Promoting Sleep Health in Children with Juvenile Idiopathic Arthritis and Their Parents Through Pilot Test, Evaluation of SLEEPSMART Intervention and Theory Reformulation

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Abstract

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Background: Sleep deficiency is highly comorbid in children with Juvenile Idiopathic Arthritis (JIA) and associated with poorer health-related quality of life, more arthritis symptoms, and healthcare utilization. Despite the prevalence of sleep deficiency in JIA, little attention has been given to supporting children and parents in managing it by enhancing their self-efficacy, problem-solving, and goal-setting skills. Guided by Social Cognitive Theory (SCT), Parent-Child Shared Management perspectives, and the Human-Centered Design (HCD) approach, we developed and pilot-tested the Sleep Shared-Management Intervention (SLEEPSMART) to support sleep health among JIA children and their families, reformulated SCT to inform future sleep interventions, and proposed a model to guide the design, development and evaluation of the behavioral interventions.

Purpose: The overall purpose of the dissertation was to understand how a novel technology-enabled sleep intervention RCT can better support JIA children's sleep and promote future sleep intervention through theory reformulation and HCD-based evaluation framework development.

Methods: The first part of the dissertation examined the feasibility, acceptability, and preliminary efficacy of SLEEPSMART among fifty 8 -13 years children with JIA and sleep deficiency and a parent. Forty-four parent-child dyads were randomized to the SLEEPSMART or control group: the SLEEPSMART group received a 6-week internet-delivered sleep coach-supported intervention, and the control group received routine clinical care. We used the percentage of eligible, enrolled, and retained dyads as feasibility, dyads who completed at least one module as engagement, and the Treatment Evaluation Inventory and dyads' exit interview for usefulness and acceptability. Sleep (total sleep time and sleep efficiency measured by actigraphy) and shared management (self-efficacy, self-regulation, and belief/attitude towards sleep) outcomes were examined at baseline, immediately post-intervention, and one-month post-intervention using Generalized Estimating Equations (GEE). When using SCT to guide the development of SLEEPSMART, we found SCT was rarely comprehensively analyzed and evaluated in the context of pediatric sleep health. To further understand SCT and advance sleep research, we used Fawcett's framework to analyze and evaluate SCT in the second part of the dissertation. We proposed a reformulation of SCT to better inform sleep research. To assess and refine the SLEEPSMART after pilot testing, we developed a conceptual model for evaluating technology-enabled behavioral intervention by integrating HCD and implementation science outcomes.

Results: Parent-child dyads perceived SLEEPSMART as feasible, acceptable, and useful. Of the 50 dyads enrolled, 88% completed the baseline, 80% completed all intervention modules and surveys, 88% achieved at least one module, 75% of children and 89% of parents reported high

acceptance, and 89% of parents and 80% of children would recommend SLEEPSMART to others. The main themes and subthemes of satisfaction, usefulness, and improvement that emerged from the exit interview highlighted the strengths and areas for future refinement. SLEEPSMART also significantly improved dyads' sleep, self-efficacy, and healthy sleep beliefs. In the second part of the dissertation, based on theory analysis and evaluation, SCT is a middle-range theory emphasizing the concept of cognition in executing behaviors. SCT addresses the metaparadigm nursing concepts of triadic determinism between people, behavior, and environment on the philosophical basis of human agency. The key concepts of SCT are self-efficacy, self-regulation, outcome expectation, and observational learning, nested within a contextualism worldview. SCT has overall strong theoretical foundations for explaining, predicting, and changing human behavior, and it has demonstrated considerable social significance and a powerful theoretical impact on nursing empirical research. However, SCT is individually focused and does not account for interdependence within relationships. We proposed reformulating SCT by integrating Parent-Child Shared Management (PCSM). PCSM is a concept that reflects the shared responsibility and interdependence that parent and child have for managing child health. SCT-SM informed interventions that engage parents and children in active roles in managing sleep have potential sustainable effects in improving sleep and quality of life. To evaluate the development process of SLEEPSMART, informed by usability and IS outcomes, we proposed a heuristic model that can guide the development and evaluation of interventions: the USIS model, in which Usability and IS are combined. USIS has five domains: 1) User-Centeredness (empathy, engagement, and equity), 2) Efficiency (cost, timeliness, and rapidity), 3) Feasibility (learnability, memorability, error reduction, low cognitive load), 4) Satisfaction (acceptability, appropriateness), and 5) Fidelity (adoption, penetration, sustainability). Applying USIS to evaluate SLEEPSMART, we

concluded that user-centeredness was prioritized throughout the design and development process using various HCD methods. The design decision based on users' input was consistently maintained and consolidated. One area that needs improvement is that participants should include diverse populations with diverse backgrounds and represent different cultural perspectives.

Conclusions: SLEEPSMART, the first technology-based sleep shared-management intervention for JIA children and their parents, is approved as feasible, acceptable, and effective in improving dyads' sleep and enhancing shared-management skills. By employing HCD approaches and PCSM, SLEEPSMART is promising to support pediatric sleep research in larger-scale trials. The reformulated SCT-SM allows researchers to better understand PCSM in pediatric sleep. We expect a sleep intervention guided by SCT-SM will improve sleep quality, enhance communication, and boost the capacity to manage chronic conditions in children and parents. We also anticipate that the reformulated SCT-SM has the potential to generalize to other pediatric chronic conditions by providing a framework for a better understanding of the shifting roles/responsibilities between parents and children. Towards the intervention evaluation and refinement, our newly developed USIS model offers specific tools to design better interventions and evaluate existing interventions to improve health innovations' translation into practice. We believe the USIS model offers a pathway for enhancing innovation advancement by incorporating the processes and tools from HCD and IS.

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Chapter 1. Introduction

Sleep deficiency, including inadequate quantity or quality of sleep, is highly comorbid in children with juvenile idiopathic arthritis (JIA), affecting an estimated 30% of children (Saidi et al., 2022; Tarakci et al., 2019; Ward et al., 2017). Prior studies show that sleep deficiency in children with JIA is associated with increased arthritis symptoms, more fatigue and pain, poorer health-related quality of life, and higher healthcare utilization (Allen et al., 2016; Armbrust et al., 2016; Butbul Aviel et al., 2011; Kuhlmann et al., 2016; Tarakci et al., 2019; Tsipoura et al., 2018; Valrie et al., 2013). Although sleep deficiency is recognized as a critical outcome for pediatric chronic pain management, sleep has rarely been targeted in nonpharmaceutical intervention studies (Palermo et al., 2021). Sleep is a missing piece in JIA management and often overlooked in clinical care.

Currently, most pediatric sleep interventions focus on the parent alone versus the parent and child together as a dyad, and the majority of interventions do not involve parents and children in the design and development (Ward et al., 2020a). Less is known about shared management, specifically how parents and children co-manage sleep problems, problem-solve, set goals and work through setbacks. A better understanding of how parents and children co-manage sleep could lead to better engagement in learning specific strategies to improve sleep (Sonney et al., 2020a; Tinker et al., 2020; Ward et al., 2020a). To gain a better understanding of how to effectively support sleep health in children with JIA and their parents, this dissertation involved a secondary analysis of a randomized controlled pilot study, Sleep Shared-Management Intervention (SLEEPSMART). SLEEPSMART was designed with a Human Centered Design (HCD) approach that involved children with JIA and their parents in the co-creation of the intervention design and development. SLEEPSMART sought to provide children with JIA and their parents the knowledge, motivation, and skills for setting and achieving goals, problem-

solving, and working through setbacks to improve their child's sleep. SLEEPSMART embedded key social cognitive theory constructs, including outcome expectations, self-efficacy, and self-regulation (Bandura, 1986). SLEEPSMART encourages child and parent activation by monitoring progress, setting new goals, and seeking the support they need as a team that provides children and parents the tools to ensure their continued success. As a result, the SLEEPSMART intervention sought to improve child sleep by modifying children's and parents' negative beliefs, increasing outcome expectations and self-efficacy, facilitating change in the social and physical environments, and encouraging the development of self-regulation.

In Chapter 3, I comprehensively analyzed and evaluated Social Cognitive Theory (SCT) in the pediatric sleep context using Fawcett's framework (Fawcett & Desanto-Madeya, 2012). SCT is a middle-range theory and has been a guiding framework in health promotion research as it helps understand people's behaviors (Bagherniya et al., 2018; Moeini et al., 2019; Tougas et al., 2015; Xiang et al., 2022; Zare et al., 2020). I advanced the argument that the parent-child shared management (PCSM) perspective is beneficial for understanding pediatric sleep health. PCSM assumes that with parents' ongoing support, children's responsibility for their health management increases over time, along with developmental progression and health-related experiences (Kieckhefer & Trahms, 2000; Sonney et al., 2020a). I proposed reformulating SCT by integrating PCSM in the pediatric sleep context: SCT with Shared Management (SCT-SM). In the future research, we believe that interventions that guided by SCT-SM engaging parents and children in active roles in managing sleep have potential sustainable effects in improving sleep and quality of life.

In Chapter 4, to assess and refine SLEEPSMART after pilot testing and informed by HCD and Implementation Science (IS) outcomes (Hermes et al., 2019; Lyon & Koerner, 2016;

Maguire, 2001; E. Proctor et al., 2011), we proposed a heuristic model to guide the design, development and evaluation of technology-enhanced interventions: the USIS model, in which Usability and IS are combined. USIS has five domains: 1) User-Centeredness (empathy, engagement, and equity), 2) Efficiency (cost, timeliness, and rapidity), 3) Feasibility (learnability, memorability, error reduction, low cognitive load), 4) Satisfaction (acceptability, appropriateness), and 5) Fidelity (adoption, penetration, sustainability). Applying USIS to evaluate SLEEPSMART, we found the strengths and areas for improvement for the SLEEPSMART project.

In each chapter, the study background, aims, methods, results, discussion of findings, and conclusion were successively presented, followed by the reference list. In the end, Figures and Tables were created to demonstrate the study results. In the last chapter, the main findings are synthesized along with a description of the implications of this work for future research and healthcare practice.

References

. Allen, J. M., Graef, D. M., Ehrentraut, J. H., Tynes, B. L., & Crabtree, V. M. (2016). Sleep and Pain in Pediatric Illness: A Conceptual Review. *CNS Neuroscience & Therapeutics*, *22*(11), 880–893. https://doi.org/10.1111/cns.12583

Armbrust, W., Siers, N. E., Lelieveld, O. T. H. M., Mouton, L. J., Tuinstra, J., & Sauer, P. (2016). Fatigue in patients with juvenile idiopathic arthritis: A systematic review of the literature. *Seminars in Arthritis and Rheumatism*, *45*(5), 587–595. https://doi.org/10.1016/j.semarthrit.2015.10.008

Bagherniya, M., Taghipour, A., Sharma, M., Sahebkar, A., Contento, I. R., Keshavarz, S. A., Mostafavi Darani, F., & Safarian, M. (2018). Obesity intervention programs among adolescents using social cognitive theory: A systematic literature review. *Health Education Research*, *33*(1), 26–39. https://doi.org/10.1093/her/cyx079

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory* (pp. xiii, 617). Prentice-Hall, Inc.

Butbul Aviel, Y., Stremler, R., Benseler, S. M., Cameron, B., Laxer, R. M., Ota, S., Schneider, R., Spiegel, L., Stinson, J. N., Tse, S. M. L., & Feldman, B. M. (2011). Sleep and fatigue and the relationship to pain, disease activity and quality of life in juvenile idiopathic arthritis and juvenile dermatomyositis. *Rheumatology (Oxford, England)*, *50*(11), 2051–2060. https://doi.org/10.1093/rheumatology/ker256

Hermes, E. D., Lyon, A. R., Schueller, S. M., & Glass, J. E. (2019). Measuring the Implementation of Behavioral Intervention Technologies: Recharacterization of Established Outcomes. *Journal of Medical Internet Research*, *21*(1), e11752. https://doi.org/10.2196/11752

Kieckhefer, G. M., & Trahms, C. M. (2000). Supporting development of children with chronic conditions: From compliance toward shared management. *Pediatric Nursing*, *26*(4), 354–363.

