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# Sleep Patterns and Awareness in Medical Imaging Students Using Wearable Technology

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## Abstract

*Fatigue is a significant concern for healthcare students in demanding and ever-changing professions. This study aims to explore medical imaging students' sleep patterns, beliefs and experiences by investigating the following research questions: (1) To what degree are medical imaging students aware of their sleep quality and the relationship between sleep and fatigue? (2) What impact might an objective sleep measure have on their understanding and appreciation of the role of sleep in their academic and professional practices? (3) What (if any) impact on behavioral change could routinely measuring, interpreting, and discussing sleep data have? This mixed-methods, exploratory study on second-year Bachelor of Health Science (Medical Imaging) students used Fitbit devices to monitor sleep, and explored participants' beliefs, knowledge, and experiences of sleep and fatigue through questionnaires and discussion groups. Guided by Social Cognitive Theory (SCT), the study emphasized observational learning, self-efficacy, and social interactions. Results showed high levels of interest in sleep and an increase in understanding of the relationship between sleep and fatigue. However, many participants struggled to maintain consistent sleep schedules due to academic and social pressures.*

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## INTRODUCTION

Fatigue is recognized as a serious and pervasive condition for clinical trainees that, if left unchecked, can reduce performance, heighten emotional instability and, in some cases, lead to burnout (Lund et al. 2010; Grady & Roberts 2017; Abdali et al. 2020; Schwartz et al. 2021). While fatigue is noted as an occupational hazard of the health profession (Parry et al. 2018), it is often paraded as a badge of honor, a sign of an altruistic diligent worker (Sokol 2013). Medical students drawn to this mindset willingly forsake sleep for the demands of work and study, continuing a professional practice that tolerates or even embraces fatigue (Olson & Ambrogetti 1998). This can create a culture where sleep is seen as an obstacle to productivity and professional growth (Popescu 2019). An investigation by Cvejic et al. (2018) into the sleep patterns of healthcare students found that while they were aware that lack of sleep was associated with higher levels of psychological distress, they accepted this as a consequence of academic achievement. This reveals a concerning dichotomy for our students. On one hand, fatigue is an accepted aspect of the profession but on the other hand, it is acknowledged as a significant contributor to cognitive impairment and medical errors (Krueger 2006; Massar et al. 2019; Rangtell et al. 2019).

There are many components to sleep quality, including: sleep duration, sleep stages, and consistency. It is known that reduced sleep quality and duration affects the process by which the brain converts short-term memory to long-term memory (McGaugh 2000). While the specifics of how this occurs is not yet fully understood, current evidence suggests that the hippocampus, a brain region involved in learning, has reduced activity after just one night of acute sleep deprivation, thus impairing memory function (McEwen 2006; Huber 2007; Watts et al. 2012). The quality of sleep is typically calculated on three sleep types or phases – light, rapid-eye-movement (REM) and deep. Light sleep is important for learning and the consolidation of new memories (Watts et al. 2012; Andrillon et al. 2017). REM sleep, on the other hand, has been found to aid the reconsolidation of memories and processing of emotional memories, connecting REM sleep with hippocampus-dependant memory consolidation (Watts et al. 2012; Andrillon et al. 2017), while declarative memory (learned information that can be consciously recalled), and procedural memory (learning that is more akin to skill learning), have been associated with deep sleep (Watts et al. 2012; Cousins & Fernández 2019). Research by Andrillon et al. (2017) found that deep sleep was also associated with the suppression of memory; it may be that a role of deep sleep is to ‘clear out’ irrelevant memories from the previous day. While the relationship between each stage of sleep and memory function is still being investigated, it is clear that sleep loss is consistently related to reduced performance (Curcio et al. 2006; Cousins & Fernández 2019) and chronic sleep deprivation leads to declining brain function (Chen & Chen 2019).

Sleep consistency is gaining traction as an important measure of sleep (Zuraikat et al. 2024). Inconsistent sleep schedules can lead to greater sleep disturbances, thus poorer sleep (Chaput et al. 2020). This poorer sleep could lead to adverse health outcomes (Chaput et al. 2020; Zuraikat et al. 2024), while greater sleep consistency has been shown to improve performance (Okano et al. 2019; Sletten et al. 2023).

