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# Modeling The Qualitative Sub-Domains of Sleep Health: A Theoretical Framework for Student Health-Related Quality of Life

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**Abstract:** This paper establishes an integrative theoretical model examining the direct mechanisms connecting sleep latency and structural sleep disturbances (both somatic and micro-environmental) to university students' Health-Related Quality of Life (HRQoL). By moving beyond traditional, unidimensional volumetric sleep metrics (such as total sleep duration), this framework bridges Sleep Hygiene Theory and the Cognitive-Behavioral Model of Insomnia to capture qualitative sleep architecture. This study aims to integrate established methods of sleep assessment (Pittsburgh Sleep Quality Index [PSQI] and health indices EuroQol [EQ-5D]) and to develop a framework of new qualitative and quantitative methods to assess the negative impact of poor sleep on the functioning and productivity of individuals. To achieve the framework's immediate relevance, functional tactical innovations were modelled based on a thorough analysis of the latest literature in the field of behavioural medicine and public health for the years 2024-2026. The main goal of the last conceptual model is to provide immediate, data-supported, and feasible recommendations to inform wellness-related policies in higher education. Institutional policies should align academic timetabling with biological circadian rhythms by capping mandatory 8:00 AM lectures for high-workload programs, allowing adequate sleep recovery windows. Furthermore, student counselling services should integrate brief PSQI-based sleep latency and disturbance screeners into standard wellness intake assessments, identifying sleep-deprived individuals early for non-pharmacological Cognitive Behavioural Therapy for Insomnia (CBT-I) workshops.

**Keywords**: *Sleep Latency, Sleep Disturbance, Health-Related Quality of Life (HRQoL), Conceptual Framework, Theoretical Scaffolding, Higher Education Policy.*

## 1. Introduction and Background

Sleep is important for physical and mental recovery. It also helps maintain a balance in the nervous system. For students, sleep is also important for how well they are able to study, how well they are able to make choices, and how productive they are able to be. Research results show that persistent sleep problems for students are in the range of 10% to 50% of the population (Dinis & Bragança, 2019). Sleep is a big concern for students, and recent research shows disruptive sleep is due to the new freedoms and new problems that are part of the on-campus experience. It is all a disruption to circadian rhythms. Sleeping well and being healthy are connected, and sleep reflects both (CDC, 2022). Historically, public health frameworks evaluated sleep health almost exclusively through volumetric parameters such as total sleep time (TST). However, empirical evidence demonstrates that sleep duration alone fails to capture functional daytime impairments. Modern behavioral medicine prioritizes qualitative sleep architecture—specifically quantifying sleep onset latency and neuro-somatic disruption frequencies—as these qualitative sub-domains directly dictate slow-wave restorative processes and subsequent Health-Related Quality of Life (HRQoL). These structural sleep parameters help create focused health system pathways within the academic environment.

### Problem Statement

Of all the factors contributing to optimal physical, mental, and social functioning, sleep quality ranks high. For all age groups, worse sleep quality has been linked to all stages of several cardiometabolic disorders. In higher education, quality sleep becomes an even greater priority because chronic sleep deprivation adversely affects working memory, alertness, concentration, and social skills.

Reduced quality and quantity of sleep has been the subject of much research in the wake of the global health crisis it has precipitated. Chronic sleep deprivation is now considered a social norm amongst university students. The health of students is often disregarded for the sake of the institution's short-term benefit. This is commonly referred to as "student syndrome," where students poorly manage their time during the semester

and consequently leave themselves with a deadline constraining the time available to complete an academic task. This severely increases stress, worsens the quality of sleep, and increases sleep latency and sleep inconsistency.

Research into sleep as a public health concern has found that sleep deprivation has a negative impact on the ability to function during the daytime. Quality sleep must include the ability to complete several cycles without interruption of deep sleep and REM sleep. Lack of quality sleep has many psychosocial ramifications including pain in the muscles and skeleton during rest.