Kuhlmann, A., Schmidt, T., Treskova, M., López-Bastida, J., Linertová, R., Oliva-Moreno, J., Serrano-Aguilar, P., Posada-de-la-Paz, M., Kanavos, P., Taruscio, D., Schieppati, A., Iskrov, G., Péntek, M., Delgado, C., von der Schulenburg, J. M., Persson, U., Chevreul, K., Fattore, G., & The BURQOL-RD Research Network. (2016). Social/economic costs and health-related quality of life in patients with juvenile idiopathic arthritis in Europe. *The European Journal of Health Economics*, *17*(1), 79–87. https://doi.org/10.1007/s10198-016-0786-1

Lyon, A. R., & Koerner, K. (2016). User-Centered Design for Psychosocial Intervention Development and Implementation. *Clinical Psychology : A Publication of the Division of Clinical Psychology of the American Psychological Association*, *23*(2), 180–200. https://doi.org/10.1111/cpsp.12154

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies*, *55*(4), 587–634. https://doi.org/10.1006/ijhc.2001.0503

Moeini, B., Bashirian, S., Soltanian, A. R., Ghaleiha, A., & Taheri, M. (2019). Examining the Effectiveness of a Web-Based Intervention for Depressive Symptoms in Female Adolescents: Applying Social Cognitive Theory. *Journal of Research in Health Sciences*, *19*(3), e00454.

Proctor, E., Silmere, H., Raghavan, R., Hovmand, P., Aarons, G., Bunger, A., Griffey, R., & Hensley, M. (2011). Outcomes for implementation research: Conceptual distinctions,

measurement challenges, and research agenda. *Administration and Policy in Mental Health*, *38*(2), 65–76. https://doi.org/10.1007/s10488-010-0319-7

Saidi, O., Rochette, E., Bourdier, P., Ratel, S., Merlin, E., Pereira, B., & Duché, P. (2022). Sleep in children and adolescents with juvenile idiopathic arthritis: A systematic review and meta-analysis of case-control studies. *Sleep*, *45*(2), zsab233. https://doi.org/10.1093/sleep/zsab233

Sonney, J. T., Thompson, H. J., Landis, C. A., Pike, K. C., Chen, M. L., Garrison, M. M., & Ward, T. M. (2020). Sleep intervention for children with asthma and their parents (SKIP Study): A novel web-based shared management pilot study. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *16*(6), 925–936. https://doi.org/10.5664/jcsm.8374

TARAKCI, E., ARMAN, N., BARUT, K., ŞAHİN, S., & KASAPÇOPUR, Ö. (2019). Fatigue and sleep in children and adolescents with juvenile idiopathic arthritis:a cross-sectional study. *Turkish Journal of Medical Sciences*, *49*(1), 58–65. https://doi.org/10.3906/sag-1711-167

Tinker, E. C., Garrison, M. M., & Ward, T. M. (2020). Development of the Sleep Health in Preschoolers (SHIP) intervention: Integrating a theoretical framework for a family-centered intervention to promote healthy sleep. *Families, Systems, & Health*, *38*(4), 406–417. https://doi.org/10.1037/fsh0000546

Tougas, M. E., Hayden, J. A., McGrath, P. J., Huguet, A., & Rozario, S. (2015). A Systematic Review Exploring the Social Cognitive Theory of Self-Regulation as a Framework for Chronic Health Condition Interventions. *PLOS ONE*, *10*(8), e0134977. https://doi.org/10.1371/journal.pone.0134977

Tsipoura, G., Lazaratou, H., Damigos, D., & Vougiouka, O. (2018). Sleep and its relationship to health-related quality of life in children and adolescents with inactive juvenile idiopathic arthritis. *The Egyptian Rheumatologist*, *40*(3), 197–201. https://doi.org/10.1016/j.ejr.2017.10.004

Valrie, C. R., Bromberg, M. H., Palermo, T., & Schanberg, L. E. (2013). A Systematic Review of Sleep in Pediatric Pain Populations. *Journal of Developmental and Behavioral Pediatrics : JDBP*, *34*(2), 120–128. https://doi.org/10.1097/DBP.0b013e31827d5848

Ward, T. M., Beebe, D. W., Chen, M. L., Landis, C. A., Ringold, S., Pike, K., & Wallace, C. A. (2017). Sleep Disturbances and Neurobehavioral Performance in Juvenile Idiopathic Arthritis. *The Journal of Rheumatology*, *44*(3), 361–367. https://doi.org/10.3899/jrheum.160556

Ward, T. M., Skubic, M., Rantz, M., & Vorderstrasse, A. (2020). Human-centered approaches that integrate sensor technology across the lifespan: Opportunities and challenges. *Nursing Outlook*. https://doi.org/10.1016/j.outlook.2020.05.004

Xiang, B., Wong, H. M., & McGrath, C. P. J. (2022). The efficacy of peer-led oral health programs based on Social Cognitive Theory and Health Belief Model among Hong Kong adolescents: A cluster-randomized controlled trial. *Translational Behavioral Medicine*, *12*(3), 423–432. https://doi.org/10.1093/tbm/ibab142

Zare, S., Ostovarfar, J., Kaveh, M. H., & Vali, M. (2020). Effectiveness of theory-based diabetes self-care training interventions; a systematic review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 423–433. https://doi.org/10.1016/j.dsx.2020.04.008

Chapter 2. A Pilot Randomized Controlled Trial of Internet-Delivered Sleep Shared-Management Intervention (SLEEPSMART) for Children with Juvenile Idiopathic Arthritis and their Parents

Abstract

Objective: To evaluate the feasibility, acceptability, and preliminary efficacy of a pilot randomized controlled trial of internet-delivered sleep shared-management intervention (SLEEPSMART) for children with juvenile idiopathic arthritis (JIA) and their parents.

Background: Sleep deficiency is highly comorbid in children with JIA and associated with poorer health-related quality of life, increased arthritis symptoms, and healthcare utilization. Despite the prevalence of sleep deficiency in JIA, little attention has been given to supporting children and parents in managing sleep deficiency, specifically enhancing self-efficacy, problem-solving, and goal-setting skills. Guided by Social Cognitive Theory and parent-child shared management perspectives, we developed SLEEPSMART to support sleep quantity and quality among JIA children before transitioning to adolescence.

Methods: We used a parallel arm pilot randomized controlled trial design to evaluate the feasibility, acceptability, and preliminary efficacy of SLEEPSMART. Fifty children, 8-13 years, with JIA and sleep deficiency, and their parents enrolled (consented) in the study. Forty-four parent-child dyads were randomized to the SLEEPSMART or control group. The SLEEPSMART group received a 6-week online intervention with sleep coach-supported weekly educational modules and goal setting. The control group received routine clinical care. Feasibility was measured by the percentage of eligible, enrolled, and retained dyads, engagement was measured when dyads completed at least one module, and usefulness and acceptability were measured with the Treatment Evaluation Inventory and exit interviews. Dyads' sleep and self - management outcomes were evaluated at baseline (T1), immediately post-intervention (T2), and one-month post-intervention (T3).

Results: Of the 50 dyads enrolled, 88% completed the baseline assessment. Of 24 dyads assigned to the SLEEPSMART group, 80% completed all intervention modules and surveys, and 88% completed at least one module. Of the 20 dyads in the control group, 85% completed all surveys. Seventy-five percent of children and 89% of parents reported high acceptance, and 89% of parents and 80% of children would recommend SLEEPSMART to others. The themes (satisfaction, usefulness, and improvement) and subthemes that emerged from the exit interview suggest high acceptability among parents and children. For preliminary efficacy, there were statistically significant differences between the SLEEPSMART and control groups on children's sleep efficiency and total sleep time at post intervention and one-month follow up, beliefs and attitudes towards sleep at one-month follow up, and self-efficacy in managing their own chronic conditions at post-intervention but not one-month follow-up. For parents, there were statistically significant differences between the SLEEPSMART and control groups on their self-efficacy in managing their children's chronic conditions and sleep at post-intervention and one-month follow-up.

Conclusion: SLEEPSMART is a feasible, acceptable, and potentially effective intervention for children with JIA and their parents to improve sleep and shared-management skills. It is promising in improving parent-child dyads' sleep and quality of life in larger-scale trials.

Key Words: Sleep, RCT, Intervention, Parent-Child Shared Management, Human-Centered Design, Social Cognitive Theory

Introduction

Sleep deficiency, including the inadequate quantity or quality of sleep, is highly comorbid in children with juvenile idiopathic arthritis (JIA), affecting an estimated 30% of children (Saidi et al., 2022; Tarakci et al., 2019; Ward et al., 2017). Prior studies show that sleep deficiency in children with JIA is associated with increased arthritis symptoms, more fatigue and pain, poorer health-related quality of life, and higher healthcare utilization (Allen et al., 2016; Armbrust et al., 2016; Butbul Aviel et al., 2011; Kuhlmann et al., 2016; Tarakci et al., 2019; Tsipoura et al., 2018; Valrie et al., 2013). Notably, sleep quality, duration, and habits are not routinely assessed in children with JIA. An estimated 10-15% of pediatric providers are not screening for sleep problems, and many have limited knowledge, skills, and confidence to manage sleep problems (Anwar et al., 2018; Honaker & Meltzer, 2016; Ramar et al., 2021). Moreover, limited access to specialty pediatric sleep centers, low provider reimbursement rates, and high caseloads are additional barriers to assessing and treating sleep deficiency in children (Honaker & Meltzer, 2016; Ramar et al., 2021). The traditional approach, such as in-person sessions, to manage sleep problems is a barrier for families because it is costly, time intensive, and requires parents and children to miss work and school.

Despite the pervasiveness of poor sleep quality, inadequate sleep, and variability of sleep timing in children with JIA, few sleep interventions have focused on school-age children with chronic health conditions. Currently, most focus on the parent alone versus the parent and child, and the interventions involve parent education, relaxation, and sleep hygiene techniques (Meltzer et al., 2021). Less is known about management behaviors (e.g., self-efficacy, activation, motivation) between children and parents that could lead to better engagement in learning specific strategies to improve sleep (Sonney et al., 2020a; Tinker et al., 2020). Parent-child shared management reflects the shared responsibility and interdependence (e.g., being dependent

upon one another) for parents and children to co-manage children's health. It assumes that with parents' ongoing support, children's responsibility for their own health management increases along with developmental progression and health-related experiences (Buford, 2004; Kieckhefer & Trahms, 2000; Schilling et al., 2006; Sonney et al., 2016). Children and parents need active assistance in solving their child's sleep problems due to the complexity of sleep behaviors, problem-solving, and compromising around barriers to boost parents' and children's self-efficacy (e.g., confidence). Sleep deficiency in JIA is multifactorial, including pre-bedtime activities (homework, media), inconsistent sleep habits (bedtime variability), and/or a lack of necessary skills and self-efficacy to follow recommendations. Without active support, children and parents may give up before reaching the tipping point where positive outcomes are readily observable.

Dr. Teresa Ward's team developed a health behavior change intervention: Sleep Shared-Management Intervention (SLEEPSMART), that provides children with JIA and their parents the knowledge, motivation, and skills for setting and achieving goals, problem-solving, and working through setbacks to improve their child's sleep (Ward et al., 2020). SLEEPSMART was guided by Bandura's Social Cognitive Theory (SCT), and parent-child shared management (PCSM) (Bandura, 1986; Kieckhefer & Trahms, 2000; Sonney et al., 2020a). SCT views behavior choices as the result of reciprocal determinism between cognitive, behavioral, and environmental influences and integrates skill-building and behavior change that is relevant even with setbacks and partial successes (Bandura, 1986). For example, the SLEEPSMART intervention sought to improve child sleep by modifying children's and parents' negative beliefs, increasing outcome expectations and self-efficacy, facilitating change in the social and physical environments, and encouraging the development of self-regulation. Thus, the purpose of this pilot RCT was to 1) determine the feasibility and acceptability of SLEEPSMART and 2) examine the preliminary

efficacy of SLEEPSMART on primary outcomes (sleep) and secondary outcomes (management behaviors) in children with JIA and their parents.