Closely related to sleep consistency, the term social jet lag (SJJL) has been used to describe the mismatch between an individual’s biological clock and their social clock and is evidenced by naturally later sleep during

weekends (Roenneberg et al. 2019). SJL is often cited as an issue in student populations as students struggle with the early morning class start times and sleep later on the weekends to catch up (Díaz-Morales & Escribano 2015) SJL is relevant to this study because of the link between high SJL and poor outcomes behaviorally, physiologically, and psychologically (Wittmann et al. 2006; Depner et al. 2019). A number of studies have associated SJL with poor academic performance (Haraszti et al. 2014; Díaz-Morales & Escribano 2015).

SJL is not only the result of students' social activities. Their pre-sleep activity often involves using a digital device (Hershner & Chervin 2014; Orzech et al. 2016). The unnatural light emitted from these devices inhibits the release of melatonin (Hershner & Chervin 2014; Walker 2018), degrading the quality of their sleep (Wood et al. 2013; Hershner & Chervin 2014; Orzech et al. 2016; Repa et al. 2018). Furthermore, the physiological reality of delayed circadian rhythm and changes in homeostatic sleep drive in young adults causes them to feel less sleepy at night (Hershner & Chervin 2014). Students may swing excessively between alcohol-fueled socializing and caffeine-fueled studying, further degrading their sleep.

Educating students about the importance of getting adequate sleep may not be enough to motivate them to prioritize it. While sleep education programs such as seminars, workshops, and online activities have been shown to increase knowledge about sleep, they typically do not result in significant changes in behavior. For example, a study of secondary school students in Hong Kong found that a sleep education program had no significant impact on sleep duration, despite the increase in knowledge (Wing et al. 2015). Recognizing the limitations of traditional sleep education programs, Scullin (2019) argues that knowledge alone is insufficient to induce changes in sleeping patterns, and that a more comprehensive approach is necessary to effect real change.

Fatigue is a significant concern for healthcare students in demanding and ever-changing professions. By leveraging Social Cognitive Theory (SCT), our study aims to explore how the use of Fitbit devices for objective sleep monitoring and subsequent discussions within the student cohort influence self-efficacy, observational learning, and behavioral changes regarding sleep. This theoretical framework guides our exploratory investigation into the impact of personal sleep monitoring on medical imaging students' perceptions of fatigue and their subsequent behavior.

## THE STUDY

The impetus for this study was the high prevalence of tiredness and exhaustion among medical imaging students, as evidenced by actions such as dozing off in class, frequent yawning, and skipping class for napping. Additionally, students have reported experiencing burnout and emotional distress, necessitating time off from the program. What is particularly concerning is that these behaviors and conversations are not limited to the end of shift cycles but also occur at the beginning of the day. The physiological or psychological nature of this phenomenon remains unclear, although students often attribute their fatigue to lack of sleep when asked about its cause.

We would like to acknowledge the gravity of fatigue experienced by healthcare students in a demanding and ever-changing profession. It is our desire to contribute fresh insights to the ongoing discussion around student sleep and fatigue by exploring the following questions:

1. To what degree are medical imaging students aware of their sleep quality and the relationship between sleep and fatigue?
2. What impact might an objective sleep measure have on the understanding and appreciation of the role of sleep in academic and professional practice?
3. What (if any) is the impact on behavioral change of routinely measuring, interpreting and discussing sleep data?

## METHOD

Ethical approval was sought and gained through Otago University and the Unitec Institute of Technology.

## PARTICIPANTS

Ten participants aged between 19 and 28 years old were chosen from a convenience sample of one tertiary education provider in Auckland, New Zealand. An invitation to participate in the research was sent to the entire second-year cohort; the first ten students to consent were accepted on a first-in basis. All participants were enrolled in their second year of the Bachelor of Health Science (Medical Imaging). There were nine women and one man, and no students dropped out during the study. All participants worked their clinical hours in a New Zealand public hospital, interspersed with time spent studying in Auckland.

## DATASETS

Two datasets were collected: 1) a wearable device was used to assess sleep patterns, and 2) group discussions were used throughout to qualify the sleep beliefs and experiences of participants.

Participants also completed the Pittsburgh Sleep Quality Index (PSQI) before wearing the Fitbit. The PSQI was used to measure perceptions of sleep. The PSQI is a survey used in medicine to differentiate between poor and good quality sleepers by measuring seven areas through self-reporting: sleep quality (subjective), sleep latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication, and daytime dysfunction (Buysse et al. 1989). The PSQI is a popular measure, despite its age, due to its reliability and validity and has been used by a variety of recent sleep studies (Lund et al. 2010; Cvejic et al. 2018; Peach et al. 2018; Scullin 2019). The PSQI was chosen to assess perceptions about sleep but was not intended as diagnostic.

