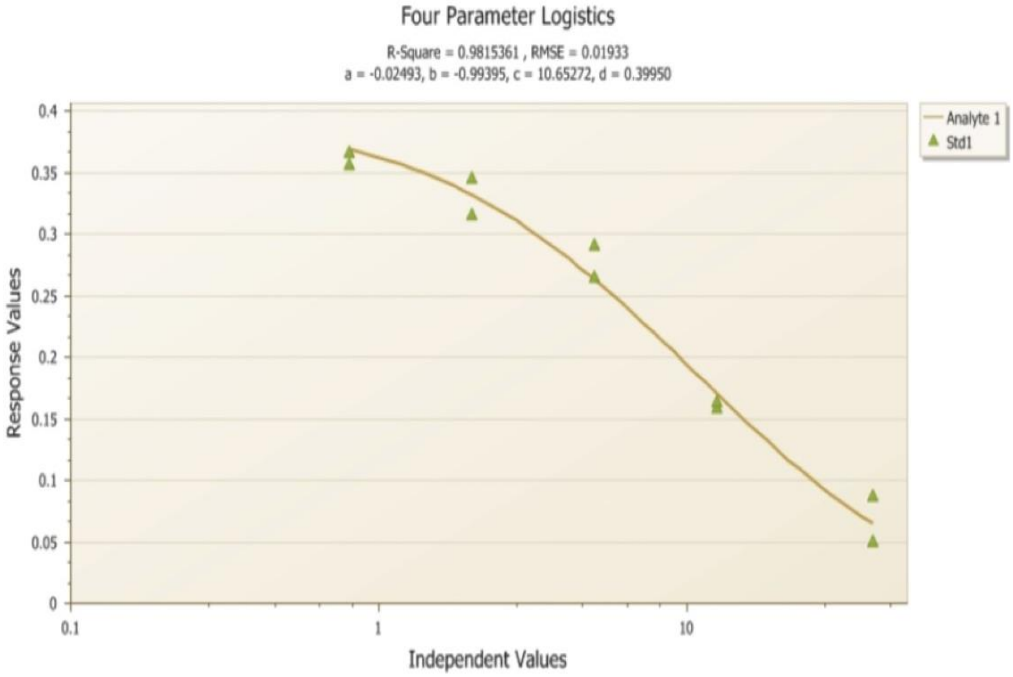
สถานการณ์	ความเป็นไปได้ที่จะง่วงจนงีบหรือเผลอหลับ
1. ขณะกำลังนั่งและอ่านหนังสือ	.....
2. ขณะกำลังดูโทรทัศน์	.....
3. ขณะกำลังนั่งเฉยๆในที่สาธารณะ เช่น ในโรงภาพยนตร์หรือที่ประชุมสัมมนา	.....
4. ขณะกำลังนั่งเป็นผู้โดยสารในรถนานกว่า 1 ชั่วโมงอย่างต่อเนื่อง	.....
5. ขณะกำลังนอนเอนหลังเพื่อพักผ่อนในตอนบ่ายถ้ามีโอกาส	.....
6. ขณะกำลังนั่งและพูดคุยกับผู้อื่น	.....
7. ขณะกำลังนั่งเงียบๆหลังอาหารกลางวันโดยที่ไม่ได้ดื่มแอลกอฮอล์	.....
8. ขณะกำลังขับรถแต่หยุดรถเพื่อรอสัญญาณจราจร นาน 2-3 นาที	.....

APPENDIX E

Calibration curve and laboratory analysis

Urinary melatonin calibration curve





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