DEVELOPMENT AND USABILITY TESTING OF AN eHEALTH SLEEP INTERVENTION PROGRAM FOR YOUTH

by

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ABBREVIATIONS AND DEFINITIONS

BNBD = Better Nights, Better Days

CBT-I = Cognitive Behavioural Therapy for Insomnia

M = Mean

n = Sample size

REM= Rapid eye movement

SD = Standard deviation

SE = Sleep efficiency. Defined as the percentage of time spent asleep while in bed.

SOL= Sleep onset latency. Defined as the amount of time it takes to go from being fully awake to sleep.

TST= Total sleep time. Defined as the total of all REM and NREM sleep in a sleep episode

ABSTRACT

Adolescence is a vulnerable time for sleep problems. It is estimated that half of adolescents worldwide do not get the sleep needed to function optimally during the day. Current interventions available to treat sleep problems are often inaccessible, costly and time consuming. The use of the internet would allow for a more accessible and cost-effective way to deliver sleep intervention. This thesis includes two parts – the development of *BNBD-Youth* and conducting usability testing of this intervention. The intervention was created using a user-centered design to treat sleep problems in adolescents. Usability testing was conducted with 8 end-users as a next step in program development. Participants were asked to complete the *BNBD-Youth* program in full while providing feedback on each session and the overall program. The program was well received by participants and there was a high level of user satisfaction. Suggestions were provided on how to improve the eHealth intervention including reducing text, adding more interactive features and reducing the length of the lessons and sessions. Implications for the future of *BNBD-Youth* as well as eHealth interventions for adolescents in general are discussed.

CHAPTER 1: AN OVERVIEW OF SLEEP: IT'S FUNCTIONS, IMPACT AND IMPORTANCE FOR ADOLESCENTS

What is sleep?

"Sleep is a universal biological feature in all species and represents a global state of immobility with greatly reduced responsiveness to environmental stimuli, which can be distinguished from coma or anesthesia by its rapid reversibility" (Brand & Kirov, 2011, p. 435). Sleep is incredibly important for a number of functions in humans including memory consolidation, attention, thinking and reasoning abilities, emotional processing, physical restoration and energy conservation (Vyazovskiy, 2015). The mechanisms that regulate sleep can be best described by the two-factor model which explains sleep regulation as a function of homeostatic and circadian processes (Carskadon, 2008). Sleep homeostasis is the idea that the longer we are awake, sleep propensity (the natural inclination to sleep) increases, and circadian rhythms are best defined by a set of bodily functions that operate in a cycle of approximately 24 hours (Cajochen, Kräuchi, & Wirz-Justice, 2003). Circadian rhythms include the sleep wake cycle as well as hormone production, body temperature and alertness, as well as performance; all of which are controlled by the suprachiasmatic nuclei (SCN), known as the circadian pacemaker in the brain (Cajochen et al., 2003). These two processes work together to regulate sleep in humans.

There are two types of sleep: rapid-eye-movement (REM) sleep and non-rapid-eye-movement (non-REM) sleep (McCarley, 2007). Non-REM sleep is further divided into stages N1, N2 and N3, and each stage of sleep has unique characteristics that include differences in brain wave patterns, eye movements, and muscle tone (Altevogt & Colten, 2006). Humans switch between non-REM and REM sleep during the night, which is referred to as a sleep cycle. Non-REM sleep stages can be between 5-15 minutes long, and REM sleep stages start around 10

minutes long with each later phase getting progressively longer as the night goes on. Human sleep cycles repeat throughout the night and individuals typically experience between four and six full sleep cycles, and each last for 90–110 minutes (Carskadon & Dement, 2005).

A typical sleep cycle begins with the first stage of non-REM sleep, N1 (Altevogt & Colten, 2006). This short sleep stage is considered the transition from wakefulness and is characterized by low-voltage, mixed-frequency brain waves as measured by EEG recordings (Carskadon & Dement, 2005). The presence of sleep spindles and K complexes in an EEG recording indicate that an individual has transitioned to stage N2 of sleep. This stage of sleep is important for memory consolidation and is when an individual's heart rate slows and their body temperature drops (Altevogt & Colten, 2006). Increased amounts of high-voltage, slow wave activity on an EEG recording signals that a person has entered stage N3 (Carskadon & Dement, 2005). During this stage of sleep, the body works to repair and regrow tissue, bone and muscle and this stage of sleep plays an important role in energy conservation (Altevogt & Colten, 2006). REM sleep is characterized by the presence of low-voltage, mixed-frequency brain waves, muscle atonia, and bursts of rapid eye movements (Carskadon & Dement, 2005). REM sleep allows the nervous system to develop as nerve cells grow and make new connections. Dreaming is often associated with REM sleep, and the muscle atonia associated with this stage of sleep prevents an individual from acting out their dreams (Bader, Gillberg, Johnson, Kadesjo, & Rasmussen, 2003). The above described stages and cycles of sleep is commonly referred to as sleep architecture, which changes with age (Altevogt & Colten, 2006).

Developmental aspects of sleep

Across the lifespan, there are changes in how sleep is initiated and maintained, and how much time a person spends in each stage of sleep (Altevogt & Colten, 2006). Newborns begin REM sleep before non-REM sleep and have a shorter sleep cycle that lasts around 50 minutes.

At the time of birth, REM sleep accounts for approximately 50% of a total sleep episode but declines to around 20% to 25% as a child enters adolescence (Carskadon & Dement, 2005). Consolidation of nocturnal sleep occurs within the first 12 months of life and becomes relatively stable until adolescence (Iglowstein, Jenni, Molinari, & Largo, 2003). In adolescence, N3 sleep decreases by about 40% and this continues to decline into adulthood (Carskadon & Dement, 2005).

Sleep needs vary for different age groups; this depends on the amount of sleep you need on a day-to-day basis ("basal sleep need") and sleep debt (i.e., accumulative missed sleep) (Hirshkowitz et al., 2015). In 2015, the National Sleep Foundation updated their sleep duration recommendations following a rigorous review of the scientific literature by an 18-member expert panel (Hirshkowitz et al., 2015). The panel agreed that, for healthy individuals with non-disordered sleep, the appropriate sleep duration for newborns (0-3 months) is between 14 and 17 hours, infants (4-11 months) between 12 and 15 hours, toddlers (1-2 years) between 11 and 14 hours, preschoolers (3-5 years) between 10 and 13 hours, and school-aged children (6-13 years) between 9 and 11 hours. For adolescents (14-17 years), 8 to 10 hours was considered appropriate, 7 to 9 hours for young adults (18-25 years) and adults (26-64 years), and 7 to 8 hours of sleep for older adults (65 years +) (Hirshkowitz et al., 2015). While sleep patterns and needs change across the lifespan, the two developmental stages with the most change include infancy and adolescence (Iglowstein et al., 2003).

Adolescent Sleep Patterns and Problems

A change in sleep patterns during adolescence (ages 14-18) can be in part attributed to a biological shift that occurs in an individual's circadian rhythms (Noland, Price, Dake, & Telljohann, 2009). Adolescence is a critical period of growth and development characterized by hormonal, somatic and behavioural changes accompanied by maturational changes in sleep

(Brand & Kirov, 2011). A change in circadian rhythms occurs around the time of puberty and the sleep wake cycle can shift by up to two hours (Leger, Beck, Richard, & Godeau, 2012). This delay in circadian rhythms, due to a delay in the secretion of melatonin, results in a decrease of homeostatic sleep pressure making it hard for the adolescent to fall asleep at night (Carskadon, 2008; Crowley, Acebo, & Carskadon, 2007; Hagenauer, Perryman, Lee, & Carskadon, 2009).

A delay in the timing of sleep during puberty has been observed in over 16 countries on 6 continents, in multiple cultural contexts (Carskadon, 2008). Even after several weeks of regulated schedules that allow for sufficient amounts of sleep, adolescents continue to show a delayed circadian phase (Carskadon, Acebo, & Jenni, 2004). This phase shift towards evenings is indicative of underlying changes to mechanisms regulating sleep and wake during puberty (Carskadon et al., 2004). The changes in mechanisms regulating sleep causes adolescents to stay up later in the night (Gradisar, Gardner, & Dohnt, 2011), resulting in a need for later wake times in the morning. However, adolescents cannot make up for their delayed sleep phase, in part due to early school start times, as their weekday wake times are determined by their school schedules.

Adolescents typically become sleepy and go to bed around 11:00 p.m. or later (O'Brien & Mindell, 2005). Due to this late bedtime, their wake time should be between 7:00 p.m. to 9:00 p.m. to meet National Sleep Foundation's recommendations (National Sleep Foundation, 2019). However, in Canada, school can start as early as 7:50 a.m. and students who attend schools with start times around 8:00 only receive on average 8 hours and 26 minutes of sleep (Gariépy, Janssen, Sentenac, & Elgar, 2016), which is at the lower end of the recommended sleep duration for this age range. Evidence that school start times play a role in sleep deficiencies in adolescents can be seen by a marked difference in weekday and weekend sleep patterns (Hansen et al., 2005). On average, Canadian adolescents extend their sleep time on the weekend by 1 hour and

20 minutes in comparison to their weekday sleep times (Gibson et al., 2006). Consecutive nights of short sleep are thought to create a sleep debt in adolescents, and this extension of weekend sleep time is an attempt to recover from the debt accumulated throughout the week (Carskadon et al., 2004).

While school start times significantly interfere with adolescents' sleep patterns, there are other factors that compete for sleep time in adolescents. Various studies have shown that stress (Bernert, Merrill, Braithwaite, Van Orden, & Joiner, 2007), caffeine and alcohol consumption (Orbeta, Overpeck, Ramcharran, Kogan, & Ledsky, 2006), jobs and homework (Carskadon, 1990), exercise behaviours (Taylor, 2001) and poor time management skills (Carskadon, 1990) all affect adolescent sleep patterns. The above-noted factors, both biological and behavioural in nature, contribute to a particularly vulnerable time for sleep problems in adolescence.

Sleep Deficits and Impact

As noted above, it is recommended that adolescents receive between 8-10 hours of sleep to achieve optimal daytime functioning (National Sleep Foundation, 2019), however evidence shows that these needs are not being met by many adolescents. Gradisar et al. (2011) conducted a meta-analysis in which they found that in 51% of adolescent samples worldwide, total sleep time was insufficient (less than 8 hours) and that in North America, the average sleep time was 7.5 hours on weeknights (Gradisar et al., 2011). At times, these sleep problems are severe enough to be considered a sleep disorder, namely insomnia, which is defined by the DSM-5 (American Psychiatric Association, 2013) as a sleep disorder characterized by frequent and chronic difficulties with falling asleep, staying asleep and and/or night awakenings, which lead to daytime impairments. A decline in sleep duration and quality in adolescents is of great concern as there are several negative effects.

A review by Shochat, Cohen-Zion and Tzischinsky (2014) summarizes the adverse consequences that inadequate sleep can have on adolescent daytime functioning across 76 peer reviewed articles which include learning, psychological, behavioural and physical health problems. Despite the large number of negative effects that inadequate sleep can have on the life of an adolescent, this area of research is still understudied. Much of the research in this area is correlational in nature and there are fewer experimental sleep manipulation/restriction studies which provide stronger evidence to help us better understand the causal relationships between sleep and daytime functioning.