Methods

SLEEPSMART is registered at clinicaltrials.org (Identifier NCT04066205) and was approved by the University of Washington Institutional Review Board. A description of the design and development of SLEEPSMART is described elsewhere (Ward et al., 2020).

Participants

Children were included if they were 1) diagnosed with JIA; 2) 8 to 13 years, and 3) reported by their parent to have difficulties with sleep (e.g., difficulty falling asleep, no bedtime routine, waking up in the middle of the night, and struggling to fall back asleep) and/or poor sleep that impacted their day-to-day function (e.g., school performance, peer-relationships). Exclusion criteria for children included 1) being diagnosed with a sleep disorder (e.g., obstructive sleep apnea), 2) lack of daily access to the internet, 3) developmental delay, and 4) currently participating in psychological therapy. Parent eligibility criteria included 1) 18 years and older, 2) having access to a computer or web-based device to complete the surveys, and 3) residing with the child more than 50% of the time. For families in which the child routinely spent the night in more than one home, a primary study parent was selected based on being a primary caregiver who resided with the child more than 50% of the time.

Procedures

Recruitment and Enrollment. From July 2019 through December 2020, JIA children and their parents were recruited from a large urban pediatric hospital. A list of names and addresses of children who met the study eligibility criteria was obtained from a clinical research assistant (CRA). Potential subjects were mailed a letter with the study website

(https://www.sleepsmartstudy.org/) and the CRA's contact information. Interested participants were directed to the SLEEPSMART study website hosted by Research Electronic Data Capture (REDCap). REDCap is a secure web application for designing clinical research and translational research databases (Harris et al., 2009, 2019) and was used to collect data surveys. After consent and assent were obtained, each parent-child dyad was provided a REDCap link to study questionnaires, daily online sleep diaries, and an actiwatch to wear for fourteen consecutive days at the three data collection points (T1, T2, T3).

Randomization. A randomized controlled trial (RCT) design was used and included assessments at baseline (T1), immediate post-treatment (T2), and one-month follow-up (T3). Following completion of baseline assessments, parent-child dyads were randomized to one of two treatment groups (treatment [SLEEPSMART] or usual care). A block randomization scheme was generated using an online program to derive randomization assignments. By the nature of the pilot feasibility, efficacy, and acceptability trial design, neither the research staff nor the participants were blinded to the intervention. During the intervention period, participants in the intervention group received access to a 6-week SLEEPSMART. SLEEPSMART included access to password-protected websites for children and parents to learn sleep shared management skills.

Flow chart. Figure 2.1 shows the Consolidated Standards of Reporting Trials (CONSORT) flow chart. In brief, 63 dyads were screened for this study, and 13 were excluded, resulting in a final sample of 50 dyads. Of the 50 dyads enrolled in the study, six dropped, 24 received access to the SLEEPSMART program, and 20 received standard care. Of those assigned to SLEEPSMART, 80% (n = 19/24) logged in and received the intervention. Assessment completion ranged from 100% at baseline (n = 24/24) to 80% (n=19/24) at follow-up.

SLEEPSMART Intervention

SLEEPSMART Development. SLEEPSMART was developed by a team of biomedical informaticians, pediatric nurses, psychologists, rheumatologists, and pediatric behavioral sleep experts with knowledge of cognitive behavioral therapy, management of behavioral sleep problems, JIA management, and Human-Centered Design (HCD) (Ward et al., 2020). HCD represents a collaborative approach that brings stakeholders and implementation teams together to co-create health interventions, services, or products that prioritize and address users' needs (Bazzano et al., 2017). Applying Participatory Design (PD), HCD emphasizes stakeholders' active engagement to improve intervention utility, uptake, sustainability, and effectiveness (Bazzano et al., 2017; Lyon et al., 2019). During the SLEEPSMART developmental phase, the content team met weekly to develop and review intervention materials, multimedia elements, the structure of the program, and paper-based prototypes (Ward et al., 2020). Three in-person PD sessions were conducted among children with JIA and their caregivers to further tailor intervention content to meet their needs. Based on the initial development, paper prototypes, PD session results, and user flows, a high-fidelity prototype of SLEEPSMART was developed. The finalized website design was hosted on the Wix platform. Wix is a customizable website builder that allows users to quickly create websites (https://www.wix.com/about/us).

SLEEPSMART Modules and content. SLEEPSMART is a web-based intervention that adapted components from the Transdiagnostic Sleep and Circadian (TransS-C) intervention for youth that is informed by fundamental sleep and circadian principles (A. G. Harvey, 2016; A. G. Harvey & Buysse, 2018). As shown in **Table 1**, the TransS-C adopted four cross-cutting components (sleep complaint, education, behavior change and motivation, and goal-setting) in each session, four core modules (learning a wind-down and wake-up routine, improving daytime functioning, correcting unhelpful sleep-related beliefs, and maintaining behavior change), and

seven optional modules that tailored to participants' needs (improving sleep efficiency, reducing time in bed, dealing with delayed or advanced phase, reducing sleep-related worry, promoting compliance with the treatment, negotiating sleep in a complicated environment, and reducing nightmares) (A. G. Harvey & Buysse, 2018). The SLEEPSMART program is built on a responsive web platform and is accessible via any web-enabled device (laptop, smartphone, tablet). The self-guided intervention teaches sleep shared-management skills, including relaxation methods, cognitive sleep coping techniques, and parental operant and communication skills. Based on input from children with JIA and parents, the SLEEPSMART website displays a space theme with a soothing color palette. Each learning module consists of a 10-to-15-minute presentation, a brief quiz, a tailored weekly activity focused on reinforcing goal setting and skills practice, and extra resources for parents and children (e.g., handouts, links to sleep organizations, videos). Children and parents visit a different weekly module and check in with a sleep coach. The sleep coach reviewed the weekly assignments, provided strategies to work through goals, encouraged skill practice, and addressed barriers and/or setbacks to completing SLEEPSMART modules. The program was metered to encourage dyads' skills practice and consolidation so that users spent one week practicing assigned skills before moving on to the next module. Sample educational modules and weekly activities are shown in **Figure 2**.

Measures

Participants completed standardized questionnaire measures, actigraphy and sleep diaries at three assessment time points: baseline (T1), after the 6-week intervention period (T2), and after one-month follow-up (T3). Participants were provided with gift card incentives after the completion of each assessment.

Intervention Outcomes

Feasibility and Acceptability Outcomes

Feasibility: The number of eligible parent-child dyads, enrollment, retention, and participant attrition rate were calculated as the intervention feasibility. The percentage of completing at least one module in the SLEEPSMART program was considered treatment engagement, while the percentage of completing five or more modules was considered adherence.

Treatment Evaluation Inventory Form (parent and child): an 11-item TEF measure of the overall acceptability of the program, including the content, the structure and format, the procedure, and how likely parents and children would recommend it to others (Kelley et al., 1989). Survey items were rated on a 1-to-5-point scale (1 = strongly disagree to 5= strongly agree); higher scores indicate higher satisfaction and acceptability of the intervention. "Moderate" satisfaction and treatment acceptability is indicated by a score of "3" for each item. The original TEF instrument showed good internal consistency with Cronbach's $\alpha = 0.85$ (Kelley et al., 1989). In this study, the internal consistency was 0.9 among children and 0.9 for parents.

Exit Interview: To assess acceptability, we conducted semi-structured exit interviews by phone for parent-child dyads at the end of the program. Each exit interview lasted 15-20 minutes. All interviews were audio recorded. The interview consisted of open-ended questions on what dyads liked about the SLEEPSMART intervention, what they would like to change, and their general feedback/suggestions.

Preliminary intervention efficacy and management behaviors

Total sleep time and sleep efficiency: total sleep time and sleep efficiency were measured by actigraphy and sleep diary. Acti-watch is a watch-like device that records sleep

patterns based on movement detected by an omnidirectional sensor in the natural home environment. Children wore an Actiwatch for seven consecutive days (Actiwatch Spectrum, Philips Respironics, Pittsburgh, PA). They were instructed to press the event marker when they attempted to fall asleep, when they woke up in the morning, at the beginning and end of naps, and when the watch was removed (e.g., swimming, showering) (Ward et al., 2012). After the Actiwatch was returned, the data were downloaded and scored using the Actiware software (Actiware Version 6.1., Philips Respironics). Activity counts were scored using a weighting algorithm with a medium threshold (40 activity counts per epoch). This algorithm has a high sensitivity to detect sleep and low specificity to detect wake compared to polysomnography in children with and without chronic conditions (Ward et al., 2012). Two separate coders coded 15 of the same records, when the inter-rater reliability reached over 90%, then the two coders continued coding all other records. Inter-rater reliability was assessed with two members who individually scored actigraphy data (>0.90). Variables derived from actigraphy included: (1) *sleep onset and offset*, defined as the first three consecutive minutes scored as sleep after the diary reported bedtime and sleep offset was defined as the last five consecutive minutes of sleep before the diary reported wake time (Meltzer et al., 2012); (2) *Total Sleep Time* (TST), defined as the minutes during the sleep period; (3) *Sleep Onset Latency* (SOL), defined as the minutes from lights off until sleep onset; (4*) Wake After Sleep Onset* (WASO), defined as the minutes scored as wake during the sleep period; and (5) *Sleep Efficiency* (SE), defined as the ratio of total sleep time/time in bed.

A web-based electronic daily sleep diary was used with actigraphy. Youth completed the sleep diaries every morning and every night at bedtime. Variables derived from the sleep diary included: (1) *bedtime*, defined as the time children recorded in the sleep diary as "falling asleep";

(2) *wake time*, defined as the time children recorded in the sleep diary as "waking up"; (3) *sleep duration*, defined as the total amount of time spent asleep between bedtime and wake time; and (4) *sleep quality*, defined as 0 = "extremely poor sleep" to 10 = "extremely good sleep" (higher numbers indicate better sleep quality); (e) pain on average, defined as 0 = "no pain" to 10 = "pain as bad as you can imagine" (higher numbers indicate greater pain). In addition, evening activities, medications, illnesses, and any unusual events that may have affected their sleep (e.g., illness, argument with a friend, worry about a test) were recorded.

PROMIS Sleep Disturbance (parent and children): an 8-item questionnaire that measures self-reported perceptions of sleep quality, depth, and restoration within the past seven days for parents' own sleep and children's sleep (Forrest et al., 2018; Hanish et al., 2017). Items are rated on a 5-point Likert scale (1= not at all/very poor, 2 = a little bit/poor, 3=somewhat/fair, 4=quite a bit/good, 5= very much/very good). We calculated T-scores using the online HealthMeasure Scoring Services program provided by the US Assessment Center (https://www.assessmentcenter.net/ac_scoringservice). Scoring (Forrest et al., 2014) Service is the most accurate scoring method because it uses IRT-based response pattern scoring. Higher scores indicate more significant sleep problems (S. J. Bartlett et al., 2015). Prior studies report Cronbach's α ranging from 0.9 to 0.99 among children aged 8-17 and adults (S. J. Bartlett et al., 2015; Forrest et al., 2018). In this pilot study, the internal consistency was 0.72 for children and 0.80 for parents.