### Sensor-based sleep data

A Fitbit is a wrist-worn, waterproof watch-like device that provides digital measurements for exercise and sleep. As a wearable technology it afforded students immediate access to physiological sleep pattern data within the context of daily life. There have been a number of papers written on the validity of the Fitbit's sleep measures (Brooke et al. 2017; De Zambotti et al. 2018; Feehan et al. 2018; Lee et al. 2018; Svensson et al. 2019). For this study, we selected the Fitbit Charge 3. Students were asked to wear the Fitbit at all times. During the 151-day observation period, a couple of students sporadically had missing data, totaling five days each (3.3%), which did not impact our analysis.

### Group discussion data

Informal group discussions took place regularly in groups of three to four. Discussions took place at cafes to provide a social and relaxed atmosphere. The participants analyzed the sleep data together to build a narrative that related to their sleep, performance in their studies, and their wellbeing. Despite only one participant professing a previous interest in sleep, all participants found the topic fascinating. Participants were encouraged to share their data with each other and enjoyed comparing their different sleep schedules and patterns. Students found they often shared feelings of fatigue, particularly in the academic setting. Discussions were audio recorded and fully transcribed. Discussions were coded and grouped into themes (Thomas 2006).

### Data collection procedures

Data collection took place over one semester (15th Jul – 13th Dec) in order to capture a complete study cycle that incorporated a mix of academic study within a university setting and clinical placements in a hospital setting (Table 1). Sensor data was captured continuously over the entire study schedule, while informal discussions (n=12) were dispersed across the study period.

**Table 1: Sequence of contexts for the 2019 Semester Two schedule**

Clinical Setting	Academic Setting	Holiday	Academic Setting	Clinical Setting
15th Jul – 1st Sept	2nd Sept – 29th Sept	30th Sept – 13th Oct	14th Oct – 24th Nov	25th Nov – 13th Dec

### Fitbit use

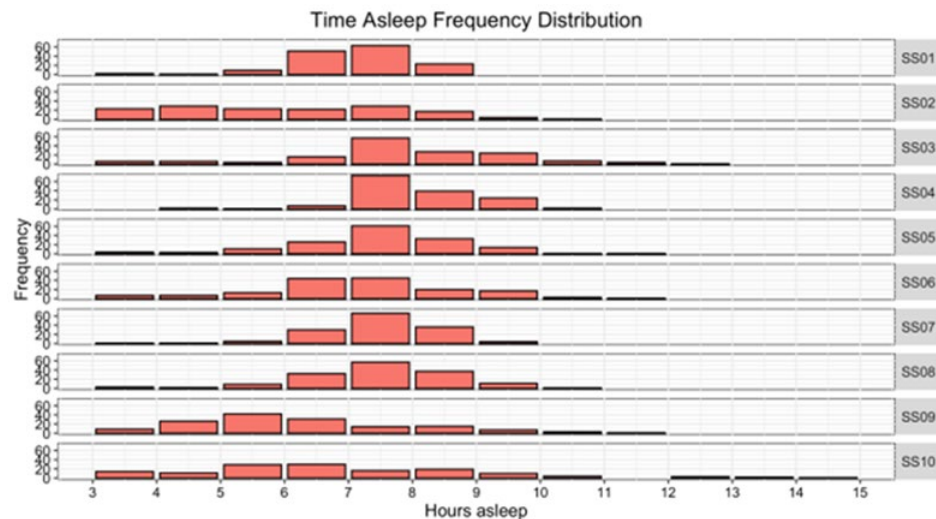
Participants undertook a training period prior to the official Fitbit data collection. In this training period, they developed a wearing routine, learned how to manage the sensor and how to read the data. This gave participants seven days to adjust to the sensor and report any issues before data collection began. All participants opted for the automated syncing of data to a personal Fitbit hosted site. A hosted Fitbit site was created for each participant using an institutional user account that was shared with the researchers. Participants wore their Fitbit on the non-dominant hand. Students were informed that they would be able to keep the devices at the end of the study.