Across the existing sleep manipulation studies that examine the effect of sleep deprivation on cognitive functioning, it has been shown that reduced sleep quantity negatively impacts quiz performance, increases inattentive behaviour and results in decreased levels of arousal (Beebe, Rose, & Amin, 2010; Fallone, Acebo, Seifer, & Carskadon, 2005; Sadeh, Gruber, & Raviv, 2003). Correlational research further explores of the relationship sleep problems and daytime functioning and these studies show that sleep is related to optimal cognitive functioning, including attention, memory, learning, and higher order executive functions and has significant influence on adolescents' academic abilities (Fredriksen, Rhodes, Reddy, & Way, 2004; Gibson et al., 2006; Roberts, Roberts & Duong, 2009; Shochat et al., 2014). Furthermore, sleep quantity and quality have been found to be highly correlated with working memory and memory consolidation in adolescents, and performance on abstract and complex tasks that involve higher brain functioning declines when adolescents do not receive the proper amount of sleep (Kopasz et al., 2010). One of the largest correlational studies that examined the impact of sleep on academic performance of 3,120 adolescents found that students with lower grades (74% and below) received on average three hours less sleep per week than students with higher grades (75% and above) (Wolfson & Carskadon,1998). Similar findings

have been found in various countries across the world, showing that academic and cognitive performance suffers as a function of sleep which has significant negative outcomes for adolescents (Shochat et al., 2014).

The relationship between sleep and mental health in adolescents is primarily and almost exclusively supported by correlational research as there are only two known sleep manipulation studies examining the effects of sleep restriction on mental health with adolescents. A study by Dagys et al. (2012) found that when adolescents were experimentally deprived of sleep, they became more vulnerable to negative moods and their self-ratings of positive affect decreased. A 2014 study by Baum et al. further explored this issue by reducing the sleep duration of adolescents between the ages of 14-17 years to only 6.5 hours of sleep per night. It was found that adolescents deprived of sleep became more anxious, tense, angry, hostile, and irritable (Baum et al., 2014). Correlational studies show associations between sleep deficits and mental health disorders and emotional dysfunction (Shochat et al., 2014). There is a bidirectional relationship between a lack of sleep and depression in adolescents as it is seen that depression causes sleep disturbances, but ongoing sleep disturbances are also associated with depression (Fredriksen et al., 2004; Lytle, Pasch, & Farbakhsh, 2011). Sleep deficiencies also put adolescents at risk for anxiety, low self-esteem, withdrawal and increased moodiness (Shochat et al., 2014). When looking at the outcomes of short sleepers (5–8 hours per night), relationships between poor mental health, low life satisfaction and sleep duration were consistently found (Gradisar et al., 2011), showing once again how important sleep is for adolescents.

Adolescence is a time where impulsive and risk taking behaviour is particularly prevalent. There is an increased amount of such behaviours during adolescence and a review of the literature suggests that impulsivity and risk taking are associated with immature ventral prefrontal development and such behaviours gradually diminish from childhood into adulthood

(Casey, Galvan & Hare, 2005). An increase in risk taking behaviour is also related to inadequate sleep (Shochat et al., 2014). Studies have found that sleep deficits are correlated to cigarette smoking (Pasch, Latimer, Cance, Moe & Lytle, 2012), alcohol and drug use (Roberts, Roberts & Duong, 2009), aggressive acts (Umlauf, Bolland, & Lian, 2011) and risky sexual activity (Yen, King & Tang, 2010). There are currently no known experimental studies examining the effect of sleep manipulation on risk taking behaviour. However, chronic and habitual short sleepers are more impulsive and have poor inhibitory control across several measures (Rossa, Smith, Allan, & Sullivan, 2014).

Sleep also impacts physical health. Both prospective and cross-sectional studies have shown that insufficient sleep puts adolescents at a risk for developing obesity and weight problems (Shochat et al., 2014) and it has been found that adolescents with shorter sleep durations (less than 10 hours a night) had relatively higher body mass indexes (Ruan, Xun, Cai, He & Tang, 2015). While there is an association between obesity and sleep deficits, future research in this area needs to address the causality and strength of this relationship. There is also emerging evidence of associations between sleep and different health conditions, including pain and cardiovascular and cardiometabolic impairments (Shochat et al., 2014) As well, a review by Lazaratou, Soldatou and Dikeos (2012) found additional medical problems that could possibly arise from poor sleep. Metabolic syndrome, growth hormone deficiency, allergic conditions and genetic and congenital disorders are all common medical conditions that are correlated with insomnia and short sleep duration in adolescents. These current research findings highlight the immense impact sleep has on an adolescent's health.

Treating Adolescent Sleep Problems

Given the number of negative consequences that can result from sleep deficits, it is critical to have effective interventions targeting sleep. It is recommended that sleep treatments

follow a specific structure and order (Morgenthaler et al., 2006). Education about sleep is the first step in an intervention program and is also a primary component of prevention programs for sleep problems in adolescents (Morgenthaler et al., 2006). Sleep education generally involves information regarding the biology of sleep, the daytime consequences of insufficient sleep, and increasing the understanding of how inadequate sleep during one's adolescence may be caused and maintained (Honaker & Meltzer, 2014). It is important to understand the basics regarding sleep to be able to commit to treatment.

Following an understanding of what sleep is, healthy sleep practices (previously known as sleep hygiene) are often the next component of sleep interventions (Morgenthaler et al., 2006; Weiss & Corkum, 2012). Healthy sleep practices involve engaging in behaviours that promote sleep, while avoiding behaviours that interfere with sleep. These recommendations include having a regular bedtime and waketime, following a bedtime routine, avoiding caffeine and exercise in the hours before bed, limiting screen time before bed and ensuring that the sleep environment is cool, quiet and dark (Stepanski & Wyatt, 2003). Next, a number of behavioural strategies can be used to help an individual sleep better. This is based on the principle that healthy sleep is a learned behaviour (Weiss & Corkum, 2012). As such, strategies based on the principles of learning can be implemented to help individuals sleep better (e.g., gradual extinction, fading, sleep scheduling). The final step in a sleep treatment would be medication, as a last resort after being unsuccessful with the other steps of the treatment (Weiss & Corkum, 2012).

These interventions are often used to facilitate healthy sleep practices in adolescents and are typically delivered one-on-one or in small groups by psychologists or other health care providers. They are often individually tailored to the specific patient and can last anywhere from three to nine sessions (Hendricks, Ward, Grodin, & Slifer, 2014; Paavonen, Huurre, Tilli,

Kiviruusu, & Partonen, 2016). Psychoeducation is usually a part of treatment; along with other components including cognitive behavioural therapy and stimulus control (Hendricks et al., 2014). Stimulus control is the idea of re-associating the bed/bedroom with sleep through various instructions including going to bed only when sleepy, getting out of bed when unable to sleep and using the bed/bedroom only for sleep. A small number of research studies have reported improvement in sleep outcomes in adolescents when administered as an in-person clinical intervention (Clarke et al., 2015; deBruin, Bogels, Oort, Meijer, 2015; Gradisar et al., 2011; Hendricks et al., 2014; Scharb, Liddle, & Hautzinger, 2011). These interventions have shown to result in moderate to large positive effects in various sleep variables such as total sleep time (TST), sleep onset latency (SOL), and sleep efficiency (SE), as well as daytime functioning, coping, and wellbeing.

While studies evaluating these interventions demonstrate that they are effective, there are significant barriers to their implementation. Interventions of this nature demand a large amount of resources and time, with each intervention involving between six to ten weekly 90-100 minute in-person sessions. In addition to the barrier of time for both the adolescents receiving service, and the therapists involved in delivery, they can be costly to the family and also require the adolescent to be physically present at a specific location, which may result in other costs such as travel and time off school or work (Minges & Redeker, 2016). Despite the evidence showing that this form of intervention can create meaningful improvements in important sleep variables, one-on-one in-person interventions are not easily scalable to reach a large number of adolescents with sleep problems at one time (Ström, Pettersson & Andersson, 2004).

One way to provide intervention to more adolescents is through targeting them within the school system. It has been proposed that changing school start times is an efficient way to treat sleep deficiencies in adolescents (Minges & Redeker, 2016). While early school times is

particularly a problem in the United States, where 43 states reported that 75%–100% of their public schools had early start times before 8:30a.m., early school start times are a reality worldwide (Season, 2015). To address the issue of chronic sleep restriction, it has been suggested that school start times should be changed to occur later in the morning to better align with adolescents' circadian rhythms and to reduce daytime dysfunction (Minges & Redeker, 2016). A recent review by Minges and Redeker (2016) found collective evidence that delaying school start times to 8:30am or later can be an effective method to improve important sleep outcomes like total sleep duration, daytime sleepiness, health outcomes, depression, and academic outcomes.

A recent study by Gariépy et al. (2016) examined school start times in Canada and the impact on adolescents' sleep and found that students from schools that started later slept longer, were more likely to get sufficient sleep on weekday nights and were less likely to report feeling tired in the morning which is in line with research from the United States, Europe, Australia and Asia (Short et al., 2016; Wheaton, Chapman, & Croft, 2016). Despite the benefits of later school start times, schools encounter many barriers in making this change. Modifying transportation schedules is a huge barrier to overcome, and a later school start time often conflicts with parental work schedules (Kirby, Maggi, & D'Angiulli, 2011). Other issues encountered when changing school start times are a delay in extracurricular and social activities, conflicts with part time employment schedules, and less time to complete homework (Wrobel, 1999). While this method would likely be effective in treating sleep deficiencies in some adolescents, it involves gaining the support of parents, teachers, coaches, administrators, transportation directors, school boards and government officials, which is not an easy task (Minges & Redeker, 2016).

Another intervention aimed at improving adolescent sleep behaviours is sleep education, with the majority of sleep education programs for adolescents being conducted within the school

system. Common components include education on sleep wake cycles, sleep physiology and patterns, causes and effects of poor sleep, sleep needs and healthy sleep practices. This information has been delivered by teachers and/or psychologists through powerpoint presentations, leaflets, posters, activities, projects, and multimedia presentations (Moseley & Gradisar, 2009; Azevedo et al., 2008; Bakotic, Radosevic-Vidacek, & Koscec, 2009; Blunden, Kira, Hull, & Maddison, 2012). While studies on sleep education show an increase in adolescents' sleep related knowledge (Bakotić et al., 2009, Blunden et al., 2012, Bonnar et al., 2015; Sousa, Souza, & Louzada, 2013) results are mixed when it comes to observing a subsequent sleep behaviour change. Some studies show positive changes in sleep habits (Gruber, Somerville, Bergmame, Fontil, & Paquin 2016; John, Bellipady, & Bhat, 2016; Sousa et al., 2013; Tamura & Tanaka, 2016; Bonnar et al., 2015; Bei et al., 2013), while others do not show a change in sleep behaviour (Azevedo et al., 2008; Beijamini & Louzada, 2012, Moseley & Gradisar, 2009, Wing et al., 2015), or the sleep behaviour changes observed were not maintained at follow up (Rigney et al. 2015).