PROMIS Sleep-Related Impairment version 1.0 and 4a (parents and children): a 4-item questionnaire that assesses self-reported sleepiness, tiredness, and functional impairments associated with sleep problems during waking hours within the past seven days for parents' own sleep and children's sleep (Hanish et al., 2017; Yu et al., 2011). Items are rated on a 5-point

Likert scale (1= never, 2= almost never, 3 = sometimes, 4 = almost always, and 5 = always). Similar to the above PROMIS instrument, we obtained T-scores using the online HealthMeasure Scoring Services programs. Higher scores indicate more significant sleep impairment. Prior studies report Cronbach's α = 0.97 to 0.98 among children aged 8-17 and adults (S. J. Bartlett et al., 2015; Forrest et al., 2018). In this pilot study, the internal consistency was 0.9 for children and 0.9 for parents.

Dysfunctional Beliefs and Attitudes about Sleep (DBAS-C10) (children): a 10-item youth-report questionnaire that assesses children's misconceptions about sleep that trigger sleep problems (Blunden, Gregory, & Crawford, 2013). Items are rated on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). DBAS consists of 3 subscales: (1) beliefs about immediate negative consequences (4 items), (2) beliefs about long-term negative consequences (4 items), and (3) need to control insomnia (2 items). A total score is computed by averaging the scores of all items; higher scores indicate more dysfunctional beliefs and attitudes about sleep. In prior studies, the internal consistency was adequate, with Cronbach's α being more than 0.75 (Blunden et al., 2013; Kaplan, Ali, Simpson, Britt, & McCall, 2014), and in this study, the Cronbach's was 0.8.

Dysfunctional Beliefs and Attitudes about Sleep (DBAS-16) (parents): a 16-item parent-report questionnaire that assesses sleep/insomnia-related attitudes and beliefs (e.g., consequences of insomnia, worry about sleep, sleep expectations, and medication) (Morin et al., 2007). The DBAS-16 includes four subscales: (1) perceived consequences of insomnia, (2) worry/helplessness about insomnia, (3) sleep expectations, and (4) medication. Items are rated on a Likert scale of 0 (strongly disagree) to 10 (strongly agree). A total score is computed by averaging the scores for all the items, with a higher score indicating more dysfunctional beliefs

and attitudes about sleep. In prior studies, internal consistency was adequate, with Cronbach's α = 0.77 to 0.80 (Chung et al., 2016; Morin et al., 2007). In this study, Cronbach's α was 0.9 among parents.

Self-Efficacy Managing Chronic Disease (parents): a 9-item survey that assesses parent confidence to manage/control their children's chronic conditions, emotional functioning, and communication with healthcare providers. Items are rated using a visual analog scale, ranging from 1 = not at all confident to 10 = totally confident (Lorig et al., 2001). A mean score is calculated with higher values indicative of higher self-efficacy. Reliability is well established, with Cronbach's alpha over 0.88 (Freund et al., 2014; Riehm et al., 2016; Ritter & Lorig, 2014). In this study, Cronbach was 0.8.

Index of self-regulation (children): a 9-item scale that measures motivation and activation concerning changing behaviors. Items are rated on a 5-point Likert scale from 1=strongly disagree, 2= disagree, 3= undecided, 4=agree to 5=strongly agree, with higher scores indicating a higher level of self-regulation for health-related behavior change. Previous studies show adequate internal consistency with Cronbach's alphas of 0.81 to 0.96 (Yeom et al., 2011). In this study, Cronbach's was 0.9 among children.

Other Measurements used for Demographics. The below measures were used to describe the sample and baseline symptom characteristics.

Demographics: Child and parent demographics (age, gender) were completed by the parents.

Adolescent Sleep Wake Scale (ASWS) (children): a 28-item youth-report measure of sleep quality and behaviors over the past month (LeBourgeois et al., 2005). ASWS includes five domains (going to bed, falling asleep, maintaining sleep, reinitiating sleep, and returning to

wakefulness) and items are scored on a six-point Likert scale (1 = always to 6 = never). Higher scores suggest better sleep quality. Prior studies show good internal consistency with Cronbach's alphas of 0.7 to 0.9 among adolescents (Ji & Liu, 2016; Lawless et al., 2020). The internal consistency was 0.76 in this pilot study.

PedsQL™ Multidimensional Fatigue Scale (children): an 18-item child-report scale on fatigue over the past month (Varni et al., 2004). Items are rated on a 5-point Likert scale (0 = never a problem, 1 = almost never a problem, 2 = sometimes a problem, 3 = often a problem, 4 = almost always a problem) and were reverse scored on a 0-100 scale (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0). A total score of less than 50 was used as a cutoff for moderate fatigue (Varni et al., 2004). Prior studies report an internal consistency of 0.7 to 0.93 among children and adolescents (Panepinto et al., 2014; Smout et al., 2022; Ye et al., 2016). In this pilot study, the internal consistency was 0.75 for the children.

PROMIS Pediatric Global Health (children): a 7-item child-report measure that assesses pain interference and fatigue in children aged 8–18 (Forrest et al., 2014). Similar to the above PROMIS instrument, we obtained T-scores using the online HealthMeasure Scoring Services programs. Higher scores indicate more significant sleep impairment. A higher T score indicates better overall health. Previous studies found good internal consistency with Cronbach's alphas of 0.8 to 0.9 (Forrest et al., 2019; Holbein et al., 2021; Kallen et al., 2022). The Cronbach's α was 0.78 in this pilot study.

Data Analysis

Deidentified data were exported from REDCap and Philips Actiware. Baseline characteristics were compared between the groups using the two-sample t-test for continuous measures and the chi-square test for categorical measures. The percentage of participants rated

TEF items as “agree” or “strongly agree,” and thematic analyses of semi-structured exit interviews were considered intervention *acceptability*. All interviews were audio recorded and transcribed verbatim in English. Data were analyzed thematically using inductive coding, a coding approach that allows researchers to read and interpret raw textual data to develop themes without pre-defined themes (Thomas, 2006). Inductive coding included six phases (Yuwen et al., 2017): 1) unitizing data; 2) open coding and identification of initial categories; 3) naming and defining initial categories; 4) developing a codebook and 5) code all data. The qualitative software ATLAS.ti 9 was used for data management and analysis.

To examine the intervention effects on parent-child dyads' sleep and shared-management outcomes over time, we used generalized estimating equations (GEE) models. GEE takes into account the dependence between repeated measurements within subjects and can deal with missing data as well as nonnormal distributed data (Salazar et al., 2016). Statistical analysis was undertaken using r within r studio (RStudio Team, 2020). We included time as a factor to investigate outcome (sleep and shared management) changes over time (three levels: baseline, immediately post-intervention, and one-month follow-up). To compare the difference in outcomes between groups over time, we included time, group (two levels: SLEEPSMART, usual care), and the interaction time x group as factors. We set the model with linear response, the distribution of the data at ‘gaussian’, the correlation structure at ‘AR(1)’, and with robust standard errors. Packages of ‘geepack’ and ‘ggeffects’ within r were used. A p-value below .05 was considered statistically significant. Children who dropped out between T1, T2, and T3 were included in the analyses according to the intention-to-treat (ITT) principle (Detry & Lewis, 2014). Multiple imputation methodology was used to accommodate missing outcome data to reduce potential bias due to the participants dropping out over time. Variables included in the

imputation models were prespecified as variables likely to be associated with the outcome variables. m = 50 complete data sets were generated, and the r package "MICE" was used to conduct the multiple imputations.

Results

Participant Characteristics

Table 2.2 summarizes the baseline characteristics between the control and SLEEPSMART groups. The baseline characteristics and self-reported sleep, multidimensional fatigue, pain, self-efficacy, and self-regulation were not significantly different between the control and intervention groups at baseline. The mean age of the children was 10.3 ± 1.7 years, and the majority (72%) were female. All parents were mothers with a mean age of 41.8 ± 5.7 years.

Feasibility and Acceptability

Sixty-three parents completed the online eligibility screening, and 56 (89%) of the dyads were eligible. Of the seven dyads who were not eligible, six were due to children participating in psychosocial therapy, and one did not meet the cutoff score for sleep problems. Of the 56 eligible dyads, 50 dyads enrolled in the study, and 44 completed baseline measures (88% participation rate).

Of the 24 dyads assigned to the intervention group, 19 (80%) completed all six intervention modules and study surveys at T1, T2, and T3, and 21 (88%) completed at least one module. Of the 20 dyads assigned to the control group, 17 (85%) completed study surveys at T1, T2, and T3. For dyads who completed six modules (n=19), the mean time spent on all modules was 7.1 ± 2.2 weeks.

Seventy-five percent of children and 89% of parents reported high acceptance (agree and strongly agree) with SLEEPSMART, and 89% of parents and 80% of children would recommend SLEEPSMART to others.

The exit interview findings suggested that the intervention was highly feasible, acceptable, and useful to dyads. Table 2.3 shows themes, subthemes, and direct quotes from participants' exit interviews. Three themes emerged with respect to satisfaction, usefulness, and improvement. Dyads were satisfied with the flexibility of online self-paced learning, the trustworthy educational content, and the research team's responsiveness. They found SLEEPSMART was useful in empowering children to take more responsibility and reconnecting parents and children to achieve the same goals. Recommended improvements included more structured and organization if a dashboard housed everything (video, survey, and sleep diary) in one place, reducing the number of surveys and making intervention modules more interactive and gamified.

Preliminary efficacy on sleep and management behaviors

Table 2.4 shows means and standard deviations of children's and parents' outcomes across each time point by treatment condition and the GEE model's results examining the treatment effects on children's and parents' outcomes, controlling for age and gender. For children's outcomes, there was a statistically significant difference between the SLEEPSMART and control group on their sleep efficiency and total sleep time at post intervention ($p < .01$) and one-month follow up ($p < .05$), beliefs and attitudes towards sleep at one-month follow up ($p < .05$), and self-efficacy in managing their own chronic conditions at post-intervention ($p < .05$) but not one-month follow-up. For parents, there was a statistically significant difference between

the SLEEPSMART and control group on their self-efficacy in managing their children's chronic conditions and sleep at post-intervention ($p < .01$) and one-month follow-up ($p < .05$).

Discussion

The primary goal of this study was to evaluate the feasibility, acceptability, and preliminary efficacy of a web-based SLEEPSMART intervention for children with JIA and their parents. SLEEPSMART was positively received by children and parents. Findings indicated that the SLEEPSMART intervention was acceptable, feasible, helpful and engaging. Eighty percent of the families completed all the intervention modules and surveys. Findings from the surveys and exit interviews indicated that SLEEPSMART was highly acceptable, with 89% of parents and 75% of children reporting overall acceptance, and 89% of parents and 80% of children would recommend SLEEPSMART to others. Three themes that emerged from the exit interviews (satisfaction, usefulness, and improvement) suggest high acceptability among parents and children. Parent-child dyads appreciated the flexibility of online learning and were satisfied with reliable and abundant knowledge and highly responsive and accessible research teams. They also reported that SLEEPSMART activated/motivated children to take more control in managing their sleep and reconnected parents and children to work towards the same goal.

For intervention preliminary efficacy, our findings suggest that there was statistically significant difference between SLEEPSMART and control group on children's sleep efficiency and total sleep time at post intervention and one-month follow up, belief and attitude towards sleep at one-month follow up, and self-efficacy in managing their own chronic conditions at post-intervention but not one-month follow-up. For parents, there was statistically significant difference between SLEEPSMART and control group on their self-efficacy in managing their children's chronic conditions and sleep at post-intervention and one-month follow-up.

Parents and children offered valuable feedback to refine SLEEPSMART in three areas: 1) structure-wise, organize all tasks in one dashboard so they can check out daily tasks and track progress; 2) reduce the number of surveys; and 3) gamify the intervention videos and develop an actual reward system for children.