Some previous research has attributed poor sleep management to acute functional impairment. However, university health administrators have been presented with a different sort of challenge. At this point, almost no research has been done to identify which sleep parameters (i.e., sleep length, sleep onset latency/initiatives, sleep disturbance, etc.) are correlated with any aspects of Health-Related Quality of Life (HRQoL). Hypothesis testing will be conducted using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS. PLS-SEM is particularly appropriate for this study given its suitability for complex theoretical models with multi-item latent constructs and exploratory structural paths. The evaluation will proceed in two stages: assessing the measurement model (internal consistency reliability, convergent validity via AVE, and discriminant validity via HTMT criteria) followed by structural model estimation (β path coefficients, $R^2$ values, effect size $f^2$, and predictive relevance $Q^2$).

Bedtime procrastination, frequently driven by academic overburdening and poor time-management behaviors, serves as a primary behavioural catalyst for sleep onset latency (Foulkes et al., 2019). Rather than functioning merely as an acute scheduling delay, this self-regulatory failure initiates a state of prolonged pre-sleep overthinking and acute psychological distress. Over time, this acute state transitions into a chronic stress pattern, impairing autonomic nervous system regulation and locking students into persistent sleep deprivation cycles.

Probably the most significant hindrance to most systems of health for students is the historic and overwhelming domination of sleep as a self-contained measure of an individual's level of baseline wellness. By focusing predominantly or exclusively on total sleep hours, health systems for students fail to recognize the more insidious aspects of sleep disturbances, such as prolonged sleep onset cues and persistent macro- somatic rest and sleep disturbances. The combination of all these factors creates a three-dimensional theoretical challenge.

**The Dynamics of Sleep Latency and Bedtime Cognitive Hyperarousal**

The bedtime procrastination of some students leads to insurmountable physiological problems in shifting from an aware active daytime state to a restful nighttime state. The confluence of academic stressors, bedtime rumination, and screen-induced high-energy visible (HEV) light exposure triggers neurobiological hyperarousal. This state activates the hypothalamic-pituitary-adrenal (HPA) axis, elevating circulating cortisol and adrenaline while delaying melatonin onset. Consequently, the physiological shift from sympathetic dominance to parasympathetic restoration is disrupted, expanding Sleep Onset Latency (SOL) and deteriorating daytime cognitive functioning. The Sleep Onset Latency (SOL) is regularly and clinically set at a maximum of 30 minutes. Anything more has a negative impact on concentration, the ability to consolidate memory, and emotional stability. The erosion of these essential components contributes to a reduction in the HRQoL of students.

**The Dynamics of Sleep Disturbance and Structural Sleep Stage Fragmentation**

Students face a double whammy when it comes to the challenges of getting a good night's sleep. Not only do they face initiation barriers, but their sleep is still interrupted by a variety of physical and environmental challenges (e.g., their dorms). Sleep is frequently interrupted by a variety of disturbances (e.g., midnight wake-ups, breathing difficulties, coughing, unsettling dreams, and other muscle spasms). It becomes very difficult to achieve an optimum amount of Stage N3 Sleep (Slow Wave Sleep) and REM Sleep. Stage N3 Sleep is the sleep stage where the body undergoes its greatest restorative process, detoxifying the brain and cellular repair. If we are not able to reach that state of sleep consistently, we not only feel tired, but we also have weakened immune systems and deteriorating memory. Additionally, if dorm rooms cause drastic temperature changes,

going from too hot to too cold, sleep will be disturbed even further. This also causes our bodies to react in ways that increase heart rate and cause sleep stress. It is no secret that this stress and disturbed sleep get harder to cope with and negatively affect our quality of life.