Sleep education programs have the potential to be effective, but behaviour change can be difficult to achieve and is often dependent on what adolescents are willing to do and what motivates them to make a change. Current findings about school-based sleep education programs suggest that sleep knowledge improves following education, but it does not always translate into a subsequent behaviour change and reasons for this may include motivation and readiness to change (Blunden, Chapman, & Rigney, 2012). A main barrier to school-based sleep education programs is that permanently implementing these programs within classrooms involves a change in curriculum, which can be a difficult task (Goodson, 2013).

While there are treatments for sleep deficits in adolescents currently available, each intervention has its own barriers. This is why there is a need for a different form of treatment

delivery for sleep interventions. The internet is a logical direction that many health care providers are perusing (Docebo, 2014).

eHealth Interventions

With the ongoing advances in technology and adolescents' widespread use and access to the internet, the creation and use of eHealth education programs are on the rise (Docebo, 2014). eHealth is defined as the intersection of medical informatics, public health and business, and refers to health services and information delivered via the internet (Eysenbach, 2001). Many studies have evaluated the effectiveness of eHealth education programs for individuals of all ages on topics including smoking cessation, nutrition and diet, and depression (Brendryen, Drozd, & Kraft 2008; Christensen, Griffiths, & Jorm, 2004; Oenema, Brug, & Lechner, 2001). Wantland et al. (2004) conducted a meta-analysis of various eHealth interventions with a health behaviour focus and 16 of the 17 studies included showed that the use of eHealth interventions in eliciting a behaviour change is efficacious for individuals between the ages of 3 and 86. Krishna et al. (2003) suggests that the internet provides a medium that can overcome barriers to delivering effective patient education. Adolescents are frequently using the internet as a resource to gather health related information (Park & Kwon, 2018). In a 2012 study of US adolescents by Ghaddar, Valerio, Garcia, and Hansen, 81% of adolescents reported that they had used the internet in the past to seek health related information. These findings highlight the role that the internet can play in supporting health-related services for this age group.

Many studies have provided evidence that delivering sleep interventions via the internet is an effective method of improving sleep. A meta-analysis by Seyffert et al. (2016) examined 15 randomized controlled trials in adults (ages 16 and over) using Cognitive Behavioural Therapy for Insomnia (CBT-I). Internet-delivered CBT-I was found to be effective in improving insomnia symptoms, TST, SOL, SE and wake time after sleep onset. When examining long term effects,

improved sleep efficacy and a decline in the severity of insomnia were maintained over a long follow-up period.

While eHealth sleep interventions have been found to be effective in adults, there are only two studies evaluating eHealth sleep interventions for adolescents. A 2019 pilot study by Werner-Seidler et al. examined the effects of an insomnia intervention for adolescents (12-16 years) delivered via a smartphone application. Sleep Ninja was designed following a participatory design and focus groups were held prior to the development of the mobile phone application. Content included psychoeducation, healthy sleep practices and sleep-focused cognitive therapy and stimulus control across six sessions. It was found that insomnia symptoms significantly improved following completion of the intervention as did sleep quality. deBruin, Bogels, Oort, and Meijer (2015) compared the effects of in-person group treatment to an internet-based sleep intervention. Their online sleep intervention included psychoeducation, sleep hygiene, restriction of time in bed, stimulus control, cognitive therapy, and relaxation techniques across six weeks. Participants had to log in at a specified time to review their sleep diaries and consult with a psychologist before completing automatic exercises such as movies and questionnaires with automated feedback. It was found that compared to wait list controls, both therapies reported significant improvement in SE, TST, and waking during the night (deBruin et al., 2015). No significant differences were found between the in-person, or internet-delivered treatment, highlighting the utility of online sleep interventions for adolescents.

Conclusion

Sleep is critical for adolescent development. However, adolescent sleep is negatively impacted by biological changes and behavioural factors which are contributing to chronic sleep deprivation in this age range (Noland et al., 2009). These sleep deficits are impacting adolescents' lives in various areas, including their cognitive functioning, their mental and

physical health and their risk taking behaviours (Shochat et al., 2014). There are various treatment options available for adolescent sleep, however, there are several barriers to each option and these interventions are not reaching the majority of individuals that have sleep problems (Ström et al., 2004). While research on the use of an online platform for treating sleep is a relatively new topic of research, eHealth is effective for treating behaviourally-based problems in adolescents (Wantland et al., 2004) and eHealth sleep interventions have been found to be effective in adults (Seyffert et al. 2016). This form of treatment delivery may overcome the barriers of other forms of intervention (Werner-Seidler et al., 2019); however, the evidence supporting the use of eHealth interventions for treating sleep in adolescence is insufficient as there are currently only two published studies. The current study aims to expand on this body of research by developing and evaluating a new eHealth sleep intervention, *Better Nights Better Days- Youth (BNBD-Youth).* This is the third BNBD eHealth intervention developed and evaluated through Dr. Corkum's research laboratory. The first was focused on typically developing children ages 1-10 years (BNBD), the second was focused on children with neurodevelopmental disorders (BNBD-NDD) and the third was focused on children with obstructive sleep apnea and insomnia (BNBD-OSA). There are two other BNBD eHealth interventions under development, including BNBD for Babies and BNBD for Young Adults. The goal is to develop and evaluate a suite of eHealth interventions focused on treating insomnia across the developmental period from babies to young adults.

CHAPTER 2: DEVELOPING *BETTER NIGHTS, BETTER DAYS- YOUTH*

This chapter will provide an overview of the development of *BNBD-Youth.* This will include a summary of the standard approach to treatment, clinical mechanisms of change, and the specific eHealth behaviour change theory. *BNBD-Youth* was developed using a user-centered participatory research design, which will be defined and outlined later in the chapter before summarizing the various components and content of the intervention.

Approach to Treatment

Behavioural interventions are the most effective treatment for sleep problems for the majority of people, including children (Weiss & Corkum, 2012) and adolescents (Mindell & Meltzer, 2008). Commonly, behaviour therapy is delivered in combination with cognitive therapy that aims to restructure beliefs and misperceptions about sleep (Mindell & Meltzer, 2008). It is recommended that sleep intervention follows a specific order as previously mentioned in Chapter 1. This starts with psychoeducation regarding sleep, then it is recommended that the individual implements various healthy sleep practices before moving onto specific behavioural strategies and then medication as a last resort (Weiss & Corkum, 2012). As such, *BNBD-Youth* was developed as a behavioural intervention for sleep problems. The creation of *BNBD-Youth* was based on *BNBD*, a pediatric behavioural intervention for children previously developed in Dr. Corkum's research laboratory. *BNBD-Youth* adopts the same behavioural approach to sleep problems and includes many of the same activities and educational pieces, re-worked for an adolescent population. More information on the specific strategies and content in *BNBD-Youth* will be covered following an overview how to promote behaviour changes via eHealth interventions.

Developing an eHealth Intervention to Promote Behaviour Change

Developing an engaging and effective eHealth sleep intervention is not as simple as

putting existing interventions on the internet (Ritterband, Thorndike, Cox, Kovatchev, & Gonder-Frederick, 2009). Rather, these programs need to be developed and tested using an eHealth focused behavioural change model. Commonly, Ritterband's eHealth behaviour change model is used (Ritterband et al., 2009). This model was proposed to help guide future internet intervention development and predict and explain behaviour changes and symptom improvement that result from eHealth interventions (Ritterband et al., 2009). The Ritterband eHealth Behaviour Change model differs from classic behaviour therapy as it combines information from various theories of motivation, social marketing/advertising strategies, web-based design and development techniques, information architecture and design, models of knowledge transfer and general research and clinical experience (Ritterband et al., 2009).

This model (see Fig. 1) predicts behaviour changes in consideration of the user, who approaches an online intervention with a set of pre-determined user characteristics, that can be influenced by environmental factors including family, friends, school, and the health care system (Ritterband et al., 2009). These include disease (i.e., the problem being targeted- in our case sleep problems), demographics, personal traits, cognitive factors, beliefs and attitudes (including motivation and readiness to change), as well as physiological factors and skills. These user characteristics in turn impact their use of the website containing the intervention, and website use is influenced by website characteristics, adherence to the site, and support offered by the program. The model then predicts that website use leads to a behaviour change through various mechanisms of change (including knowledge, motivation, attitudes, and self-efficacy). This behaviour change then results in symptom improvement and success of a treatment is maintained through relapse prevention (Ritterband et al., 2009). By drawing on multiple disciplines, this model allows us to conceptualize and identify factors that are likely to contribute to behaviour change (and symptom improvement) in an online sleep intervention.

While Ritterband's eHealth Behaviour Change model emphasizes the user, it is actually rare that health care intervention programs follow a user-centered design and many fail to involve the user early in the development process (Majid, Noor, Adnan, & Mansor, 2010). It is important to bridge the gap between researchers and users through a user-centered participatory research design (Skeels & Pratt, 2008), as incorporating user preferences when designing online programs is predicted to increase use of the application (Glasgow et al., 2004; Johnson, Johnson, & Zhang, 2005). As such, the user, as well as relevant stakeholders, have been involved in the development of *BNBD-Youth* from the beginning, starting with a focus group study.

Previous Focus Group Study

To inform program development of *Better Nights Better Days-Youth* in consideration of the user, focus groups were held with adolescents and stakeholders (parents and educators). This work was the first step in the development of *BNBD-Youth* (Mugford, 2017). The results of the study were used to get a greater understanding of what problems adolescents have in regard to their sleep, what to include in our eHealth sleep intervention and how to best engage and motivate adolescents to change their current behaviours.

A total of 6 focus groups were held: three with adolescents (n = 14) and three with various stakeholders (parents n = 4, teachers n = 7, guidance counsellors n =1). During the focus group discussion, adolescents' sleep experiences were reported to be problematic both from the adolescents themselves as well as the stakeholders and it became clear that adolescents are not getting the recommended amount of sleep each night. They reported these problems to be a consequence of difficulties falling asleep, issues maintaining sleep, and delaying bedtimes due to distractions and busy lifestyles. The negative impact of these sleep problems is evident to both parents and educators; however, some adolescents failed to see the importance of proper sleep. Educators reported noticing that their students are often fatigued in class, leading to difficulties

concentrating and a decrease in academic performance consistent with current literature on the impact of sleep deficits (Shochat et al., 2014).

Concerning program development, several ideas on how to best create an eHealth sleep intervention were also identified during the focus groups. In regard to content, sleep education was reported to be key in terms of motivating adolescents to practice healthier sleep habits and participants felt as though a better general understanding of sleep would motivate adolescents to practice healthier sleep habits. All of the focus groups provided suggestions on topics that they would like to see included in a sleep intervention (e.g., the importance of sleep, biology of sleep, time management skills, etc.). Participants also suggested a number of interactive features to be included as a part of the program, including tailoring the program to the user, videos, and a monitoring/tracking system. Adolescents also discussed that they did not want to have to sit down and complete a large amount of content in a specified period. They preferred to be able to come and go to the website and consume information at a rate that they could control.

Opinions of an eHealth sleep intervention were also discussed throughout the focus groups. Adolescents, parents, and educators were all receptive to the idea of having such a program available and they thought that this is something that would be helpful to adolescents. Participants reported many advantages of the program being presented online; the main one being how convenient and widely available this program will be. Adolescent participants were also key in suggesting ideas on the look and design of the program. It was suggested that the program be simple, and easy to navigate to promote continuous use.