Our results suggest that technology-enabled sleep intervention may be a potentially accessible alternative to more cost/time-consuming traditional in-person interventions. Of the pediatric interventions developed for children with JIA, several have focused on pain symptom monitoring with an mHealth app (Lee et al., 2020, Lalloo et al., 2021), e-pain diaries (Stinson, Petroz, et al., 2008; Stinson et al., 2008; Stinson et al., 2014), web-based pain assessment tools (Stinson et al., 2012), web-based CBT-pain programs (Armbrust et al., 2017; Lelieveld et al., 2010); self-management skills with online CBT programs (Connelly et al., 2019; Stinson et al., 2010, 2020), and a web-based peer-mentoring program (Stinson et al., 2016). Among these interventions, only one study included sleep as one of the outcomes (Stinson, Petroz, et al., 2008). Although sleep deficiency is recognized as a critical outcome for pediatric chronic pain management, sleep has been rarely targeted in nonpharmaceutical intervention studies (Palermo et al., 2021).

To date, less attention has been given to engaging both parents and children in active roles to improve children's sleep (Sonney et al., 2020a; Ward et al., 2020b). Our findings fill important gaps in the literature in that SLEEPSMART engaged parents and children throughout the design and development of the web-based intervention with HCD approaches through active engagement, co-design, and support for iterative idea refinement in response to testing and feedback (Beres et al., 2019; Melles et al., 2021), and integrated parent-child shared management. In working to change sleep behaviors in children, it is vital to account for parent-

child interdependence to effectively manage children's sleep. Parents play critical roles in shaping children's health management skills. HCD allows parents and children to provide valuable insights into how real-world participants interact with the planned intervention. By infusing intervention design with HCD principles, our team gained a deeper understanding of the parents' and children's needs to improve their experience and motivate engagement.

This pilot study has several limitations. First, our sample was relatively small, given that this was a pilot study. Our sample was also predominantly White and middle class, which limits generalizability. Our results may not generalize to diverse populations from various racial, socioeconomic, and geographic backgrounds. Our follow-up period was limited to one-month post-intervention, and some children and parents may have needed a longer time to see the effects of SLEEPSMART. Lastly, this study was conducted during the COVID-19 pandemic, and stay-at-home guidance may have altered sleep routines and patterns for children and parents.

Implications

SLEEPSMART is a novel web-based intervention that targets sleep shared management among children with JIA and their parents. The findings expand our understanding of JIA families' needs by integrating HCD and parent-child shared management perspectives into the intervention. Further research is needed to revise SLEEPSMART based on the exit interviews and conduct a larger RCT to evaluate the efficacy of SLEEPSMART in a more diverse and larger sample.

Drawing upon parent-child shared management, SLEEPSMART partnered up parent and child as a team to improve sleep. To our knowledge, only one intervention has integrated a shared management perspective for children with asthma and their parents (Sonney et al., 2020a). The intervention was highly feasible and acceptable by participants, resulting in positive

changes in children's and parents' outcomes. Given the inseparable connection and interdependence between parent and child, sleep interventions that engage both parent and child and enable shared responsibility hold promise in helping build children's lifelong self-management skills. Healthcare professionals have a critical role in promoting parent-child shared management within families by encouraging and supporting the development of collaborative plans for parent-child dyad care in sleep management, coaching their practice, and monitoring progress at each appointment.

Sleep is a missing piece in the JIA management puzzle that has been overlooked. As managing children with JIA involves a multidisciplinary approach, health care providers should conduct assessments on sleep, given the sleep-pain relationship among JIA children. In addition, healthcare professionals must regularly receive training on health and technology information as technology rapidly evolves. They can also be informative in developing an effective technology-based intervention as they routinely engage with patients and their families to plan and treat symptoms (Ward et al., 2020b). SLEEPSMART will undergo revisions, and a larger scale study is needed to test the current findings and examine possible mechanisms connecting sleep and quality of life among children with JIA and their parents.

Conclusion

This pilot RCT addressed current gaps in the literature and provided preliminary data for a larger study. SLEEPSMART is a feasible, acceptable, and potentially effective intervention for children with JIA and their parents to improve sleep and shared-management skills. By employing HCD approaches and a parent-child shared-management perspective, SLEEPSMART is promising in improving parent-child dyads' sleep and quality of life in larger-scale trials.

References

Allen, J. M., Graef, D. M., Ehrentraut, J. H., Tynes, B. L., & Crabtree, V. M. (2016). Sleep and Pain in Pediatric Illness: A Conceptual Review. *CNS Neuroscience & Therapeutics*, *22*(11), 880–893. https://doi.org/10.1111/cns.12583

Anwar, A., Yingling, M. D., Zhang, A., Ramtekkar, U., & Nicol, G. E. (2018). Assessment and Treatment of Pediatric Sleep Problems: Knowledge, Skills, Attitudes and Practices in a Group of Community Child Psychiatrists. *Medical Sciences*, *6*(1), 18. https://doi.org/10.3390/medsci6010018

Armbrust, W., Bos, G. J. F. J., Wulffraat, N. M., van Brussel, M., Cappon, J., Dijkstra, P. U., Geertzen, J. H. B., Legger, G. E., van Rossum, M. A. J., Sauer, P. J. J., & Lelieveld, O. T. H. M. (2017). Internet Program for Physical Activity and Exercise Capacity in Children With Juvenile Idiopathic Arthritis: A Multicenter Randomized Controlled Trial. *Arthritis Care & Research*, *69*(7), 1040–1049. https://doi.org/10.1002/acr.23100

Armbrust, W., Siers, N. E., Lelieveld, O. T. H. M., Mouton, L. J., Tuinstra, J., & Sauer, P. (2016). Fatigue in patients with juvenile idiopathic arthritis: A systematic review of the literature. *Seminars in Arthritis and Rheumatism*, *45*(5), 587–595. https://doi.org/10.1016/j.semarthrit.2015.10.008

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory* (pp. xiii, 617). Prentice-Hall, Inc.

Bartlett, S. J., Orbai, A.-M., Duncan, T., DeLeon, E., Ruffing, V., Clegg-Smith, K., & Bingham, C. O. (2015). Reliability and Validity of Selected PROMIS Measures in People with Rheumatoid Arthritis. *PLoS ONE*, *10*(9). https://doi.org/10.1371/journal.pone.0138543

Bazzano, A. N., Martin, J., Hicks, E., Faughnan, M., & Murphy, L. (2017). Human-centred design in global health: A scoping review of applications and contexts. *PloS One*, *12*(11), e0186744. https://doi.org/10.1371/journal.pone.0186744

Beres, L. K., Simbeza, S., Holmes, C. B., Mwamba, C., Mukamba, N., Sharma, A., Munamununugu, V., Mwachande, M., Sikombe, K., Bolton Moore, C., Mody, A., Koyuncu, A., Christopoulous, K., Jere, L., Pry, J., Ehrenkranz, P. D., Budden, A., Geng, E., & Sikazwe, I. (2019). Human-Centered Design Lessons for Implementation Science: Improving the Implementation of a Patient-Centered Care Intervention. *Journal of Acquired Immune Deficiency Syndromes (1999)*, *82*(3), S230–S243. https://doi.org/10.1097/QAI.0000000000002216

Buford, T. A. (2004). Transfer of asthma management responsibility from parents to their school-age children. *Journal of Pediatric Nursing*, *19*(1), 3–12. https://doi.org/10.1016/j.pedn.2003.09.002

Butbul Aviel, Y., Stremler, R., Benseler, S. M., Cameron, B., Laxer, R. M., Ota, S., Schneider, R., Spiegel, L., Stinson, J. N., Tse, S. M. L., & Feldman, B. M. (2011). Sleep and fatigue and the relationship to pain, disease activity and quality of life in juvenile idiopathic arthritis and juvenile dermatomyositis. *Rheumatology (Oxford, England)*, *50*(11), 2051–2060. https://doi.org/10.1093/rheumatology/ker256

Chung, K.-F., Ho, F. Y.-Y., & Yeung, W.-F. (2016). Psychometric Comparison of the Full and Abbreviated Versions of the Dysfunctional Beliefs and Attitudes about Sleep Scale. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, *12*(6), 821–828. https://doi.org/10.5664/jcsm.5878

Connelly, M., Schanberg, L. E., Ardoin, S., Blakley, M., Carrasco, R., Chira, P., Hayward, K., Ibarra, M., Kimura, Y., Kingsbury, D. J., Klein-Gitelman, M. S., Lawson, E., & Stinson, J. (2019). Multisite Randomized Clinical Trial Evaluating an Online Self-Management Program for Adolescents With Juvenile Idiopathic Arthritis. *Journal of Pediatric Psychology*, *44*(3), 363–374. https://doi.org/10.1093/jpepsy/jsy066

Detry, M. A., & Lewis, R. J. (2014). The Intention-to-Treat Principle: How to Assess the True Effect of Choosing a Medical Treatment. *JAMA*, *312*(1), 85–86. https://doi.org/10.1001/jama.2014.7523

Forrest, C. B., Bevans, K. B., Pratiwadi, R., Moon, J., Teneralli, R. E., Minton, J. M., & Tucker, C. A. (2014). Development of the PROMIS® pediatric global health (PGH-7) measure. *Quality of Life Research*, *23*(4), 1221–1231. https://doi.org/10.1007/s11136-013-0581-8

Forrest, C. B., Meltzer, L. J., Marcus, C. L., de la Motte, A., Kratchman, A., Buysse, D. J., Pilkonis, P. A., Becker, B. D., & Bevans, K. B. (2018). Development and validation of the PROMIS Pediatric Sleep Disturbance and Sleep-Related Impairment item banks. *Sleep*, *41*(zsy054). https://doi.org/10.1093/sleep/zsy054

Forrest, C. B., Zorc, J. J., Moon, J., Pratiwadi, R., Becker, B. D., Maltenfort, M. G., & Guevara, J. P. (2019). Evaluation of the PROMIS pediatric global health scale (PGH-7) in children with asthma. *Journal of Asthma*, *56*(5), 534–542. https://doi.org/10.1080/02770903.2018.1471701

Freund, K. M., Battaglia, T. A., Calhoun, E., Darnell, J. S., Dudley, D. J., Fiscella, K., Hare, M. L., LaVerda, N., Lee, J.-H., Levine, P., Murray, D. M., Patierno, S. R., Raich, P. C., Roetzheim, R. G., Simon, M., Snyder, F. R., Warren-Mears, V., Whitley, E. M., Winters, P., … Paskett, E. D. (2014). Impact of Patient Navigation on Timely Cancer Care: The

Patient Navigation Research Program. *JNCI: Journal of the National Cancer Institute*, *106*(6). https://doi.org/10.1093/jnci/dju115

Hanish, A. E., Lin-Dyken, D. C., & Han, J. C. (2017). PROMIS Sleep Disturbance and Sleep-Related Impairment in Adolescents: Examining Psychometrics Using Self-Report and Actigraphy. *Nursing Research*, *66*(3), 246–251. https://doi.org/10.1097/NNR.0000000000000217

Harris, P. A., Taylor, R., Minor, B. L., Elliott, V., Fernandez, M., O'Neal, L., McLeod, L., Delacqua, G., Delacqua, F., Kirby, J., Duda, S. N., & REDCap Consortium. (2019). The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics*, *95*, 103208. https://doi.org/10.1016/j.jbi.2019.103208

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*(2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010

Harvey, A. G. (2016). A Transdiagnostic Intervention for Youth Sleep and Circadian Problems. *Cognitive and Behavioral Practice*, *23*(3), 341–355. https://doi.org/10.1016/j.cbpra.2015.06.001

Harvey, A. G., & Buysse, D. J. (2018). *Treating sleep problems: A transdiagnostic approach* (pp. xv, 192). The Guilford Press.