**The Deficiency of Evidence-Based Institutional Alignment**

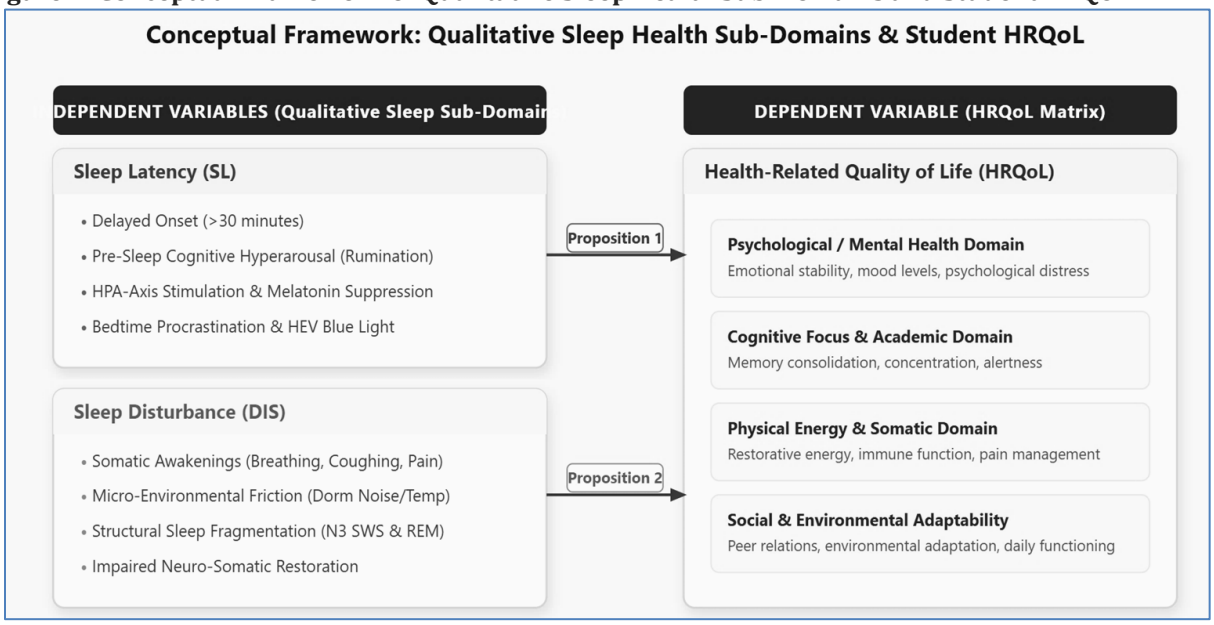
Measuring and analysing the Effects of Sleep Latency and Sleep Disturbance separately from the influences of Sleep Duration remain virtually impossible. In the absence of a clear framework, university administrators, the medical team, and even campus counselling services are compelled to undertake broad, non-evidence-based, in the best case scenario, less harmful practices, e.g., the improvement of soundproofing in students' halls. This is, however, only helpful if Sleep Disturbance is the result of outside noise. If the students are the cause of their own Sleep Latency because of extreme pre-bed annoying behaviours, including the use of digital gadgets (which are also a significant cause of AI stress and cognitive overload), then the new practices will not be helpful.

A significant theoretical gap persists regarding how specific qualitative sub-domains of sleep independently drive multidimensional HRQoL outcomes in undergraduate populations. By establishing a dual-axis framework—differentiating pre-sleep cognitive hyperarousal (latency) from neuro-somatic fragmentation (disturbance)—this model provides the theoretical scaffolding required to design evidence-based, non-pharmacological wellness interventions within higher education institutions. In this case, we hope to develop that theoretical model that allows us to deliver on our moral obligation to our students.

**Proposed Conceptual Architecture & Propositions**

The main purpose of the independent conceptual pipeline is to illustrate the direct links between sleep architecture and quality of life by employing a multi-disciplinary approach.

**Figure 1: Conceptual Framework of Qualitative Sleep Health Sub-Domains and Student HRQoL**




The proposed conceptual framework models Sleep Latency (SL), driven by bedtime cognitive hyperarousal and melatonin suppression, as well as Sleep Disturbance (DIS), driven by somatic discomfort and micro-environmental dormitory friction, as primary qualitative predictors of multidimensional Health-Related Quality of Life (HRQoL).

To direct future empirical validation and structural verification, two core theoretical propositions are advanced

**Proposition 1**
Sleep Latency resulting from pre-sleep cognitive hyperarousal, behavioural inhibition, and melatonin suppression negatively impacts cognitive focus and psychological satisfaction within the HRQoL framework.

**Proposition 2**
Structural sleep disturbances arising from somatic discomfort and micro-environmental friction inhibit sleep stage continuity, directly eroding physical energy, somatic recovery, and social adaptability within the HRQoL framework.

## 2. Proposed Methodology & Instrumentation Strategy

To empirically test this conceptual framework, a quantitative cross-sectional survey design will be employed (Wang & Cheng, 2020). The target population comprises full-time undergraduate business management students at Universiti Teknologi MARA (UiTM) Puncak Alam. Using Krejcie and Morgan's (1970) sample size determination matrix for a finite population, a minimum sample size of N = 196 will be recruited using a stratified random sampling technique to ensure proportional representation across different academic years and living arrangements (on-campus dormitories vs. off-campus housing).