The focus group study was a meaningful and constructive first step in the development of *BNBD-Youth* and it provided valuable ideas from a range of perspectives. By gaining this insight into the user through qualitative methods, we aimed to take these ideas and use them to create an effective and engaging treatment for adolescent sleep problems.

Developing *Better Nights, Better Days-Youth*

When *BNBD-Youth* was designed, it was done so by combining the users' ideas and preferences with existing research evidence for content delivery and managing sleep. Content was written by the *BNBD-Youth* team and is focused on the first 2 steps of the sleep care hierarchy – psychoeducation and healthy sleep practices (Weiss & Corkum, 2012). Once content was written, the team then worked collaboratively with Velsoft to determine how to deliver the program using their interactive e-learning platform. Velsoft had previously developed the *BNBD* program for children, however a new platform needed to be built to tailor the program to the preferences of the user. Several activities were taken from the already existing child program and implemented within the *BNBD-Youth* program; however, the majority of the content was redeveloped for more suitable delivery to an adolescent population and the *BNBD-Youth* team created many new interactive activities.

The intervention is organized into 4 sessions, with each session being comprised of multiple microlearning lessons (see Table 1 for content summary). A microlearning approach delivers content through short, interactive, and engaging lessons and is a method for learning and education which deals with short and small learning units (Gassler, Hug, & Glahn, 2004). Information throughout the program is delivered via many different interactive forms, including videos, quizzes, questionnaires, diagrams and interactive text. The program follows the recommended treatment delivery structure (Morgenthaler et al., 2006) and includes psychoeducation about sleep, effective healthy sleep practice strategies, and various sleep recommendations. Across all sessions, participants are encouraged to track their sleep habits via the sleep diary within the *BNBD-Youth* program which provides them with visual feedback of their overall sleep habits. Throughout the program, participants also set sleep-related goals and receive session plans upon completion of each session with the essential information they need to

improve their sleep. In session 3 of *BNBD-Youth*, participants identify the specific areas of healthy sleeping they are struggling with and build a sleep plan with evidence-based recommendations that they are to use to improve their sleep. These activities are seen throughout the sessions of *BNBD-Youth;* however, each session has a variety of different lessons that are described below.

Following an introduction into the program and video tutorial, participants gain access to Session 1: "What is Sleep?". The aim of this session is for adolescents to better understand what sleep is, and the importance of sleep itself. The content in session 1 covers a broad definition of sleep and a sleep cycle before introducing the biological phase shift that occurs during adolescence (Noland et al., 2009). Following this information, sleep needs are covered before discussing the impact of sleep problems on daytime functioning.

Session 2 of *BNBD-Youth* is titled "Your Sleep". The objective of this session is to understand various sleep measures and disorders while relating this information back to the participant's current sleep habits. During this session of the program, adolescents learn about different sleep variables and sleep measurement tools. They also learn about the various sleep disorders and measure their own sleep quality and healthy sleep practices. They next calculate their optimal bedtime and waketime. There is a one-week delay between session 1 and session 2 where adolescents are encouraged to start to go to bed and wake up at the correct time that allows them to meet their sleep needs.

Session 3 is titled "Healthy Sleep Practices". This session educates adolescents on the various healthy sleep practices while developing a plan on how to improve their sleep via evidence-based strategies and recommendations. This is done through following the ABCs of SLEEPING mnemonic (Allen, Howlett, Coulombe, & Corkum, 2016), and each lesson comprises of a single recommendation, each representing a letter in the mnemonic. The ABCs of

SLEEPING mnemonic was developed to serve as an organizing framework for common pediatric sleep recommendations and it captures common practices and recommendations that aim to improve sleep. The mnemonic stands for 1) **a**ge appropriate **b**edtimes and wake-times with **c**onsistency, 2) **s**chedules and routines, 3) **l**ocation, 4) **e**xercise and diet, 5) no **e**lectronics in the bedroom or before bed, 6) **p**ositivity 7) **i**ndependence when falling asleep and 8) **n**eeds met during the day, 9) equal **g**reat sleep (Allen et al., 2016).

***A**ge appropriate **b**edtimes and wake-times with **c**onsistency* refers to the fact that participants should go to bed at the same time and wake up at the same time each night, allowing them to get the proper amount of sleep. In this lesson, participants use the interactive bedtime calculator to find out what time they should go to bed in order to wake up at the correct time and receive the proper amount of sleep each night. ***S**chedules and routines* are a key recommendation for sleep problems and it refers to establishing a nightly bedtime routine which helps signal the body that it is time to sleep (Allen et al., 2016). In *BNBD-Youth,* participants are able to create a routine of their own via the bedtime routine creator drag and drop interaction. This is then saved for them to follow and practice each night. ***L**ocation* refers to the conditions within the bedroom and if they are conducive of sleep. *BNBD-Youth* participants learn about ideal bedroom conditions (e.g., light, temperature, comfort) through a dynamic bedroom activity. They are then encouraged to evaluate their own bedroom and make any necessary adjustments to the setting to promote a good night's sleep. It is important that individuals engage in regular physical activity and follow a healthy diet as outlines by the ***e**xercise and diet* lesson. Adolescents learn about when to exercise (i.e., not too close to bedtime) and what foods to avoid leading up to bedtime (i.e., caffeine, heavy meals) during this *BNBD-Youth* lesson. Next is the no ***e**lectronics in the bedroom or before bed* lesson where participants learn about the negative impact that screen time can have on sleep in the hours leading up to bedtime via an interactive video. The next

recommendation is ***p****ositivity and relaxation*. It is important that participants have a positive attitude towards sleep and go to bed feeling relaxed (Allen et al., 2016). This *BNBD-Youth* lesson teaches participants various relaxation strategies like deep breathing, progressive muscle relaxation and visualization via audio and video recordings. The ***i****ndependence when falling asleep* lesson teaches the adolescent participants about sleep associations and how it is important that they associate the right things (i.e., white noise, comfort) with sleep rather than activities that are not conducive to sleep (i.e., a television, music or cannabis). Finally, ***n****eeds met during the day* discusses a 24-hour approach to good sleep. Participants are taught to meet their nighttime needs (i.e., getting enough good quality sleep) as well as their daytime needs; both physical (i.e., enough activity, food and water) and emotional (i.e., spending time with others and having downtime to enjoy) all of which are important for a **g**ood night's sleep. Throughout session 3 of *BNBD-Youth*, participants build a sleep plan to follow over the next week before entering into the final session.

Finally, the intervention ends with Session 4: "Checking In". The purpose of this session is to see if the adolescents are making progress since starting the program, to solve any issues and problems through providing extra recommendations and to plan and prepare for great sleep. Common roadblocks to getting a good night's sleep are discussed (e.g., illness, time change and traveling) and additional outside resources related to sleep are provided. Participants are encouraged to keep following their sleep plan they developed in session 3 and to continue to access the program and track their sleep via the online sleep diary.

In comparing the two existing eHealth sleep interventions for adolescents with *BNBD-Youth* there are several similarities and differences. The content between all 3 program overlaps, however the study by deBruin et al. (2015) also included restriction of time in bed which was supported by sleep therapist consultation. While all interventions lasted for 6 weeks, participants

in the deBruin et al. (2015) were required to log in once per week at a fixed time for a session that lasted on average one hour. The intervention evaluated by Werner-Seidler et al. (2019) consisted of six "training sessions" that were each between 5 and 10 minutes long and ongoing sleep tracking via a sleep diary. The size of *BNBD-Youth* appears to be in-between these two existing interventions as it consists of 4 sessions with multiple short lessons within the sessions. *BNBD-Youth* is also a self-guided eHealth program that does not require support from health care providers or sleep coaches. This form of eHealth has the ability to build a large clientele quickly as there is no need to hire outside professionals to support the demand of the intervention.

Next Steps in the Development of *BNBD-Youth*

It has been shown that involving end-users in design and testing increases the likelihood of promoting intended health outcomes (Rubin & Chisnell, 2008). Therefore, usability testing is a logical next step in the development of *BNBD-Youth* to ensure that it is user-friendly and accessible, which will result in user satisfaction (Rubin & Chisnell, 2008). Chapter 3 provides the results of the usability study in which end users completed the intervention in full while providing their feedback on the program, which will inform any final modifications to the content and activities. The final step in program development will be a effectiveness trial. The results of the usability study will inform the final step of program evaluation.

Table 1. *Better Nights, Better Days- Youth* Program Summary.

Topic	Topic Overview	Delivery Method
Session 1: What is sleep?	Learning objective: To understand sleep and its importance	
Separating fact from fiction	Distinguishing fact from fiction about sleep topics	Interactive question tool
What is sleep?	Learning about sleep and its function	Video
Sleep and pain	Learning about the relationship between sleep and pain	Video
The sleep cycle	Learning about the stages of sleep	Text, diagram, sorting game
Regulation of sleep	Learning about how sleep is regulated	Video
Lark or owl?	Learning about own circadian rhythms	Personality Quiz
How sleep changes in adolescence	Learning about changes to sleep in adolescents	Video
How much sleep do we need?	Learning sleep duration needs	Interactive bar graph, text, image
Sleep and mental health	Learning about the relationship between sleep and mental health	Interactive text flow, images
What happens when we do not get enough sleep?	Learning about what happens in the body with poor sleep	Interactive body image and descriptions
Session 2: Your Sleep	Learning objective: To understand various sleep measures and sleep disorders	
Important sleep variables	Learning about the different variables that measure sleep	Interactive text
Sleep diaries	Learning about sleep diaries, analyzing own diary data	Text, image, checklist

Topic	Topic Overview	Delivery Method
Methods for measuring sleep	Learning about actigraphy, polysomnography, sleep technology	Text, interactive images
Common sleep disorders	Learning about different sleep disorders	Interactive text and image
Sleep quality	Learning about, and calculating sleep quality	Text, image, quiz
Healthy sleep practices	Learning about, and calculating healthy sleep practices	Text, image, quiz
Bedtimes and waketimes	Learning about, and calculating bedtimes and waketimes	Text, interactive bedtime calculator
Session 3: Healthy Sleep Practices	Learning objective: To understand the importance of healthy sleep practice and develop a plan on how to improve their sleep	
The ABCs of SLEEPING	Learning about the ABCs acronym	Text and image
Schedules and routines	Learning about consistency, schedules and routines	Text, questions, routine builder
Sleeping locations	Learning about sleep environment	Interactive image, questions & feedback
Electronics	Learning about the impact of electronics on sleep	Video, questions & feedback
Exercise & Diet	Learning about the role of exercise and diet on sleep	Text, questions & feedback
Positivity & Relaxation	Learning about the role of positivity toward sleeping and going to bed relaxed	Interactive text, questions & feedback
Independence	Learning about the importance of independent sleep	Text, questions & feedback
Needs met during the day	Learning about needs to meet during the day	Text, image, questions & feedback

Topic	Topic Overview	Delivery Method
Great sleep	Learning about extra resources and future planning	Text, plan builder
Session 4: Checking In	Leaning objective: Plan and prepare for great sleep	
Checking in	Checking in about progress since starting the program, solving issues/problems	Text, checkbox, questions
Roadblocks	Learning about what to do about sleep when vacationing, sick, ill, or during a time change	Text
Resources	Providing extra resources related to sleep	Text
Congratulations!	Congratulating user for completing the program	Text, image