Holbein, C. E., Plevinsky, J., Patel, T., Conrad, M. C., & Kelsen, J. R. (2021). Pediatric Global Health in Children with Very Early-Onset Inflammatory Bowel Disease. *Journal of Pediatric Psychology*, *46*(7), 747–756. https://doi.org/10.1093/jpepsy/jsab035

Honaker, S. M., & Meltzer, L. J. (2016). Sleep in pediatric primary care: A review of the literature. *Sleep Medicine Reviews*, *25*, 31–39. https://doi.org/10.1016/j.smrv.2015.01.004

Ji, X., & Liu, J. (2016). Subjective sleep measures for adolescents: A systematic review. *Child: Care, Health and Development*, *42*(6), 825–839. https://doi.org/10.1111/cch.12376

Kallen, M. A., Lai, J.-S., Blackwell, C. K., Schuchard, J. R., Forrest, C. B., Wakschlag, L. S., & Cella, D. (2022). Measuring PROMIS® Global Health in Early Childhood. *Journal of Pediatric Psychology*, *47*(5), 523–533. https://doi.org/10.1093/jpepsy/jsac026

Kelley, M., Heffer, R., Gresham, F., & Elliott, S. (1989). Development of a modified Treatment Evaluation Inventory. *Journal of Psychopathology and Behavioral Assessment*, *11*, 235–247. https://doi.org/10.1007/BF00960495

Kieckhefer, G. M., & Trahms, C. M. (2000). Supporting development of children with chronic conditions: From compliance toward shared management. *Pediatric Nursing*, *26*(4), 354–363.

Kuhlmann, A., Schmidt, T., Treskova, M., López-Bastida, J., Linertová, R., Oliva-Moreno, J., Serrano-Aguilar, P., Posada-de-la-Paz, M., Kanavos, P., Taruscio, D., Schieppati, A., Iskrov, G., Péntek, M., Delgado, C., von der Schulenburg, J. M., Persson, U., Chevreul, K., Fattore, G., & The BURQOL-RD Research Network. (2016). Social/economic costs and health-related quality of life in patients with juvenile idiopathic arthritis in Europe. *The European Journal of Health Economics*, *17*(1), 79–87. https://doi.org/10.1007/s10198-016-0786-1

Lawless, C., Turner, E. M., LeFave, E., Koinis-Mitchell, D., & Fedele, D. A. (2020). Sleep hygiene in adolescents with asthma. *Journal of Asthma*, *57*(1), 62–70. https://doi.org/10.1080/02770903.2018.1553049

LeBourgeois, M. K., Giannotti, F., Cortesi, F., Wolfson, A. R., & Harsh, J. (2005). The relationship between reported sleep quality and sleep hygiene in Italian and American adolescents. *Pediatrics*, *115*(1 Suppl), 257–265. https://doi.org/10.1542/peds.2004-0815H

Lee, R. R., Shoop-Worrall, S., Rashid, A., Thomson, W., & Cordingley, L. (2020). "Asking Too Much?": Randomized N-of-1 Trial Exploring Patient Preferences and Measurement Reactivity to Frequent Use of Remote Multidimensional Pain Assessments in Children and Young People With Juvenile Idiopathic Arthritis. *Journal of Medical Internet Research*, *22*(1), e14503. https://doi.org/10.2196/14503

Lelieveld, O. T. H. M., Armbrust, W., Geertzen, J. H. B., de Graaf, I., van Leeuwen, M. A., Sauer, P. J. J., van Weert, E., & Bouma, J. (2010). Promoting physical activity in children with juvenile idiopathic arthritis through an internet-based program: Results of a pilot randomized controlled trial. *Arthritis Care & Research*, *62*(5), 697–703. https://doi.org/10.1002/acr.20085

Lorig, K. R., Sobel, D. S., Ritter, P. L., Laurent, D., & Hobbs, M. (2001). Effect of a self-management program on patients with chronic disease. *Effective Clinical Practice: ECP*, *4*(6), 256–262.

Lyon, A. R., Munson, S. A., Renn, B. N., Atkins, D. C., Pullmann, M. D., Friedman, E., & Areán, P. A. (2019). Use of Human-Centered Design to Improve Implementation of Evidence-Based Psychotherapies in Low-Resource Communities: Protocol for Studies Applying a Framework to Assess Usability. *JMIR Research Protocols*, *8*(10), e14990. https://doi.org/10.2196/14990

Melles, M., Albayrak, A., & Goossens, R. (2021). Innovating health care: Key characteristics of human-centered design. *International Journal for Quality in Health Care*, *33*(Supplement_1), 37–44. https://doi.org/10.1093/intqhc/mzaa127

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews*, *16*(5), 463–475. https://doi.org/10.1016/j.smrv.2011.10.002

Meltzer, L. J., Wainer, A., Engstrom, E., Pepa, L., & Mindell, J. A. (2021). Seeing the Whole Elephant: A scoping review of behavioral treatments for pediatric insomnia. *Sleep Medicine Reviews*, *56*, 101410. https://doi.org/10.1016/j.smrv.2020.101410

Morin, C. M., Vallières, A., & Ivers, H. (2007). Dysfunctional Beliefs and Attitudes about Sleep (DBAS): Validation of a Brief Version (DBAS-16). *Sleep*, *30*(11), 1547–1554.

Palermo, T. M., Walco, G. A., Paladhi, U. R., Birnie, K. A., Crombez, G., de la Vega, R., Eccleston, C., Kashikar-Zuck, S., & Stone, A. L. (2021). Core outcome set for pediatric chronic pain clinical trials: Results from a Delphi poll and consensus meeting. *PAIN*, *162*(10), 2539. https://doi.org/10.1097/j.pain.0000000000002241

Panepinto, J. A., Torres, S., Bendo, C. B., McCavit, T. L., Dinu, B., Sherman-Bien, S., Bemrich-Stolz, C., & Varni, J. W. (2014). PedsQL™ Multidimensional Fatigue Scale in Sickle Cell Disease: Feasibility, Reliability and Validity. *Pediatric Blood & Cancer*, *61*(1), 10.1002/pbc.24776. https://doi.org/10.1002/pbc.24776

Ramar, K., Malhotra, R. K., Carden, K. A., Martin, J. L., Abbasi-Feinberg, F., Aurora, R. N., Kapur, V. K., Olson, E. J., Rosen, C. L., Rowley, J. A., Shelgikar, A. V., & Trotti, L. M. (2021). Sleep is essential to health: An American Academy of Sleep Medicine position statement. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the*

American Academy of Sleep Medicine, *17*(10), 2115–2119. https://doi.org/10.5664/jcsm.9476

Riehm, K. E., Kwakkenbos, L., Carrier, M.-E., Bartlett, S. J., Malcarne, V. L., Mouthon, L., Nielson, W. R., Poiraudeau, S., Nielsen, K., Baron, M., Frech, T., Hudson, M., Pope, J., Sauve, M., Suarez-Almazor, M. E., Wigley, F. M., & Thombs, B. D. (2016). Validation of the Self-Efficacy for Managing Chronic Disease Scale: A Scleroderma Patient-Centered Intervention Network Cohort Study. *Arthritis Care & Research*, *68*(8), 1195–1200. https://doi.org/10.1002/acr.22807

Ritter, P. L., & Lorig, K. (2014). The English and Spanish Self-Efficacy to Manage Chronic Disease Scale measures were validated using multiple studies. *Journal of Clinical Epidemiology*, *67*(11), 1265–1273. https://doi.org/10.1016/j.jclinepi.2014.06.009

Saidi, O., Rochette, E., Bourdier, P., Ratel, S., Merlin, E., Pereira, B., & Duché, P. (2022). Sleep in children and adolescents with juvenile idiopathic arthritis: A systematic review and meta-analysis of case-control studies. *Sleep*, *45*(2), zsab233. https://doi.org/10.1093/sleep/zsab233

Salazar, A., Ojeda, B., Dueñas, M., Fernández, F., & Failde, I. (2016). Simple generalized estimating equations (GEEs) and weighted generalized estimating equations (WGEEs) in longitudinal studies with dropouts: Guidelines and implementation in R. *Statistics in Medicine*, *35*(19), 3424–3448. https://doi.org/10.1002/sim.6947

Schilling, L. S., Knafl, K. A., & Grey, M. (2006). Changing Patterns of Self-Management in Youth with Type I Diabetes. *Journal of Pediatric Nursing*, *21*(6), 412–424. https://doi.org/10.1016/j.pedn.2006.01.034

Smout, M. F., Manzoni, G. M., Guerrini-Usubini, A., Caroli, D., De Col, A., Castelnuovo, G., Pietrabissa, G., Molinari, E., & Sartorio, A. (2022). Responsiveness of the Italian version of the Pediatric Quality of Life Multidimensional Fatigue Scale in adult inpatients with obesity. *Scientific Reports*, *12*(1), Article 1. https://doi.org/10.1038/s41598-022-15261-z

Sonney, J. T., Gerald, L. B., & Insel, K. C. (2016). Parent and child asthma illness representations: A systematic review. *Journal of Asthma*, *53*(5), 510–516. https://doi.org/10.3109/02770903.2015.1116088

Sonney, J. T., Thompson, H. J., Landis, C. A., Pike, K. C., Chen, M. L., Garrison, M. M., & Ward, T. M. (2020). Sleep intervention for children with asthma and their parents (SKIP Study): A novel web-based shared management pilot study. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *16*(6), 925–936. https://doi.org/10.5664/jcsm.8374

Stinson, J., Ahola Kohut, S., Forgeron, P., Amaria, K., Bell, M., Kaufman, M., Luca, N., Luca, S., Harris, L., Victor, C., & Spiegel, L. (2016). The iPeer2Peer Program: A pilot randomized controlled trial in adolescents with Juvenile Idiopathic Arthritis. *Pediatric Rheumatology Online Journal*, *14*(1). https://doi.org/10.1186/s12969-016-0108-2

Stinson, J. N., Connelly, M., Jibb, L. A., Schanberg, L. E., Walco, G., Spiegel, L. R., Tse, S. M., Chalom, E. C., Chira, P., & Rapoff, M. (2012). Developing a standardized approach to the assessment of pain in children and youth presenting to pediatric rheumatology providers: A Delphi survey and consensus conference process followed by feasibility testing. *Pediatric Rheumatology*, *10*(1), 7. https://doi.org/10.1186/1546-0096-10-7

Stinson, J. N., Jibb, L. A., Lalloo, C., Feldman, B. M., McGrath, P. J., Petroz, G. C., Streiner, D., Dupuis, A., Gill, N., & Stevens, B. J. (2014). Comparison of Average Weekly Pain Using

Recalled Paper and Momentary Assessment Electronic Diary Reports in Children With Arthritis. *The Clinical Journal of Pain*, *30*(12), 1044. https://doi.org/10.1097/AJP.0000000000000072

Stinson, J. N., Lalloo, C., Hundert, A. S., Campillo, S., Cellucci, T., Dancey, P., Duffy, C., Ellsworth, J., Feldman, B. M., Huber, A. M., Johnson, N., Jong, G., Oen, K., Rosenberg, A. M., Shiff, N. J., Spiegel, L., Tse, S. M. L., Tucker, L., & Victor, J. C. (2020). Teens Taking Charge: A Randomized Controlled Trial of a Web-Based Self-Management Program With Telephone Support for Adolescents With Juvenile Idiopathic Arthritis. *Journal of Medical Internet Research*, *22*(7), e16234. https://doi.org/10.2196/16234

Stinson, J. N., McGrath, P. J., Hodnett, E. D., Feldman, B. M., Duffy, C. M., Huber, A. M., Tucker, L. B., Hetherington, C. R., Tse, S. M. L., Spiegel, L. R., Campillo, S., Gill, N. K., & White, M. E. (2010). An internet-based self-management program with telephone support for adolescents with arthritis: A pilot randomized controlled trial. *The Journal of Rheumatology*, *37*(9), 1944–1952. https://doi.org/10.3899/jrheum.091327

Stinson, J. N., Petroz, G. C., Stevens, B. J., Feldman, B. M., Streiner, D., McGrath, P. J., & Gill, N. (2008). Working out the kinks: Testing the feasibility of an electronic pain diary for adolescents with arthritis. *Pain Research & Management*, *13*(5), 375–382. https://doi.org/10.1155/2008/326389