Guided by SCT, the study method emphasized observational learning, self-efficacy, and social interactions. The study design facilitated an environment where students could observe and reflect on their own sleep data, discuss their findings with peers, and learn from each other's experiences. This participatory approach aimed to enhance self-efficacy regarding sleep behavior changes through mutual reinforcement and shared learning experiences.

## RESULTS

### DATASET-1: SENSOR-BASED SLEEP DATA

#### Sleep quantity



**Figure 1: Time Asleep Frequency Distribution**

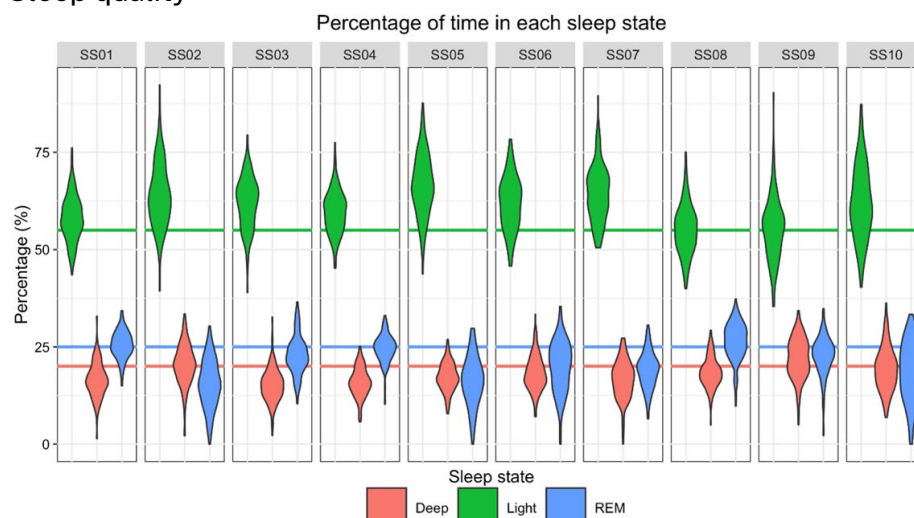
Note. Figure 1 shows the range of sleeps by duration for each participant. The X axis shows the duration of sleep to the nearest hour, and the Y1 axis shows how many times that sleep duration occurred. The Y2 axis demonstrates which participant the data belongs to. Students with a wide sleep frequency distribution show inconsistent sleep scheduling. The ideal sleeper would achieve the majority of their sleeps within the range of between seven and nine hours with minimal variation. Naps were defined as sleeps fewer than three hours and were removed in the construction of this graph.

Despite being on the same course with roughly the same commitments, students had differing sleep patterns night to night. Some students, such as SS01, SS04, SS07, and SS08 achieved the recommended sleep duration on most nights. However, students SS02 and SS10 showed very little pattern at all, demonstrating an inconsistent sleep schedule

Interestingly, sleep consistency was not a topic that came up in discussion. Students focused more on sleep duration data and sleep stages data. Going to sleep and waking up on a consistent schedule was not considered a priority. In fact, students seemed to imply sleep was a thing of chance. As a whole, they spoke about duration as something they could not control. SS05, for example, spoke about feeling tired no matter how long they slept, but never spoke about sleep consistency as something they could try and change. SS02 and SS09 showed the most interest in changing their sleep durations, but regular sleep and wake times were not considered. It is possible that while sleep duration is well-recognized by students, knowledge about sleep consistency is lacking.

Measuring sleep through a wearable device as opposed to a more traditional survey allowed us to see the true picture of sleep. Had we simply taken an average of sleep duration for each student, it is likely it would have shown they slept on average seven to nine hours per night. Using a frequency distribution allows us to look at sleep duration and consistency, showing that a) many students did not achieve over seven hours per night every night, and thus were possibly suffering from chronic sleep deprivation, and b) student sleep durations varied from night to night, indicating a lack of routine and consistency.