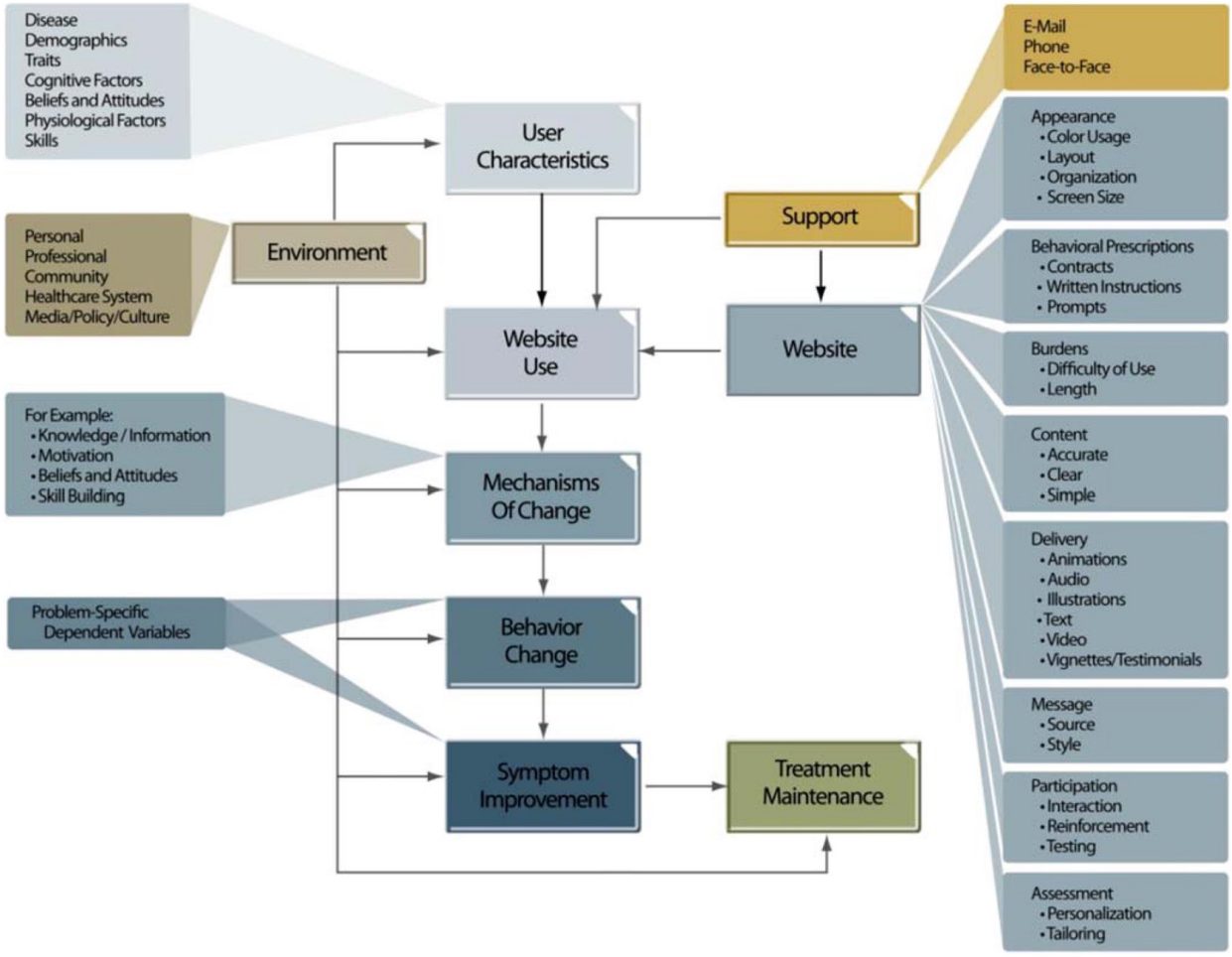

Figure 1. The Ritterband eHealth Behaviour Change Model.

CHAPTER 3: USABILITY OF THE BETTER NIGHTS, BETTERY DAYS-YOUTH eHEALTH PROGRAM

Sleep is critical for adolescent development. However, there are a number of factors that compete for adolescent sleep time including both biological (Hagenauer et al., 2009) and behavioural factors (Hansen, Janssen, Schiff, Zee, & Dubocovich, 2005). Once a child enters adolescence, sleep patterns begin to change (Noland, Price, Dake, & Telljohann, 2009). This biological change can be attributed to a phase shift that occurs in a child's circadian rhythms that causes their sleep-wake cycles to shift by up to two hours (Leger, Beck, Richard, & Godeau, 2012). This delayed sleep phase results in adolescents staying up later in the night, which creates a need for later wake times in the morning. However, this is not possible, especially on weekdays, as adolescent's sleep schedules are determined by their school start times (Gradisar, Gardner, & Dohnt, 2011). Behavioural factors such as caffeine and alcohol consumption, jobs and homework, exercise behaviours, poor time management skills and stress also play a significant role in adolescent sleep problems (Carskadon, 1990; Orbeta, Overpeck, Ramcharran, Kogan, & Ledsky, 2006; Taylor, 2001).

It is recommended that adolescents receive between 8-10 hours of sleep each night to achieve optimal functioning (National Sleep Foundation, 2019), however evidence shows that these needs are not often being met. A meta-analysis found that in 51% of adolescent samples worldwide, total sleep time was insufficient (less than 8 hours), and that in North America, the average sleep time was 7.5 hours on weeknights (Gradisar et al., 2011). Consecutive nights of short sleep are thought to create a sleep debt in adolescents (Carskadon, Acebo, & Jenni, 2004). In what is hypothesized to be an attempt to recover from the debt accumulated throughout the week, adolescents extend their sleep time on average by 1 hour and 20 minutes on weekends (Gibson et al., 2006). In doing so, adolescents are not following a main healthy sleep practice- a

consistent sleep schedule (Allen et al., 2016). The combination of biological and behavioural factors, in addition to the fact that the environment does not accommodated these changes (i.e., early school start times), creates a vulnerable time for adolescents' sleep patterns and habits. This situation often results in sleep problems and at times these problems are severe enough to meet the clinical threshold for a diagnosis of insomnia (Gradisar et al., 2011). Insomnia, as defined by the DSM-5 (American Psychiatric Association, 2013) is a sleep disorder characterized by trouble falling asleep, staying asleep and night awakenings that are frequent (at least 3 times a week), chronic (at least 3 months in duration), and impairing (i.e., impact daytime functioning).

Shorter sleep duration during adolescence is of great concern as reduced sleep time is related to problems in cognitive functioning, mental health and physical health (Shochat, Cohen-Zion, & Tzischinsky, 2014). Sleep is necessary to achieve optimal cognitive functioning, including attention, memory, learning, and higher order executive functions (Shochat et al., 2014). One of the largest correlational studies that examined the impact of sleep on academic performance of 3,120 adolescents found that students with lower grades (74% and below) received on average three hours less sleep per week than students with higher grades (75% and above) (Wolfson & Carskadon,1998). Similar findings have been found in various countries across the world, showing that academic and cognitive performance suffers as a function of sleep which has significant negative outcomes for adolescents (Shochat et al., 2014). Experimental sleep restriction studies have confirmed that sleep deficits directly cause impairments in adolescents' academic abilities (Beebe, Rose & Amin, 2010). Sleep deficits also puts adolescents at risk for mental health disorders and emotional problems, increased impulsive and risk-taking behaviour and may also impact physical health (Shochat et al., 2014). Research to date highlights the immense impact that sleep can have on an adolescents' psychological and physical

health, showing that it is important that adolescents receive an adequate amount of sleep each night.

Given the number of negative consequences that can result from sleep problems, it is critical to have effective interventions targeting sleep practices. In person clinical sleep interventions typically include psychoeducation, cognitive behavioural therapy and stimulus control, along with other behavioural strategies (Hendricks et al., 2014). This usually involves between six to ten weekly 90-100 minute in-person or group therapy sessions. Systematic reviews have found that clinical interventions result in meaningful improvements in various aspects of sleep such as total sleep time (TST), sleep onset latency (SOL), sleep quality as well as daytime functioning, coping, and wellbeing (Hendricks et al., 2014). However, there are significant barriers in treatment delivery for these programs as they demand a large amount of resources and time, and are limited in that they cannot treat a large sample of adolescents with sleep problems at one time (Ström, Pettersson, & Andersson, 2004).

eHealth interventions (i.e., health services and information delivered via the internet) may help to reduce barriers to treatment and increase access to interventions. With the ongoing advances in technology and adolescents' widespread use and access to the internet, the creation and use of eHealth education programs are on the rise (Docebo, 2014). Many studies have demonstrated that delivering sleep interventions via the internet is an effective method of improving sleep in adults. A meta-analysis by Seyffert et al. (2016) examined 15 randomized controlled trials in adults (ages 16 and over) using Cognitive Behavioural Therapy for Insomnia (CBT-I). Internet-delivered CBT-I was found to be effective in improving insomnia symptoms, total sleep time, sleep onset latency, sleep efficiency and wake time after sleep onset. When examining long term effects, a decline in the severity of insomnia was maintained over a long follow-up period.

There are only two published eHealth sleep interventions that have been evaluated for use with adolescence. A pilot study by Werner-Seidler et al. (2019) examined the effects of an insomnia intervention for adolescents (12-16 years) delivered via a smartphone application. The intervention included psychoeducation, stimulus control, sleep hygiene and sleep-focused cognitive therapy across six sessions. The intervention was designed following a participatory design and focus groups were held prior to the development of the mobile phone application. It was found that insomnia symptoms significantly improved following completion of the intervention as did sleep quality. A second study by deBruin, Bogels, Oort, and Meijer (2015) compared the effects of in-person group treatment to an internet-based sleep intervention. Their online sleep intervention included psychoeducation, sleep hygiene, restriction of time in bed, stimulus control, cognitive therapy, and relaxation techniques across six weeks. Participants had to log into a website at a specified time to review their sleep diaries and consult with a psychologist before completing automatic exercises such as movies and questionnaires with automated feedback. It was found that compared to wait list controls, both therapies reported significant improvement in sleep efficiency, time to fall asleep, waking during the night, and total sleep duration (deBruin et al., 2015). No significant differences were found between the in-person or internet-delivered treatment, highlighting the utility of online sleep interventions for adolescents.

While research on the use of eHealth sleep interventions in adolescence is a relatively new topic of research, eHealth sleep interventions targeting change in other physical and mental health problems have been demonstrated to be effective with adolescents (Wantland et al., 2004) and eHealth sleep interventions have been found to be effective in adults (Seyffert et al., 2016). However, the evidence for use of eHealth interventions for treating sleep in adolescence is insufficient as there are currently only two published studies. Moreover, one of the interventions

(deBruin et al., 2015) did not follow a user-centered design and was simply an adapted version of in person CBT-I. The current study aims to expand on this body of research by evaluating a new eHealth sleep intervention, *Better Nights Better Days- Youth (BNBD-Youth),* which was developed using a user-centered participatory research that ensured that user preferences were incorporated into the program (Glasgow et al., 2004).