Data will be collected using a structured, self-administered questionnaire divided into three distinct sections. All measurement items will be adapted from validated psychometric tools and evaluated on a standardized 5-point Likert scale ranging from 1 ('Strongly Disagree' / 'Never') to 5 ('Strongly Agree' / 'Always') to ensure measurement uniformity and simplify respondent processing.

Sleep Latency (Construct A) and Sleep Disturbance (Construct B) will be measured using 8-item sub-scales adapted from the Pittsburgh Sleep Quality Index (PSQI) sub-domain framework established by Shahid et al. (2011). To adapt these items from clinical diagnostic indicators into a student-facing survey, standard open-ended time entries (e.g., minutes taken to fall asleep) were converted into 5-point frequency items focusing on pre-sleep overthinking, delayed onset (>30 minutes), somatic pain, and micro-environmental temperature fluctuations.

Health-Related Quality of Life (Construct C) will be evaluated via an 18-item multidimensional matrix adapted from Jankovic et al. (2021), assessing physical energy, psychological state, peer relationships, and academic adaptability. Before full deployment, the complete instrument will undergo content validation by a panel of expert academic researchers and a pilot test (n = 30) to confirm item readability, face validity, and acceptable baseline reliability ($\alpha \geq .70$).

## 3. Theoretical Synthesis & Contemporary Literature Integration

To isolate the unique effect of sleep latency and sleep disturbance on HRQoL, potential confounding variables will be statistically controlled. The survey protocol will capture control metrics including daily caffeine consumption, self-reported diagnosis of clinical sleep disorders (e.g., obstructive sleep apnea), chronic medical conditions, and shift-work/part-time employment status. Respondents meeting clinical exclusion criteria will be filtered to maintain homogeneous non-clinical baseline parameters.

### Sleep as a Physiological Imperative

Sleep is an essential homeostatic process and one of the three essential biological needs alongside food and water, occupying about a third of our total life. Studies in the field of neurology identify sleep as a prerequisite for the development and maintenance of the neural pathways needed for the consolidation of memories and the process of learning. The detrimental effects of lack of sleep on concentration, mental alertness, and the speed of reactions are well known. Cognitive and psychological health deteriorate with the deprivation of sleep, and physical health is likely to follow.

### Dimensions of Sleep Quality and the Student Demographic

Subjective sleep quality refers to a person's perception of their sleep and how they experience the quality of their sleep. Sleeping well has a myriad of benefits. Daytime alertness, improved reflexes, and enhanced

interpersonal relations are a few. Poor sleep quality, on the other hand, is associated with chronic fatigue, poor and erratic productivity, impaired cognition, and unhealthy coping habits, such as increased caffeine intake or increased alcohol consumption. University is the most damaging to the quality of people's sleep; students are at the highest risk of all demographics for developing sleep disorders. Studies show that the mental health of 10 to 50% of the student population is negatively impacted due to poor sleep quality. There is a lot of stress and lifestyle changes that occur during the high school-to-university or high school-to-work gap. These changes are often deleterious to health and detract from academic performance.

**Conceptualizing Health-Related Quality of Life (HRQoL)**

Examining sleep in conjunction with existing health constructs can help to understand the implications of sleep deprivation more broadly. The World Health Organization (WHO) states that Quality of Life (QoL) is the way individuals assess their position in the world, considering their cultural contexts and value systems and their personal goals. Narrowing it down, Health-Related Quality of Life (HRQoL) concerns how individuals assess their mental and physical health at different times. HRQoL is a diverse construct that combines physical, psychological and social domains of well-being and is an essential construct for valuing health interventions directed at students.