### Sleep quality



**Figure 2: Sleep states. The height of each violin shows the distribution of the sleep states, while the width shows the density of points at each percentage level**

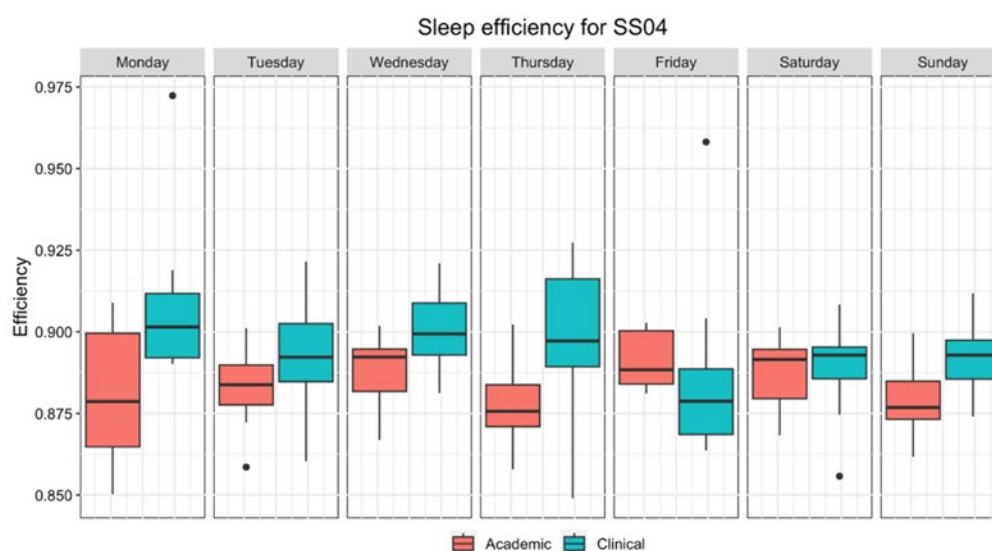
Sleep quality is a term widely used but with no real definitional consensus. Researchers have suggested that sleepers only perceive sleep quality in how quickly they fall asleep and how many times they wake up overnight, although they often have no memory of awakenings (Åkerstedt et al. 1994). It is well accepted, however, that stages of sleep from N1–N3 and REM play a significant role in quality of sleep. Hence the amount of time spent in each sleep stage can be taken as a measure of sleep quality. The ideal sleeper for this age bracket would have about 55% of their sleep in light sleep, around 20–25% in deep sleep, and about 20–25% of their sleep in REM sleep (Siclari & Tononi 2016).

SS09 was a student who experienced sleep that was shorter than recommended, regularly sleeping for only six hours per night, and often as little as five. They rarely slept more than eight hours per night and attributed this to late-night phone use. Looking at duration alone, SS09 would appear to have poor sleep. However, SS09 regularly spent more than 20% of the night in deep sleep, and about 20% of the night in REM. This showed that despite its short duration, the sleep SS09 was getting was of high quality. This was reflected in discussions with the student, where they noted they felt fine despite the short sleep, and only desired eight hours per night because that was what society told them they needed. A true understanding

of sleep quality allowed this student to see their sleep in a different, more positive, way.

Conversely, SS05 was a student who appeared to get adequate sleep when measuring duration alone but had poorer sleep quality. They regularly surpassed the recommended amount of light sleep, often by a significant margin. This indicates they had less time spent in REM and deep sleep. This student often complained of feeling tired and exhausted. They also self-reported low mood. This student felt little motivation to change their sleep patterns, despite experiencing fatigue.