Developing an engaging and effective eHealth sleep intervention is not as simple as putting existing interventions on the internet (Skeels & Pratt, 2008). It is important to bridge the gap between researchers and users through a user-centered participatory research design (Skeels & Pratt, 2008), as incorporating user preferences when designing eHealth programs is predicted to increase use of the application (Glasgow et al., 2004; Johnson, Johnson, & Zhang, 2005). As such, potential users as well as relevant stakeholders, have been involved in the development of *BNBD-Youth* from the beginning.

To inform program development of *BNBD-Youth* in consideration of the user, focus groups were held with adolescents and stakeholders. The focus groups revealed that adolescents desired an interactive program that they can use when they want, for short periods of time. Following the focus group study, *BNBD-Youth* was created combining the users' ideas and preferences with existing research evidence and clinical best practice interventions for managing sleep problems (sleep deficits and insomnia-like symptoms). The aim of the program is to educate adolescents on healthy sleep practices to improve sleep behaviours that influence sleep outcomes.

Based on feedback from the focus groups, the treatment program is delivered using a microlearning delivery approach, which delivers content through short, interactive and engaging methods. The intervention is organized into 4 sessions and content includes psychoeducation about sleep, effective healthy sleep practice strategies, and behavioural sleep interventions, as

well as goal setting, session plans and a sleep diary to allow participants to track their sleep and sleep habits over time. The first session educates adolescents on sleep and its importance. In session 2, participants learn about various sleep measures and disorders while relating this information back to their current sleep habits. The session ends with a bedtime calculator and there is one-week delay to implement this bedtime before session 3 begins. Session 3 of *BNBD-Youth* covers the healthy sleep practices and adolescents develop their own personalized sleep plan to help them better their sleep. There is one again the one-week delay for participants to implement these strategies. Finally, the program ends with session 4 where adolescents further plan and prepare for better sleep and what to do when they encounter roadblocks to such a behaviour change.

The next steps in program development and evaluation was to conduct usability testing of *BNBD-Youth* with potential end-users. Usability testing is an important step in the development of an intervention to ensure they are user-friendly, accessible, and result in user satisfaction (Rubin & Chisnell, 2008). Peter Morville's user experience honeycomb model (Morville & Sullenger, 2010) defines the user experience in consideration of multiple dimensions related to the usability of an eHealth program including the usefulness, usability, findability, desirability, value, accessibility, and credibility (see Table 2 for category descriptions). These variables contribute to the overall experience of the user and their satisfaction and are thus important to evaluate at this time (Morville & Sullenger, 2010).

The current usability study required participants to complete the full eHealth *BNBD-Youth* program, and to provide feedback on each of the sessions, as well as feedback on the program as a whole. It was predicted that there would be high ratings in all of the categories of the user experience honeycomb model across each session feedback questionnaire as well as the program feedback questionnaire. Likewise, it was predicted that there will be a high level of user

satisfaction and that *BNBD-Youth* will be rated as ready for use by adolescents with sleep problems. Key features of the sessions and overall program were believed to also be strongly endorsed by participants. These hypotheses were made due to the user-centered participatory research design that was taken during the program development stage. Results from the usability testing will be used to inform any final modifications needed to the program prior to a trial to establish the interventions efficacy.

Methods

Participants

Adolescents were eligible to participate if they were between the ages of 14-18 years, experience symptoms of insomnia, had no diagnosed medical or mental health disorders, had access to the internet and an email account, were enrolled in a Canadian school, and could understand and speak English fluently. These eligibility criteria were ascertained via participant's self-report (see measures section below). The target number of participants was 20, as previous usability studies have found that 10 participants are sufficient for usability testing and recruiting 20 was thought to allow for drop-out.

Adolescent participants were recruited from across Canada via online advertisements on social media and relevant websites (e.g., Kijiji.ca, IWK Pulse, Facebook), print materials, word of mouth, and by contacting participants from the previous focus group study who indicated a willingness to be contacted for future studies on the consent form.

Measures

Eligibility Questionnaire. The eligibility questionnaire assesses inclusion and exclusion criteria. This was created by the study authors for the previous focus group testing. The questionnaire asked participants about their access to a computer with internet and email, the ability to speak and read fluently in English, and whether they have lived in Canada for the last

six months. In addition, participants were asked their age, if they were enrolled in a Canadian school, and it also assessed whether participants self-reported any hearing or cognitive deficits that would have interfered with participating in the intervention testing.

Insomnia Severity Index (ISI) (Morin et al., 2011). The ISI is a 7-item self-report questionnaire with possible scores ranging from 0-28. Questions asked about the severity of sleep onset, sleep maintenance and early morning wakening problems, sleep dissatisfaction, interference of sleep difficulties with daytime functioning, noticeability of sleep problems by others, and distress caused by the sleep difficulties. The Insomnia Severity Index shows high internal consistency (Cronbach $\alpha = 0.90$) and high convergent validity ($r = 0.80$, $P < 0.05$) (Morin et al., 2011). In order to participate in the study, participants had to meet the sub-threshold (scores from 8-12) or clinical insomnia range (scores 15-28). Participants that scored no clinically significant insomnia (scores < 8) were excluded from the study.

Sleep Hygiene Index (SHI) (Mastin, Bryson, & Corwyn, 2006). The SHI was administered to describe the participant's current sleep behaviours and practices prior to completing the intervention. The index consists of 13 items and asked participants to indicate how frequently they perform certain behaviours thought to be important for healthy sleep practices, such as daytime naps, irregular sleep routine, and use of caffeine within four hours of going to bed. Answers were provided through selecting one option from a five-point scale. These scores were summed resulting in a global sleep hygiene score ranging from 13 to 65, where higher scores indicate poorer sleep hygiene. The Sleep Hygiene Index has been found to have moderate internal consistency (Cronbach $\alpha = 0.66$), which is superior to other sleep hygiene questionnaires (Mastin et al., 2006). The test- retest reliability over a five-week interval is good ($r = 0.71$, $P < 0.01$) (Mastin et al., 2006).

Demographic Questionnaire. The demographic questionnaire, created by the study authors for the previous focus group testing, was used for the current study. The demographic questionnaire asked participants to report their age, sex, type of community, as well as city and province in which they live, their ethnic or cultural heritage, what grade they were in, their employment status and title of any work positions.

Usability Measures. The Session Feedback Questionnaire consists of 24 closed-ended and 9 open-ended questions (total = 33 questions) and was administered at the end of each of the four *BNBD-Youth* session. The Program Feedback Questionnaire consists of 40 questions (30 closed-ended and 10 open-ended) and was administered once the participant completed the program in its entirety. The questionnaires ask about the usefulness, usability, findability, desirability, value, accessibility, and credibility of the *BNBD-Youth* session/program. Participants were asked to indicate how much they agree with each statement using a 5-point likert-scale (Strongly Agree, Agree, Neither Agree or Disagree, Disagree, Strongly Disagree), as well as to elaborate on what they thought was working well and what they think may need to be changed via open ended questions. The questionnaires also asked about participants' impressions of the program's features such as videos, activities, and tracking sleep through diaries. The questionnaire is based on Peter Morville's user experience honeycomb model (Morville & Sullenger, 2010) and adapted from questions used in a previous usability study evaluating the *BNBD* intervention conducted in Dr. Penny Corkum's research laboratory lab (Isaacs et al., 2018; Tan et al., 2016; Speth et al., 2015).

Procedure. Ethics clearance was gained from IWK Health Centre and Mount Saint Vincent University. All advertisements directed interested participants to an online survey hosted on Opinio to complete the eligibility questionnaire. At this time, participants also completed the ISI. If participants did not meet the eligibility criteria, they were informed and redirected to an

exit page. If participants met the eligibility criteria, they were directed to an online consent form. Informed, electronic consent preceded participation in the study.

Once consent was obtained from eligible participants, they were assigned a unique participant ID and were directed via email communications to complete the demographic questionnaire. At this time, participants also completed the SHI to gather descriptive information about their current sleep behaviour prior to completing the *BNBD-Youth* intervention program.

Participants were then given access to the intervention for up to six weeks. Participants completed the session feedback questionnaire after each of the four program sessions. Further, participants completed the overall program feedback questionnaire after completion of the entire program to gather feedback on their overall experiences.

Adolescent participants were provided with reimbursement via an Amazon.ca gift card based on the number of tasks that they completed. Participants received $5.00 for each usability measure completed (4 sessions + overall feedback) for a maximum of $25.00, as well as $10.00 for completing the one-week pre- and post- sleep diary for a maximum of $20.00, and an additional $15.00 bonus if all diaries and measures were completed contributing to a potential overall maximum of $60.00 per participant.

Data Analysis

Demographics. Descriptive statistics using frequency counts and percentages were used to analyze the data from the demographic questionnaire. The ISI and SHI questionnaires were summed and averaged.

Usability Testing. Means, standard deviations, and ranges were used to summarize the closed-ended questions of the session and program feedback questionnaires. Each of the suggestions on the open-ended questions regarding how *BNBD-Youth* could be improved were analyzed and coded using directed content analysis, which allows coding to be made within an

existing framework, in this case, Morville's honeycomb categories: usefulness, usability, findability, desirability, value, accessibility, and credibility (Morville & Sullenger, 2010). Two coders independently coded the comments for themes, and inter-rater reliability was calculated by looking at percent agreement between raters. Qualitative data (i.e., open-ended questions) was analyzed using Microsoft Word and Microsoft Excel.

Results

Participants. The participants' demographic characteristics are detailed in Table 3. Of the 39 participants that were recruited and consented to participate, 30 completed the demographics questionnaire but only 8 participants completed at least one usability measure and were therefore included in the analysis. A high dropout rate of 79.5% will be reviewed in the discussion section. Of the 8 participants (7 females, 1 male) in the analysis, the average age was 15.5 years old (range: 14 to 17) and there was representation from grades 8 to 11. These participants were from four different provinces (Nova Scotia, Quebec, Ontario and Alberta), and were mostly Caucasian (n = 5). Based on the ISI, 3 participants scored within the subthreshold range, 4 within the clinical insomnia (moderate severity) range, and 1 within the clinical insomnia (severe) range. Adolescents' current sleep habits, as assessed by the SHI, were within the upper half of the scale (mean score = 34.75), where higher scores indicate poorer sleep practices. Mean school start and end times, as well as extra-curricular times were consistent with previous research examining these factors in Canadian schools (Gariépy et al., 2016). In comparing these participants with the participants who did not complete usability measures, no major differences were noted in terms of age, grade, geographical location, severity of insomnia symptoms, and healthy sleep practices. However, the non-completers were more likely to be male (15 males and 7 females), and non-Caucasian.

Usability Questionnaire. For the purpose of better understanding the results, the quantitative and qualitative results will be integrated together, below, organized by session. Average ratings for all of the usability categories for each session and overall are presented in Table 4. Ratings for the key program features for each session and overall are reported in Table 5. Of the 8 participants that completed usability questionnaires, 6 provided feedback on session 1, 6 provided feedback on session 2, 5 provided feedback on session 3, 5 provided feedback on session 4 and 6 provided feedback on the overall *BNBD-Youth* program. In interpretation of 5-point Likert scale, scores of 4 or 5 were considered to be positive, scores of 3 and 4 were considered neutral, and scores of 1 or 2 were considered negative.