**The Dynamic Interaction Between Sleep Volume, Academic Outcomes, and QoL**

It is clear that sleep impacts academic success in higher education. While some studies may report small effects, most studies agree that the quantity and especially the quality of sleep impact success in higher education, measured as a higher GPA and better learning engagement. In the National Sleep Foundation's study, adults 18-64 should receive 7 to 9 hours of sleep, while older adults should receive 7 to 8 hours of sleep. Sleep quantity and especially sleep quality impacts quality of life. Poor sleep quality also impacts daily functioning. Positive daytime experiences are a result of good quality sleep. Good quality sleep is associated with greater life satisfaction, better mental health, and reduced work stress and poor sleep quality is associated with reduced life satisfaction.

**Determinants of Sleep Interruption: Technology and Academic Pressure**

Current lifestyle habits pose significant challenges to the sleep hygiene of young adults. A major reason for disrupted sleep is the widespread habit of going to sleep with electronic devices. This habit reduces total sleep hours and disrupts the circadian cycle. Using mobile devices within 30 minutes of going to sleep increases the risk of serious sleep disruptions. Personal habits are not the only reason for disrupted sleep. There are also sleep-inhibiting factors that result from the pressure of classroom instruction and academic demands on most young adults. The long-term effects of stressful events, such as the COVID-19 pandemic, show that stressful academic years can deteriorate to the level of clinical anxiety and psychological distress. Insufficient and non-restorative sleep elevates the negative effects on young adults which manifests as sleep-related deficits in the ability to focus, concentrate, and endure any sustained mental effort and work during their daytime scholarly activities.

**Sleep Latency: The Tri-Axis Mechanics of Cognitive Hyperarousal and Melatonin Suppression**

Behavioral architecture has recently examined sleep problems and discovered that long sleep onset latency (SOL) is more than just a neurobiological problem that alters sleep. It can be broken down into three components: Sleep Time Displacement, Melatonin Suppression due to High-Energy Visible (HEV) Blue Light, and Pre-Sleep Cognitive Hyperarousal. The Pre-Sleep Cognitive Hyperarousal factor is the most relevant in higher education, as the leading contributor to this factor is students' excessive use of their smartphones to view social media (or other forms of digital) content right before going to sleep (Zhang et al., 2025). Beyond basic behavioural procrastination, the prolonged initiation phase in student populations can be understood through the lens of Harvey's (2002) Cognitive Model of Insomnia. Pre-sleep intrusiveness—characterized by anxious rumination over academic deadlines—initiates a cascade of emotional distress and physiological hyperarousal. This autonomic activation directly opposes the somatic relaxation required for sleep onset, confirming that latency is predominantly a cognitive-emotional dysfunction rather than a simple scheduling failure.

Cognitive stimulation right before sleep is an important factor in delaying the release of melatonin from the pineal gland due to blue light. The HPA axis is then activated and the resulting overproduction of cortisol and

adrenaline prevents the most critical and necessary transition of the autonomic nervous system from being dominated by the sympathetic nervous system (or fight or flight) to being dominated by the parasympathetic nervous system (or rest and digest). The cumulative effect of the Pre-Sleep Cognitive Hyperarousal, Melatonin Suppression, and Sleep Time Displacement components has recently been shown to adversely impact the processes of sleep in the brain. Researchers have indicated that this deficit negatively impacts emotional regulation and has been associated with a 25% decrease in subjective well-being.

Based on our framework, Sleep Latency is likely to undermine psychological and cognitive satisfaction within the relevant HRQoL matrix.

**Sleep Disturbance: The Neuro-Somatic Fragmentation Matrix and Macro-Environmental Friction**
To fully evaluate its theoretical contribution, sleep disturbance must be analyzed through a comprehensive neuro-somatic fragmentation matrix rather than treated simply as isolated, ill-defined nighttime awakenings. Modern behavioral medicine recognizes structural sleep fragmentation as being characterized by recurrent micro-arousals and physical discomfort stemming from nighttime temperature fluctuations, respiratory disruptions, and somatic pain. This continuous fragmentation disrupts the natural architecture of the sleep cycle, truncating the duration and depth of both Stage N3 Slow-Wave Sleep (SWS) and Rapid Eye Movement (REM) sleep. Because Stage N3 sleep is essential for human growth hormone (HGH) secretion, cellular repair, and neuro-immunological restoration, persistent disruptions within this phase severely undermine systemic physical recovery.