Stinson, J. N., Stevens, B. J., Feldman, B. M., Streiner, D., McGrath, P. J., Dupuis, A., Gill, N., & Petroz, G. C. (2008). Construct validity of a multidimensional electronic pain diary for adolescents with arthritis. *PAIN*, *136*(3), 281. https://doi.org/10.1016/j.pain.2007.07.002

TARAKCI, E., ARMAN, N., BARUT, K., ŞAHİN, S., & KASAPÇOPUR, Ö. (2019). Fatigue and sleep in children and adolescents with juvenile idiopathic arthritis:a cross-sectional

study. *Turkish Journal of Medical Sciences*, *49*(1), 58–65. https://doi.org/10.3906/sag-1711-167

Tinker, E. C., Garrison, M. M., & Ward, T. M. (2020). Development of the Sleep Health in Preschoolers (SHIP) intervention: Integrating a theoretical framework for a family-centered intervention to promote healthy sleep. *Families, Systems, & Health*, *38*(4), 406–417. https://doi.org/10.1037/fsh0000546

Tsipoura, G., Lazaratou, H., Damigos, D., & Vougiouka, O. (2018). Sleep and its relationship to health-related quality of life in children and adolescents with inactive juvenile idiopathic arthritis. *The Egyptian Rheumatologist*, *40*(3), 197–201. https://doi.org/10.1016/j.ejr.2017.10.004

Valrie, C. R., Bromberg, M. H., Palermo, T., & Schanberg, L. E. (2013). A Systematic Review of Sleep in Pediatric Pain Populations. *Journal of Developmental and Behavioral Pediatrics : JDBP*, *34*(2), 120–128. https://doi.org/10.1097/DBP.0b013e31827d5848

Varni, J. W., Burwinkle, T. M., & Szer, I. S. (2004). The PedsQL Multidimensional Fatigue Scale in pediatric rheumatology: Reliability and validity. *The Journal of Rheumatology*, *31*(12), 2494–2500.

Ward, T. M., Beebe, D. W., Chen, M. L., Landis, C. A., Ringold, S., Pike, K., & Wallace, C. A. (2017). Sleep Disturbances and Neurobehavioral Performance in Juvenile Idiopathic Arthritis. *The Journal of Rheumatology*, *44*(3), 361–367. https://doi.org/10.3899/jrheum.160556

Ward, T. M., Lentz, M., Kieckhefer, G. M., & Landis, C. A. (2012). Polysomnography and actigraphy concordance in juvenile idiopathic arthritis, asthma and healthy children.

Journal of Sleep Research, *21*(1), 113–121. https://doi.org/10.1111/j.1365-2869.2011.00923.x

Ward, T. M., Skubic, M., Rantz, M., & Vorderstrasse, A. (2020b). Human-centered approaches that integrate sensor technology across the lifespan: Opportunities and challenges. *Nursing Outlook*, *68*(6), 734–744. https://doi.org/10.1016/j.outlook.2020.05.004

Ye, Q., Liu, K., Wang, J., Bu, X., & Zhao, L. (2016). Reliability and validity of the Chinese version of the PedsQL Multidimensional Fatigue Scale in children with acute leukemia. *International Journal of Nursing Sciences*, *3*(2), Article 2. https://doi.org/10.1016/j.ijnss.2016.04.001

Yeom, H.-A., Choi, M., Belyea, M., & Fleury, J. (2011). Psychometric evaluation of the index of self-regulation. *Western Journal of Nursing Research*, *33*(2), 268–285. https://doi.org/10.1177/0193945910378854

Yu, L., Buysse, D. J., Germain, A., Moul, D. E., Stover, A., Dodds, N. E., Johnston, K. L., & Pilkonis, P. A. (2011). Development of Short Forms from the PROMIS Sleep Disturbance and Sleep-Related Impairment Item Banks. Behavioral Sleep Medicine, 10(1), 6–24. https://doi.org/10.1080/15402002.2012.636266

Figure 2.1 Consolidated Standards of Reporting Trials (CONSORT) flow chart.

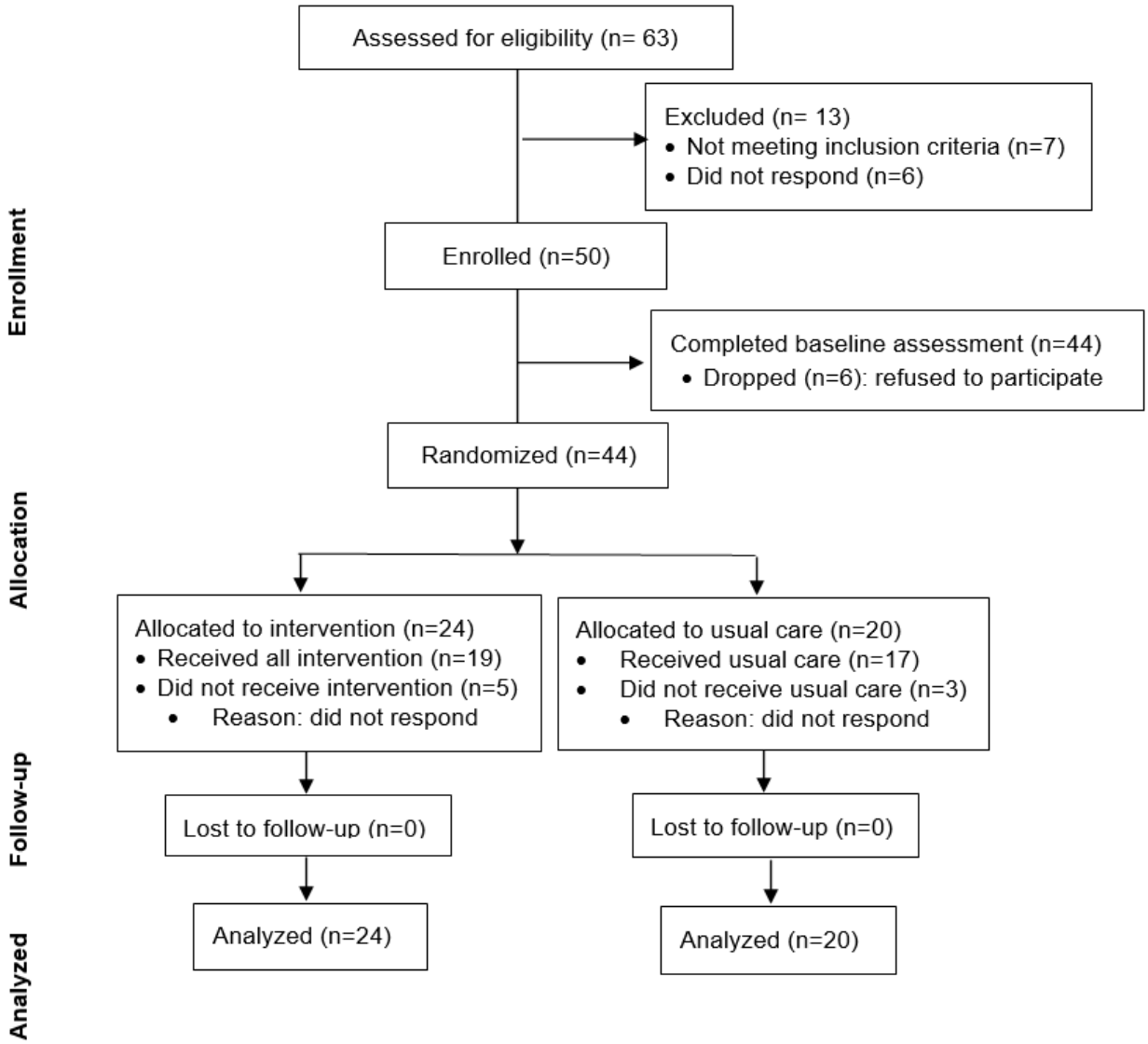
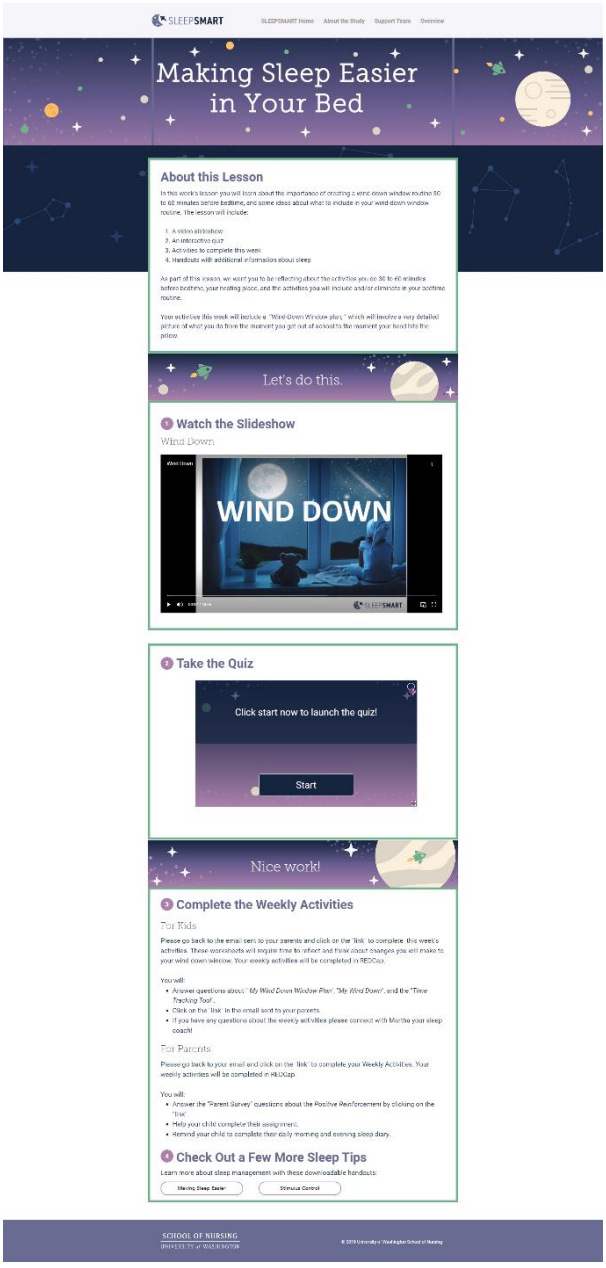