### Sleep efficiency



**Figure 3: Sleep efficiency for SS04, for academic and clinical settings**

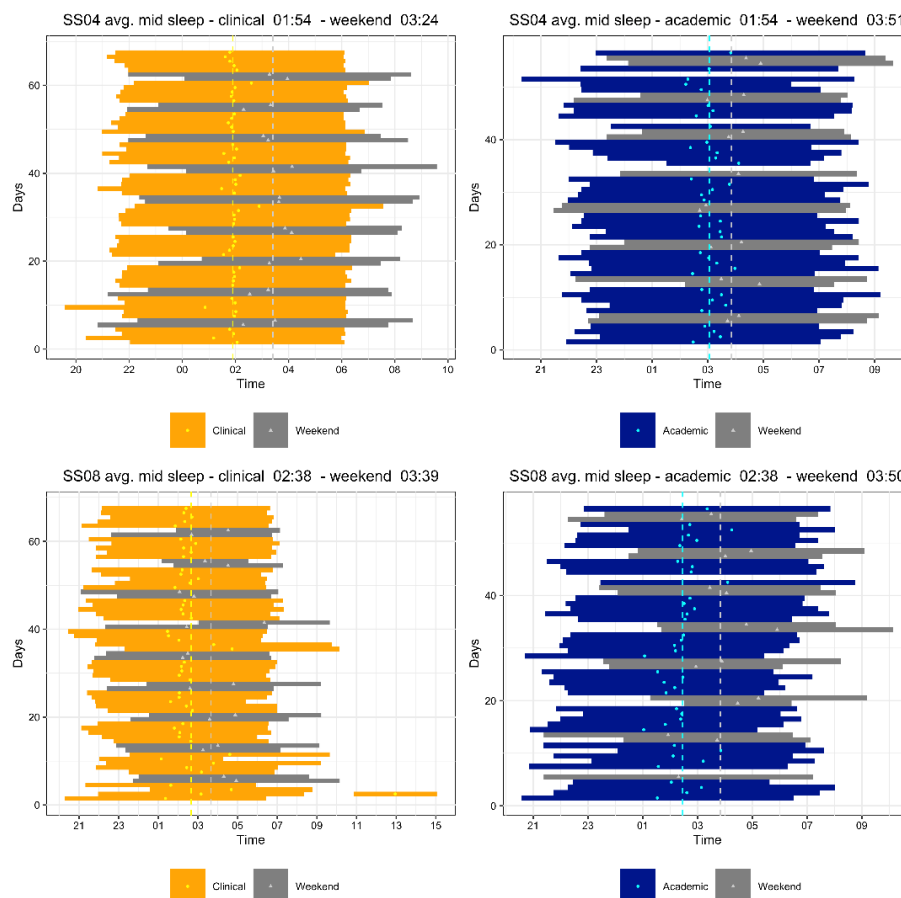
Sleep efficiency can be defined as the ratio of total sleep time to time in bed (Desjardins et al. 2019). Sleep efficiency is an important marker of sleep quality (Adnane et al. 2012; Albqoor & Shaheen 2021). We found that students' sleep efficiency varied between clinical and academic settings, as shown above for participant SS04. SS04 tended to have better sleep efficiency when working in the clinical setting than when studying in the academic part of the semester.

The clinical setting may force students into a routine and promote greater efficiency. In discussions, several students commented that they saw their academic lectures as optional attendance activities, but felt they had to turn up for the clinical work. They described activities such as choosing to stay in bed during academic periods. Conversely, during the clinical period, students were more likely to force themselves to get out of bed. SS07 indirectly referred to sleep efficiency when they said they became more physically tired during the time in the clinical setting, and thus they went to bed earlier and slept 'better'. SS08 agreed that they felt more physically exhausted during clinical work periods. The professional space of the clinical setting meant students kept a stricter bedtime routine; this promoted greater sleep efficiency and consistency.



## Social jet lag

For this study, mid-sleep times were used to analyze SJL. Mid-sleep points are considered the best indicator of melatonin onset, a marker of the circadian phase (Umemura et al. 2018). Additionally, the mid-sleep point difference between weekdays and weekends is frequently used as a measure of SJL (Umemura et al. 2018; Islam et al. 2019; Südy et al. 2019).



**Figure 4: Mid-sleep shift: academic vs. clinical settings**

Both SS04 and SS08 showed evidence of SJL, indicated by the size of the gap between the weekday and weekend mid-sleep lines. However, SS04 showed SJL in the clinical space only. It is possible that this student saw the clinical setting as a professional space in which they had to work harder and turn up on time, shown by the more consistent wake-up times. The academic setting, alternatively, had varying hours and class attendances. SS04 said that they slept later during academic blocks, and also stayed up later.

SS08 showed SJL in both spaces and spoke of catching up on sleep in the weekends. Talking about the clinical experience, SS08 said, "I feel exhausted by the end of the day because you are doing so much, but I don't mind because the people there are so nice... because everyone else is happy to be there it makes a difference." This was a common sentiment – that there was a feeling of positive exhaustion after a hard day's work in the clinical setting, as opposed to negative feelings of mental fatigue from time spent

in academic study, which was mainly sedentary. The feeling of exhaustion may have been positive, but SJL may have serious impacts on performance.

SJL measurements allow us to see what sleep duration and quality measurements could not – a feeling of exhaustion by the end of the week, with the weekend used to catch up on sleep. Yet only by analyzing all three factors could students get a true picture of how they slept.