Qualitative data were coded by two raters. Codes were sorted into the pre-existing honeycomb categories (usefulness, usability, findability, desirability, value, accessibility, and credibility) (Morville & Sullenger, 2010). Four new codes were added to the coding guide: technology issues, liked features, disliked features and suggestions for improvement. Once this coding guide was agreed upon, inter-rater reliability was assessed at 88.37% agreement.

Session 1. Participants rated session 1's usability, desirability, value, accessibility, credibility, and findability as positive. The only non-positive rating was the neutral rating of usefulness *(M* = 3.58, *SD* = 1.08). Participants felt as though the session was easy and quick to use (e.g., "*I had no problem working through the session"* and "*Easy to use, emails were very helpful. To enter sleep diary was very fast").* The findability of the session was also highly endorsed both by quantitative ratings and qualitative comments (e.g., "*information was easy to access"*) as was the accessibility (e.g., "*Very simple which made understanding it very easy"* and "*Easy interface. Clear information"*). Adolescents found the session highly desirable (e.g., "*Website looked good and professional")* however some comments were made on how to improve this area (e.g. "*Shorter information will be better."* and "*The appearance was missing*

something…"). While the information was rated as highly credible (e.g., "*Anything with DAL involved would seem reputable"*) it was suggested that sources of information be included within the program itself to improve the credibility. It also appears as though the adolescents learned something of value (e.g., "*I understand that I am not sleeping enough on school nights"*). Despite the neutral rating in the usefulness category, qualitative data was largely positive with some comments on how to improve the session (e.g., "*The visuals and mini games were very useful. Having more of those would make it the most successful!"* and "*I like the short videos and schemas. Diary is a little boring!"*). One key feature in session 1, the "Are you a lark or owl" quiz, participants indicated this helped them better understand their natural sleep timing. Overall, participants were highly satisfied with session 1 and rated the session as ready for use by adolescents experiencing sleep problems ($M = 4.67$, $SD = 0.52$).

Session 2. Similar to session 1, the usability, desirability, value, accessibility, credibility, and findability of session 2 were rated as positive, and the usefulness of the session was neutral ($M = 3.83$, $SD = 0.83$). Participants found this session of *BNBD-Youth* easy to use (e.g., "*Very easy access and took about 2 min per day"*) and well organized (e.g., "*Everything was labelled and had no problem finding the diary's and sessions"*). Participants also reported enjoying session 2 and its content (e.g., "*I find sleep interesting so yes, the information was intriguing"*). Based on comments across the categories, at this stage of the program the participants were learning new information and beginning a journey towards improving their sleep (e.g., "*I learned new info but I am still on route to improving my sleep"* and "*It [is] helping me to fix my small goals and gives me hope to sleep better").* In terms of the sessions usefulness, it appears as though participants learned new information but were unsure how to use it to reach their sleep goals (e.g., "*I learned things however I don't know how much it would help me really reach my sleep goals*" and "*I'm not sure it is true for everyone"*). Specific ways to improve the session

were noted including having access to the entire program at once, including more basic information and reducing the number of diagrams within the session. In terms of key features of session 2, participants agreed that reviewing their sleep diary data as well as completing a questionnaire to measure their sleep quality helped them better understand their sleep problems, however they felt neutral towards completing the Sleep Hygiene Index within the session. Overall, participants were highly satisfied with session 2 and felt as though it was ready for use (M = 4.17, SD = 0.75).

Session 3. Session 3 was positively endorsed across the dimensions of usefulness, usability, accessibility, credibility, and findability. The desirability (M = 3.70. SD = 1.06) and value (M = 3.90, SD = 0.57) were rated as neutral. Participants found the session to be easy to navigate (e.g., "*Quite useful and easy to use"*) and found the information easy to understand (e.g., "*Lessons were easy to understand and simple to learn from"*). Participants enjoyed the appearance of the session which resulted in user satisfaction (e.g., "*The look of the website was professional and helped me to enjoy the course more"*) and participants appeared to be learning more about their sleep, and how to improve it (e.g., "*I learned a lot about sleep and how important it is along with what factors contribute to sleep quality"* and "*It was the most helpful session…. I got many suggestions and I have a lot of work!"*). Despite this positive feedback, the desirability and value of the session, were rated lower than the other categories. Feedback was provided on ways to improve the session in these areas including reducing the amount of text, making the relaxation exercises more appealing to a younger audience and shortening the session. Some participants reported technical issues with the session including the site crashing and error messages, which may have contributed to the lower ratings of this session. In terms of the key features that were evaluated for session 3, participants positively endorsed the personalized feedback on the ABCs of SLEEPING as well as the sleep plan that was developed

throughout the session (e.g., *"I like the personal suggestions that the programs sends me"*). The rating of readiness for use was neutral (*M* = 3.80, *SD* = 1.30); however, participants were highly satisfied with this session as a whole (*M* = 4.20, *SD* = 0.44).

Session 4. The usability, value, accessibility, credibility, and findability of session 4 were rated as positive, and the usefulness (*M* = 3.90, *SD* = 1.10) and desirability (*M* = 3.80, *SD* = 1.14) of the session were neutral. Once again, participants found the session easy to use and the information was accessible to the adolescents (e.g., *"Fast and easy for me to use. Rarely felt confused and out of place"*). Participants found the information to be interesting and they appeared to enjoy working through the program (e.g., *"The lessons were intriguing and the website also looked well put together which wanted me to do it more.")*. Through exploring the qualitative comments across the usability categories, participants demonstrated that they were learning a lot of new and useful information (e.g., *"I understood what was wrong with my sleep and how to fix it…"* and *"I learned a lot that I didn't know before about sleep"*) however, in terms of the usefulness, it appears as though some participants were still struggling to make progress with improving their sleep (e.g., *"A little upset about my progress but I still need time to change my patterns"* and *"… I have a hard time with the actual fixing part"*). There were some additional suggestions made on how to improve the desirability of the session including changing the colours of the content and shortening the length of the sessions. There were neutral feelings towards both key features evaluated, including the outside resources (*M* = 3.00, *SD* = 1.00) and the roadblocks (*M* = 3.40, *SD* = 0.89) lessons. Despite this, there was a high rating of satisfaction (*M* = 4.40, *SD* = 0.55) with this session of *BNBD-Youth* and participants indicated that the session was generally ready for use.

Overall Program. Participants also rated the overall program as a whole following completion of *BNBD-Youth*. The program was positively endorsed across the usefulness,

desirability, value, accessibility, credibility and findability dimensions, with neutral feelings towards the usability (M = 3.90, SD = 1.10). Participants reported that through the program, they learned more about their sleep and how to improve it (e.g., *"I understand how I can improve my sleep not only by amount of time but by quality"*). The program was reported as easy to navigate and the information was easy to understand (e.g., "*super easy to use and wasn't complicated*") and participants found the program to be visually appealing (e.g., *"I liked the way the program looked on the screen"*). Participants reported that they had learned a lot of new, useful and credible information (e.g., *"I now know more about sleep than I did before"* and *"I can trust the information I am being provided with"*). Within the opened ended questions of the program feedback questionnaire, several suggestions for improvement were noted including simplifying language, shortening questionnaires/surveys, reducing the amount of text and adding more colour to the design. Participants also positively endorsed key features of the program such as the sleep diary, the videos educational value and the email reminders. There were neutral feelings towards the interactive features (e.g., games, videos, quizzes) as well as the length between sessions 2 and 3 and sessions 3 and 4. Some felt that it was too long to wait one week to move onto the next session and they just wanted to continue without time to implement sleep positive strategies. Participants agreed that they were satisfied with the program (M = 4.33, SD = 0.82) and that it was ready for use by adolescents with sleep problems (M = 4.60, SD = 0.55).

In summary, it was found that there was a high level of satisfaction with *BNBD-Youth* at this stage of program development. There were positive ratings for the findability, credibility, accessibility and satisfaction categories for each *BNBD-Youth* session and for the overall program. Across the sessions, usefulness was the category with the lowest scores, however it was more positively endorsed when participants evaluated the overall program as a whole. It is also

important to note that there were no negative evaluations of *BNBD-Youth* and that there were only 7 neutral ratings out of a total of 45 ratings (15%).

Discussion

The purpose of the current study was to gain feedback from potential-end users on a newly developed eHealth sleep intervention for youth, *BNBD-Youth*. Participants were asked to complete the *BNBD-Youth* program in its entirety while providing their feedback on the content of each of the four sessions, key features, and implementation, as well as on the overall program. The results of the study indicate that *BNBD-Youth* was generally well received by adolescents. There was a high level of positive feedback, as 85% of ratings were positive and 15% of ratings were neutral with no negative ratings. These results are similar to the usability study of the original *BNBD* program (Speth et al., 2015) which is encouraging at this early stage of development.

The amount of positive feedback and user satisfaction can be attributed to the user-centered participatory research design used to develop this intervention (Skeels & Pratt, 2008). Past research shows that incorporating user preferences when designing online programs increases use and satisfaction of the application (Glasgow et al., 2004; Johnson Johnson & Zhang, 2005), and through our previous focus group study we were able to gain a variety of useful ideas and inspiration that lead to the creation of *BNBD-Youth.* Several interactive and key features of the *BNBD-Youth* program were positively endorsed by participants including the sleep diary, videos, the development of a personalized sleep plan with tailored feedback and interactive features such as quizzes and games.

While participants reported that they were learning new information, and they were satisfied with the program, several participants reported that they were having trouble actually improving their sleep. While a future pilot study is needed to properly assess the effectiveness of

BNBD-Youth, comments of this nature first appeared in the session 2 feedback questionnaire. Treating adolescent sleep problems is challenging due to the various factors that compete for sleep time. These behaviour changes are often dependent on what adolescents are willing to do and what motivates them to make a change (Blunden et al., 2012). There are several roadblocks including the biological phase shift in circadian rhythms (Leger et al., 2012) and psychosocial factors (Kaur & Bhoday, 2017). While it is important to treat sleep problems in adolescence, the reports from our participants reflect the challenges past researchers have faced in creating change, and this highlights that this lack of progress may not be because of the *BNBD-Youth* program and instead be due to the aforementioned factors.

Despite these challenges, there are several ideas to consider from our participants' comments in terms of moving forward with *BNBD-Youth*. The first being the level of support provided by the program itself. Support (e.g., consultation time with a therapist/psychologist) is an important aspect to consider when developing an eHealth sleep intervention as support can affect website use, which can in-turn affect symptom improvement (Ritterband et al., 2009). The study by deBruin et al. (2015) provided support and this strategy proved to be effect in creating a sleep behaviour change in adolescents. While a decision was made to not include formal support in *BNBD-Youth*, it may be useful to require participants to use the sleep diary within the program to progress onto the next session as this was only encouraged and not required in *BNBD-Youth*. This is a strategy used in the existing *BNBD* programs and requiring use may help adolescents track their improvement and provide them with personalized feedback. The self-guided microlearning approach taken with *BNBD-Youth* allowed us to create an engaging intervention that adolescents can work through at their own pace. It will also allow us to reach many more individuals who need such an intervention in comparison to traditional intervention options. However, this form of intervention has a history of low adherence (Michie et al., 2017), and

lacks the support that other interventions have to offer. It is important to properly assess the efficacy of *BNBD-Youth* to make concrete conclusions.