Empirical literature demonstrates a strong bidirectional association between structural sleep fragmentation, psychological distress, and academic burnout among student populations (Zhang et al., 2025). While nocturnal micro-awakenings deplete physical energy and impair daytime coping mechanisms, elevated daytime stress conversely heightens baseline sympathetic tone at night. This bidirectional feedback loop transforms acute environmental disruptions into chronic neuro-somatic distress, exponentially deteriorating long-term HRQoL sub-domains. Once structural sleep continuity is broken, daytime fatigue increases, and the body's baseline physiological stress response to environmental demands becomes significantly heightened.

Recent environmental and public health research has increasingly emphasized the role of dormitory micro-environments in regulating circadian architecture. Thermal discomfort and ambient noise in shared student housing disrupt thermoregulation—specifically preventing the physiological drop in core body temperature necessary to sustain Stage N3 slow-wave sleep. Consequently, macro-environmental friction directly triggers autonomic micro-arousals, truncating deep restorative sleep independent of individual sleep hygiene behaviors. Suboptimal room conditions and poorly insulated student housing—where ambient temperatures fluctuate drastically between extremes—cause nocturnal cardiac acceleration and autonomic arousal responses. Ultimately, the physical strain induced by structural sleep fragmentation serves as a primary depressor of physical functioning, social engagement, and environmental adaptability within the HRQoL domain matrix.

## 4. Strategic Institutional Design & Future Research Direction

The Strategic Independent Qualitative Model provides a framework for higher education system designers interested in specific kinds of wellness interventions. These include:

**Digital Cognitive Interventions**
Rather than relying on passive wellness flyers, campus health centers should implement targeted digital hygiene protocols to mitigate bedtime cognitive hyperarousal. University IT and academic systems can support this by establishing automated Learning Management System (LMS) quiet zones—restricting assignment submission deadlines to 8:00 PM rather than midnight—and integrating evening 'screen-down' prompts across student portals 30 to 60 minutes before scheduled dormitory quiet hours.

**Macro-Environmental Dormitory Design**
University facilities management can utilize the Sleep Disturbance sub-axis to implement concrete structural upgrades in student housing. Key micro-environmental interventions include installing programmable

nocturnal thermostatic controls to maintain optimal sleeping ambient temperatures (18°C–21°C), retrofitting hall windows with high-grade acoustic insulation to minimize micro-awakenings, and utilizing low-kelvin warm LED lighting in communal hallways to reduce circadian melatonin suppression.

**Statistical Model Expansion for Future Research**

Those interested in advancing the work presented in this model will have a strong starting point. The model conveniently allows for hidden mediator blocks to be inserted. Future studies related to the model may include unmeasured variables such as academic workload pressure and Pre-bedtime Screen-Time Hours of students to gain a better understanding of student wellness.

## 5. Conclusion

This conceptual paper advances a streamlined theoretical framework positioning Sleep Latency (SL) and Sleep Disturbance (DIS) as distinct, qualitative predictors of Health-Related Quality of Life (HRQoL) among university students. By shifting the public health paradigm away from crude, volumetric sleep metrics (such as total sleep hours) toward structural qualitative sub-domains, the model demonstrates strong conceptual clarity and content validity. It effectively bridges neurobiological mechanisms, including pre-sleep cognitive hyperarousal, HPA-axis activation, and slow-wave sleep fragmentation with multidimensional student well-being. However, formal empirical construct validity, evaluated through convergent and discriminant validity testing, remains to be statistically confirmed upon field data collection.

Beyond its theoretical contributions, this framework provides higher education administrators and student affairs professionals with a structured, evidence-informed foundation for designing targeted, non-pharmacological interventions. By recognizing that sleep latency is largely driven by pre-sleep overthinking and digital blue-light exposure, university leaders can implement structural academic adjustments, such as enforcing earlier LMS assignment submission deadlines and establishing late-night digital quiet hours. Concurrently, addressing sleep disturbance requires macro-environmental campus housing upgrades, including nocturnal thermostatic controls and soundproofing, to eliminate physical micro-arousals during deep sleep stages.

Ultimately, prioritizing qualitative sleep health is essential for fostering resilient, high-performing academic communities. While future empirical research is necessary to confirm the structural path coefficients and test for underlying behavioral mediators, this study establishes that protecting student sleep quality is a fundamental prerequisite for optimizing health-related quality of life and long-term academic success.

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