## **DATASET-2: PSQI AND DISCUSSION DATA**

Before the study, students were more aware of the importance of sleep duration than quality or consistency of sleep. For their PSQI, SS09 rated their sleep quality as 'fairly bad' despite not meeting any other criteria for poor sleep except for their self-reported sleep duration of five hours. In discussions, SS09 spoke about it being common knowledge that eight hours' sleep was considered the ideal sleep duration. The best sleeper in regard to sleep quantity, SS01, stated that their sleep goal was seven and a half hours per night. They recorded meeting this on their PSQI. If they did sleep less than seven hours, they reported feeling fatigued and were more likely to take naps. Although most students related a lack of sleep to feeling fatigued, SS03, SS09, and SS10 described a relationship between feeling unhappy and sleeping longer. SS10 said, "I had a 12-hour sleep one day but that was because I was down in the dumps. I sleep more if my mood is poor. I snooze my alarm if I am not feeling good."

While students did not name sleep deprivation in conversations, they seemed aware that they caught up on sleep during the weekend. There was also much conversation around alarms, with some students saying they set multiple alarms in order to wake up on time. Alarms were used as a justification for keeping the phone in the bedroom, even after students were informed that phone use could be detrimental to sleep. While students seemed to accept that phones could be harmful to sleep latency and quality, they could not envision keeping their phones away from their beds.

Students often discussed feeling physically tired during clinical placement, but they felt they could skip the academic space if they needed to sleep in:

I think I will sleep more during academic because I don't always go. It is how I am feeling on the day. I have the best intentions and I set my alarm, but in the morning, I wake up and I am like I don't want to get out of bed, I want to sleep. If I have a good sleep, I force myself to get out of bed, but if I have a bad sleep, I think, 'what is the point of going?' because I will feel bad in class. (SS03)

It is possible that these students suffered tiredness more frequently in the clinical space because they were committed to going. This may be because the clinical space is a professional space and students behaved professionally in it.

## **DISCUSSION**

The aim of this study was to explore the sleep patterns, beliefs, and experiences of second-year Bachelor of Health Science (Medical Imaging)

students at a New Zealand tertiary education provider. The study was exploratory in nature and adopted a case-based approach that promoted collaboration and encouraged personal investigation and sharing of experiences and interpretations among the participants. Through informal discussions, the participants were actively involved in shaping the research and were not merely passive donors of raw data. They learned how to capture, monitor, and read their data and spoke openly about their interest in the study and the potential benefits they could derive from it.

By incorporating the principles of SCT, the study emphasized the role of observational learning, self-efficacy, and social interactions. At the beginning of the study, participants primarily focused on sleep duration as a measure of sleep quality, believing that eight hours of sleep per night was ideal. Analyzing sleep quality allowed students to see past sleep duration. Looking at their own data, they became curious about the functions of different sleep stages. The sleep-stage information allowed a student like SS09 to feel more positive about their short sleep, and others to see where their sleep may be improved. By adding education around sleep stages, students were given the tools to make changes, if desired.

The participants attempted to make connections between their sleep and mood, noticing that a lack of sleep led to fatigue, while longer sleep sometimes made them feel unhappy. However, as the study progressed and students were presented with their personal sleep data and educated about sleep quality, their perceptions began to evolve. They shifted their focus to factors such as deep sleep and REM percentages as indicators of sleep quality and aimed for at least six hours of sleep per night. This change in perspective resulted in improvements in their mood, with SS09, for example, reporting feeling happier in the mornings.

Before the study, the students had limited knowledge regarding sleep stages, the impact of sleep on performance and memory, and sleep consistency. However, they showed significant interest in learning more about sleep as they engaged actively with their data. Through the lens of SCT, these changes can be attributed to increased self-efficacy and observational learning, as students observed their own and their peers' sleep patterns and behaviors, discussed their findings, and received social reinforcement. As the study progressed, the participants shifted their focus from discussing sleep duration to the impact of different sleep stages on sleep quality patterns. The students were particularly interested in how their shorter sleep affected their learning ability. In group discussions, they discovered that short sleep was likely to have negative effects on memory and learning (Huber 2007; Thacher 2008; Chen & Chen 2019). After learning more about their sleep, some students, especially SS02, were motivated to change their sleeping patterns.