Another important aspect to consider when thinking of creating a sleep related behaviour change is the length of time. While we do not know for sure if our participants made progress with the sleep goals or not, it is possible that six weeks was not enough time for adolescents to create positive behaviour changes and they need more time with the intervention. This cannot be determined until a proper pilot study is conducted.

This research has a number of practical implications. This usability study emphasizes why it is important to conduct different forms of research at different stages of the development of an eHealth intervention (Majid, Noor, Adnan, & Mansor, 2010; Skeels & Pratt, 2008), as doing this has allowed us to design an engaging intervention for adolescent sleep problems. This work can be used by other researchers when they are developing eHealth interventions for adolescents, as it provides ideas on what users want in such a program. The hope this that eHealth can be an effective method of treatment delivery that can overcome the barriers of traditional intervention.

This study also advances the field of adolescent eHealth sleep interventions as there are currently only two published programs. Together, our results that show a high level of satisfaction with this treatment delivery form, along with the positive results assessing the efficacy of the other existing interventions for adolescents (deBruin et al., 2015; Werner-Seidler et al. 2019) demonstrate that eHealth very well could be an engaging and effective form of sleep intervention for adolescents.

From the perspective of a practitioner, having self-guided, eHealth interventions can support the work of clinicians across many different disciplines. These interventions allow the simultaneous treatment of a large number of individuals with minimal demand on the health care

system. From a more specialized scope, the primary focus of a school psychologist is on learning and behaviour, however sleep plays an important role in both (Shochat et al., 2014). If school psychologists are more aware of the various sleep problems that occur in adolescence, and the impact that this can have on a client's cognitive and academic performance, it can improve their practice. As well, if school psychologists have access to a program like *BNBD-Youth* they could refer to it when working with their clients to help them improve their sleep, while treating a large number of adolescents at once. This can have a positive impact not only on the client's school performance, but also on their daily functioning.

There are several limitations to the current study. The first being the small sample size. As previously mentioned, a total of 39 eligible participants consented to participate in the study; however, only 8 completed at least one usability measure resulting in a dropout rate of 79.5%. This is higher than the dropout rate of the previous usability study for the original *BNBD* program (Speth et al., 2015) and is much higher than the 72% retention rate in Werner-Seidler et al.'s 2019 pilot study with an adolescent population. This can be attributed to a number of factors. The first being that this usability study was part of a larger study that included pilot testing, which required participants to track their sleep for one week prior to receiving access to the *BNBD-Youth* intervention. A large number of participants (n = 19; 48.72%) did not complete the one week external sleep diary and therefore did not receive access to *BNBD-Youth*. There was then further drop out (n = 12; 30.77%) throughout the time that participants had intervention access. Some participants (n = 2; 5.13%) never logged into *BNBD-Youth* after receiving their log in information, while others (n = 10; 25.64%.) failed to complete the program and usability questionnaires despite multiple reminders. There were many technological issues that occurred in the first week of *BNBD-Youth* going live that may have resulted in frustration in the user and contributed further to the drop out. At one point, participants were spammed with over 20 emails

at once due to a flaw in the programming. Other issues included participants not being able to access the tutorial upon first log in and therefore not being able to start the program, not being able to log in altogether, and sessions not automatically unlocking for participants. It is hypothesised that these issues discouraged some participants from using the program.

In comparing the participants that consented but did not complete the study, with the 8 participants included in our analysis, it appears as though males, specifically non-Caucasian males, were more likely to drop out of the study. It may be possible that the program was not engaging to these populations. Interestingly enough, participants in the previous focus group study that was used to inform program development were more likely to be female with only 29% of participants being male. Perhaps the perspectives we gained from that study and incorporated into *BNBD-Youth* were more suited to a female perspective. It does not appear that other participant characteristics (e.g., insomnia symptoms, sleep practices, age, location or school and extracurricular start/end times) contributed to the drop out as there were no major differences between the groups upon examination. Our sample in the current study was also primarily female Caucasians. A more diverse study population would make the results of the study more generalizable and it would be preferable to have a variety of ethnicities and a balance of male and female participants. A final limitation of the study is that not all participants completed all usability measures. This is a limitation because we do not have consistent feedback across all sessions of the program.

The results of this study will be used to inform any modifications and edits to the current *BNBD-Youth* program before assessing its preliminary efficacy. While during the development of *BNBD-Youth*, we incorporated the feedback gained from the previous focus group study as much as possible, the results of the usability study will allow us to further tailor the program to the preferences of the user. It appears that adolescents want a program that is shorter, with

minimal text, and a multitude of interactive features; whether these be games, quizzes or educational videos. The hope is that this eHealth intervention can be an effective method of treatment delivery for adolescent sleep problems that can overcome the barriers of traditional intervention. Current interventions available to treat sleep problems are often inaccessible, costly and time consuming and the use of the internet would allow for a more accessible and cost-effective way to deliver sleep intervention.

Table 2. Peter Morville's User Experience Honeycomb Model (Morville & Sullenger, 2010).

Honeycomb Category	Description
Usefulness	Usefulness refers to the purpose of the program and if it is fulfilling a need.
Usability	Usability refers to the simplicity of the program and how easy it is to use. Programs and websites should be designed in such a way that the user should experience a short and painless learning curve.
Findability	Findability is centered around how findable the information is within the website and how easy it is to navigate to find this information.
Desirability	Desirability includes the image, identity and brand of a program, which should be attractively designed.
Value	Value refers to assessing if the program and the information is advancing it's mission and goals.
Accessibility	Accessibility refers to if the information is easy to understand, and if people of different levels of ability are able to access the information via different methods.
Credibility	Credibility is an important variable to consider, as the information needs to be trustworthy.

Table 3. Demographic Characteristics of Participants

Characteristic	In Analysis (n = 8)	Not in Analysis (n = 22)
Gender n (%)		
Male	1 (12.5%)	15 (68.2%)
Female	7 (87.5%)	7 (31.8%)
Age *M (SD)*	15.5 (1.2)	15.7 (1.2)
Grade n (%)		
Grade 8	2 (25.0%)	1 (4.5%)
Grade 9	1 (12.5%)	9 (40.1%)
Grade 10	2 (25.0%)	3 (13.6%)
Grade 11	3 (37.5%)	4 (18.2%)
Grade 12	-	5 (22.7%)
Province n (%)		
Nova Scotia	3 (37.5%)	6 (37.5%)
New Brunswick	-	1 (4.5%)
Quebec	1 (12.5%)	2 (9.1%)
Ontario	3 (37.5%)	10 (45.5%)
Alberta	1 (12.5%)	1 (4.5%)
British Columbia	-	2 (9.1%)
Ethnicity n (%)		
White/Caucasian	5 (62.5%)	18 (81.8%)
Chinese	2 (25.0%)	-
South Asian	-	2 (9.1%)
Aboriginal	-	1 (4.5%)
Tibetan	-	1 (4.5%)
Mixed Race	1 (12.5%)	-
Insomnia Severity Index *M (SD)*	16.75 (5.1)	16.95 (5.4)
Min - Max	11 - 26	9 - 26
Sleep Hygiene Index *M* (*SD)*	34.75 (5.3)	35.91 (6.3)
Min - Max	26 - 43	18 - 47
School Start Time *M (SD)*	8:22 a.m. (44 minutes)	8:05 a.m. (45 minutes)
Min - Max	7:00 a.m. - 9:05 a.m.	7:00 a.m. - 9:15 a.m.
School End Time *M (SD)*	2:56 p.m. (22 minutes)	3:36 p.m. (1h 49 minutes)
Min - Max	2:15 p.m. - 3:25 p.m.	2:15 p.m. – 4:00 p.m.
Extra-Curricular Start Time *M (SD)*	9:50 a.m. (4h 19 minutes)	10:40 a.m. (5h 6 minutes)
Min - Max	6:00 a.m. - 5:00 p.m.	4:55 a.m. - 6:00 p.m.
Extra-Curricular End Time *M (SD)*	7:51 p.m. (2h 27 minutes)	6:52 p.m. (2h 32 minutes)
Min - Max	4:00 p.m. - 11:00 p.m.	3:00 p.m. - 11:00 p.m.

Table 4. Participants' Ratings of *BNBD-Youth* Usability Categories (*M*).

	Session 1 *M (SD)*	Session 2 *M (SD)*	Session 3 *M (SD)*	Session 4 *M (SD)*	*BNBD-Youth* Overall *M (SD)*
Honeycomb Category					
Usefulness	3.58 (1.08)	3.83 (0.83)	4.30 (0.82)	3.90 (1.10)	4.25 (0.45)
Usability	4.33 (0.49)	4.67 (0.49)	4.00 (0.94)	4.40 (0.70)	3.92 (0.90)
Desirability	4.08 (0.51)	4.92 (1.08)	3.70 (1.06)	3.80 (1.14)	4.25 (0.87)
Value	4.25 (0.62)	4.00 (1.13)	3.90 (0.57)	4.60 (0.70)	4.12 (0.72)
Accessibility	4.25 (0.62)	4.42 (0.67)	4.00 (0.94)	4.60 (0.52)	4.33 (0.89)
Credibility	4.08 (0.90)	4.50 (0.52)	4.30 (0.67)	4.60 (0.52)	4.67 (0.49)
Findable	4.44 (0.49)	4.00 (0.95)	4.50 (0.70)	4.80 (0.42)	4.42 (0.51)
General Feedback					
Satisfied	4.50 (0.55)	4.33 (0.82)	4.20 (0.44)	4.40 (0.55)	4.33 (0.82)
Ready for use	4.67 (0.52)	4.17 (0.75)	3.80 (1.30)	4.60 (0.55)	4.12 (0.75)

Note: Ratings were provided on a 5-point scale where 5 = strongly agree, 4 = agree, 3 = neither agree or disagree, 2 = disagree, 1- strongly disagree. Higher ratings indicate higher satisfaction.

Table 5. Participants' Ratings of *BNBD-Youth* Key Features

Feature	Rating *M (SD)*
Session 1	
Lark or Owl? Quiz	4.50 (0.55)
Session 2	
Reviewing sleep diary data	4.17 (1.17)
Sleep Hygiene Index	3.67 (1.03)
Sleep quality questionnaire	4.33 (0.52)
Session 3	
Personalized feedback on ABCs of Sleeping	4.00 (0.71)
Developing a sleep plan	4.20 (1.10)
Session 4	
Additional outside Resources	3.00 (1.00)
Roadblocks lesson	3.40 (0.89)
Overall Program	
Interactive features	3.67 (1.03)
Sleep diary	4.00 (1.26)
Sleep diary reminder emails	4.17 (1.60)
Liked the videos	3.67 (1.37)
Videos added educational value	4.33 (0.82)
Length of time between sessions	3.40 (1.35)

Note: Ratings were provided on a 5-point scale indicating that such features added educational value where 5 = strongly agree, 4 = agree, 3 = neither agree or disagree, 2 = disagree, 1- strongly disagree. Higher ratings indicate higher satisfaction.

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