Interestingly, at the beginning of the study, SS02 believed that sacrificing sleep in order to study was necessary and even pulled all-nighters. However, after learning about the impact of sleep on memory consolidation, they stopped pulling all-nighters before exams and even tried forgoing naps to improve their mood. Similarly, SS08 began sleeping without their phone in their room after learning about the negative impacts of technology on sleep. Meanwhile, SS01 decided to wake up 25 minutes later, which improved their mood, but they still struggled to fall asleep earlier. In contrast, SS01, who had prior education on sleep, had banished their phone from their room long before the study and was considered to have the best sleep. Students were not explicitly told to change their

behavior or to remove phones from their rooms; instead, education was presented and advice was given if asked, but ultimately students were left to make their own decisions. This approach reflects SCT's emphasis on enhancing self-efficacy and enabling individuals to take control of their behavior change process. While many students identified that phone use had a negative impact on their sleep, motivation to remove phones from the bedroom was low.

As the study progressed, students also became fascinated with the sleep of their peers. They were surprised by the variability in sleep patterns and bedtime habits among their peers, which helped them to view their own sleep as a personal and individual experience. This aligns with SCT's emphasis on social modeling and observational learning.

As students gained knowledge and self-efficacy through observational learning and social interaction, some were able to modify their behaviors to optimize their sleep and overall wellbeing. This newfound knowledge led them to experiment with the concept of quantified-self, which involves tracking personal data to improve one's quality of life. The students' interest in learning about sleep and using that knowledge to make changes represents a small foray into this movement (Lupton 2017).

Although personal analytics were seen by students as a catalyst for change, the motivation to change varied among them. Some students, such as SS01, SS02, and SS08, were able to successfully change some of their behaviors. However, others, such as SS09, SS05, and SS10, expressed a desire for better sleep but lacked the motivation to change. For example, SS10 stated that sleep was not a priority in their life, while SS05 was unsure of what changes to make. Despite conversations about phone use and sleep consistency, SS09 was unable to sleep earlier during the study and did not seem to feel in control of their sleep. These varied responses highlight the SCT concept of self-efficacy and the importance of addressing personal and environmental factors in behavior change.

Overall, the study found that students were not concerned about sleep consistency and often saw sleep as a matter of chance. While they recognized that phones could be harmful to sleep, they were reluctant to keep them away from their beds. The study provides valuable insights into the sleep patterns and beliefs of university students and highlights the need for further education on the importance of sleep quality and consistency.

## CONCLUSION

This study explored the sleep patterns, beliefs, and experiences of medical imaging students using Fitbit devices to monitor sleep. The integration of SCT helped to explain how observational learning, social interaction, and self-efficacy influenced students' perceptions and behaviors regarding sleep. The findings suggest that, while personal analytics and peer discussions can foster better sleep habits, individual motivation and environmental factors are crucial for sustained behavior change. The study underscores the importance of comprehensive sleep education programs that enhance self-efficacy and leverage social learning opportunities to improve sleep health among healthcare students.

Survey responders were asked to provide feedback about the acceptability of personalising the online program using EMR data. All participants either agreed or strongly agreed with the statement that 'the

questions in the online program felt linked to their clinical practice', and with the statement that 'the program felt engaging because it used clinical data relevant to their organisation'. All respondents indicated that the program was a helpful means of feeding back data on their patient presentations. Three respondents indicated that they agreed or strongly agreed with the statement that the data-personalised program encouraged them to engage in reflective practice activities such as reviewing their own patient records in the EMR.

## LIMITATIONS

This study was case-based, and the small sample size limits the generalizability of the findings. Additionally, discussion groups can exhibit social desirability bias, dominant voices, and group-dynamics challenges. Students might have withheld opinions to avoid conflict, and these views may not be fully reflected in survey comments. The principal researcher was known to the participants as their lecturer, which may have caused students to withhold some opinions to protect their academic reputation.

While the Fitbit is reliable at detecting sleep with a sensitivity of 92.1% (De Zambotti et al. 2018), it has limited accuracy in predicting sleep stages, particularly deep sleep (Svensson et al. 2019). To enhance accuracy, data was recorded over an entire semester; however, it is important to note that the Fitbit, while fairly accurate, is not a completely reliable measure of sleep stages.

Finally, SJL might be under-represented in this group of students because the researchers did not account for weekend work during data analysis. The topic of weekend work came up in discussions, revealing that at least two students worked on weekends. Any SJL in these students may have been hidden as they were getting up early for work on weekends. Future research should consider weekend work hours in data analysis.

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