Figure 2.2 SLEEPSMART Online Educational Modules and Activities



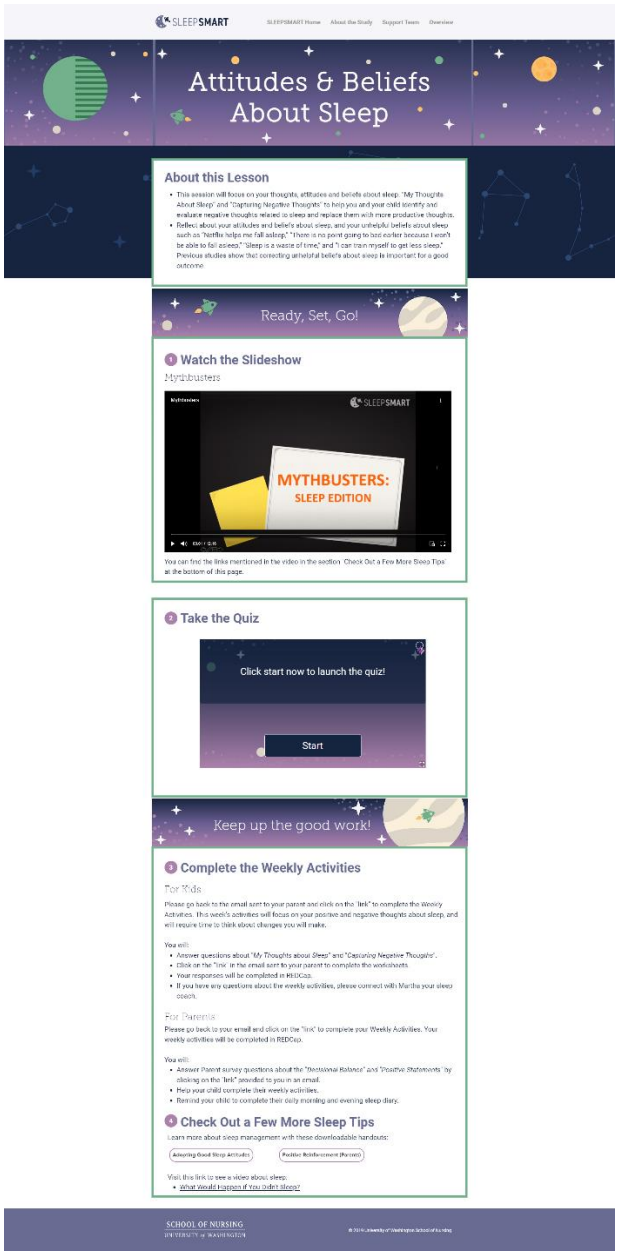


Table 2.1 SLEEPSMART Modules

Cross-Cutting Modules				Common Transdiagnostic Sleep-Circadian Problems	Treatment Module
Case Formulation	Education	Behavior Change & Motivation	Goal Setting	Establishing regular sleep-wake times	Core Module 1
				Learning a wind-down routine	Core Module 1
				Learning a wake-up routine	Core Module 1
				Improving daytime functioning	Core Module 2
				Correcting unhelpful sleep-related beliefs	Core Module 3
				Improving sleep efficiency	Optional Module 1
				Reducing time in bed	Optional Module 2
				Dealing with delayed or advanced phase	Optional Module 3
				Reducing sleep-related worry/vigilance	Optional Module 4
				Maintenance of behavior change	Core Module 4

Adapted by the TransS-C model

Table 2.2 Demographic and Symptom Characteristics of the Sample by Group at baseline

	Variables	SLEEPSMART (n=24) *M* (*SD*) or *n* (%)	Control group (n=20) *M* (*SD*) or *n* (%)	*p* value
Children outcomes	Age, years	10.1 (1.7)	10.5 (1.8)	.3
	Gender, Female	18 (62)	18 (86)	.4
	Total Sleep Time	464.0 (46.1)	483.2 (25.1)	.1
	Time in Bed	631.4 (95.9)	617.6 (50.2)	.8
	Sleep Efficiency	.7 (.1)	.8 (.1)	.1
	Wake After Sleep Onset	71.4 (22.6)	60.4 (22.7)	.6
	PROMIS Sleep Disturbances	62.1 (5.4)	62.4 (7.3)	.2
	PROMIS Sleep Impairment	57.4 (8.9)	56.2 (9.6)	.9
	DBAS*	29.1 (6.3)	27.2 (6.7)	.5
	ASWS*	2.2 (.4)	2.2 (.4)	.7
	Self-Efficacy	2.5 (.8)	2.4 (.8)	.8
	Self-Regulation	3.3 (.6)	2.9 (.9)	.1
	PedsQL™ Multidimensional Fatigue	63.7 (10.1)	68.2 (11.6)	.3
	PROMIS Global Health Pain	52.7 (8.0)	53.3 (7.7)	.5
Parents outcomes	Age, years	40.7 (5.4)	43.2 (6.0)	.9
	Gender, Female	29 (100%)	21 (100%)	
	PROMIS Sleep Disturbances	51.6 (3.7)	52.6 (3.5)	.7
	PROMIS Sleep Impairment	54.9 (8.1)	53.3 (7.1)	.8
	DBAS*	4.2 (1.2)	4.4 (1.5)	.4
	Self-Efficacy	5.8 (1.9)	6.5 (1.6)	.6

*DBAS (dysfunctional beliefs about sleep), AWSW (Adolescent Sleep Wake Scale)

Table 2.3 Themes and Subthemes from Exit Interview

Theme 1 Satisfaction Dyads were positive with SLEEPSMART flow, structure, content, and functions		
Subtheme 1 The flexibility of online learning	Dyads appreciated the flexibility of online learning for SLEEPSMART	*a. "The web-based program is convenient access anywhere to avoid COVID exposure."(child)* *b. "You can replay the modules if you wanted to review a section or did not understand." (child)* *c. "I could help my child with any questions he had."(parent)* d. *"We can do the program with child and parent together." (parent)*
Subtheme 2 Intervention content and structure	Dyads were satisfied with reliable and abundant intervention knowledge	*a."I love the knowledge learned from SLEEPSMART modules and quizzes to reinforce." (child)* *b."I liked the mini quizzes afterward [after each module]. And just like you know, it was nice to get practical." (child)*
Subtheme 3 Research team response	Dyads found the research team was highly responsive, informative, and accessible	*a. "Research assistants' timely response and sleep coach's regularly check-in to help us back on track." (parent)*
Theme 2 Usefulness SLEEPSMART is valuable for participants and worth their time to use		
Theme 1 Empowering children	SLEEPSMART activated/motivated children to take control to improve their sleep	*a."[the program] empowers children to control their sleep by learning new strategies and useful tips on healthy sleep." (parent)* *b."…it gave the kind of handle the power or the control of it to the kids where they realized that they could make changes. Instead of just mom saying OK, this is your new bedtime. It is more I think I need to do that. It was a little different, kind of, put them in making some decisions for themselves." (parent)* *c."You saw actual changes start to happen pretty quick. … it didn't take a really long time for something to start shifting it. It was fairly quick that she could start to see some changes." (parent)*

Theme 2 Parent-Child shared management	Dyads like how SLEEPSMART reconnected them together for the same goal	a. *"It gave us a common language to discuss sleep issues. It also provided an expert voice to common parenting issues around bedtime avoidance behaviors." (parent)* b. *"Reinforcing the importance of communication between parent and child and child self-talk is so important for us to reconnect with each other." (parent)*
Theme 3 Improvement Suggestions for future SLEEPSMART refinement		
Subtheme 1 System	Organize the tasks more structured in one dashboard, with tools to check out daily tasks and track the progress; more coaching.	a. *"I think having everything in one place would be helpful. Instead of having to click in different parts in the email for the surveys and then the modules would separate." (parent)* b. *"Maybe like an in-person appointment just to have like face to face. A conversation about it and that might be helpful. " (child)*
Subtheme 2 Surveys	Reduce the burden of too many surveys and provide more explanations for survey	a. *"Shorter surveys and fewer questions for younger kids." (parent)* b. *"started that section parent questionnaire section with just a little paragraph that said that like we're asking about your sleep to see how your child's disease or how your child sleep impacts your sleep, that would have been kind of helpful." (parent)*
Subtheme 3 Intervention Modules	Divide the videos into smaller sections, visualize and gamify the knowledge to make them more storytelling and playful, interact more with real person guides, and develop an actual rewarding system.	a. *"I kind of wish that they had been broken up a little bit more just because it was sometimes it's hard to get have her stay with me as far as what we're doing so." (parent)* b. *"they're very sophisticated parts like some of the concepts are quite sophisticated. So I guess actually I'm breaking into two parts. The learning part. Yeah, like more storytelling, more playfulness. for younger kids, I think there might have to be some other way of thinking, like how do you ask that question in a playful way." (parent)* c. *"a sticker after finishing one module, and other physical rewards after completing the quizzes to motivate children." (child)*

Table 2.4. Means and standard deviation for children and outcomes by groups at the three assessment time points

		Baseline		Immediately post-intervention		One-month post-intervention		Time X Group Interaction Effect[1]	
		SLEEP-SMART n=24	Control Group n= 20	SLEEP-SMART n=19	Control Group n= 17	SLEEP-SMART n=19	Control Group n= 17	Post-intervention	One-month follow up
		M(SD)	M(SD)	M(SD)	M(SD)	M(SD)	M(SD)	β(SE)	β(SE)
Children outcomes	Sleep Efficiency	.7 (.1)	.8 (.1)	.8 (.1)	.8 (.04)	.8 (.1)	.8 (.04)	.08 (.02) **	.05 (.02) *
	Total Sleep Time	464.0 (46.7)	483.2 (25.1)	508.6 (57.4)	483.6 (28.1)	506.8 (48.1)	488.7 (33.4)	38.5 (11.0) **	23.6 (11.1) *
	Sleep Disturbances	62.1 (5.4)	62.4 (7.3)	57.7 (4.3)	58.3 (7.6)	56.4 (2.8)	58.5 (7.1)	-.8 (2.1)	-1.4 (2.4)
	Sleep Impairment	57.4 (8.9)	56.2 (9.6)	52.8 (7.8)	54.7 (10.2)	51.8 (7.7)	52.8 (9.2)	-3.0 (2.1)	-2.6 (2.6)
	DBAS	29.1 (6.3)	27.2 (6.7)	27.1 (4.7)	25.4 (7.3)	23.1 (4.4)	25.2 (7.3)	-1.0 (1.8)	-3.4 (1.7) *
	Self-Efficacy	2.5 (.8)	2.4 (.8)	2.0 (.6)	2.3 (.8)	2.0 (.8)	2.2 (.9)	-.6 (.2) *	-.2 (.3)
	Self-Regulation	3.3 (.6)	2.9 (.9)	3.7 (.6)	3.1 (.5)	3.6 (.7)	3.1 (.8)	.2 (.2)	.1 (.2)
Parents outcomes	Sleep Disturbances	51.6 (3.7)	52.6 (3.5)	50.5 (3.2)	51.5 (5.6)	49.5 (3.5)	51.5 (5.7)	-.8 (1.4)	-.7 (1.4)
	Sleep Impairment	54.9 (8.1)	53.3 (7.1)	50.0 (9.4)	50.8 (9.6)	49.9 (9.4)	48.9 (8.4)	-4.5 (2.8)	-.1 (2.8)
	DBAS	4.2 (1.2)	4.4 (1.5)	3.4 (1.4)	3.2 (2.0)	3.1 (1.2)	2.9 (1.8)	.6 (2.1)	.5 (.7)
	Self-Efficacy	5.8 (1.9)	6.5 (1.6)	7.1 (1.3)	6.6 (1.9)	7.5 (1.4)	7.2 (1.9)	.8 (.5) **	1.3 (.6) *

- *<0.05, **<0.01.
- [1]Parameter estimates reflect the effect of the interaction between time and group status (treatment vs. control), from baseline to post-treatment and from baseline to follow-up.
- DBAS: Dysfunctional Beliefs and Attitudes about Sleep

Chapter 3: Analysis, Evaluation, and Reformulation of Social Cognitive Theory: Towards Parent-Child Shared Management in Sleep Health

Abstract

Objectives: Behavioral Insomnia of Childhood (BIC) is highly prevalent, affecting up to 45% of typically developing children and 80% of children with special healthcare needs. BIC leads to sleep deficiency, disrupted physical and psychological health, poor school performance, behavioral dysfunction, and negatively affects parental and family functioning. Social Cognitive Theory (SCT) is a useful framework for understanding health behaviors. We aim to analyze and evaluate SCT in a pediatric sleep context and propose a reformulation of SCT to better inform sleep research.

Methods: Fawcett's framework was used to guide the analysis and evaluation of SCT. Theory analysis focuses on the theory's scope, context, and content; theory evaluation considers the theory's significance, internal consistency, parsimony, testability, empirical adequacy, and pragmatic adequacy.

Results: SCT is a middle-range theory that was expanded and renamed after social learning theory, emphasizing the concept of cognition in executing and changing behaviors. SCT addresses the nursing metaparadigm concepts of triadic determinism between people, behavior, and environment on the philosophical basis of human agency. The key concepts of SCT are self-efficacy, self-regulation, outcome expectation, and observational learning. The worldview of contextualism can be inferred. SCT has overall strong theoretical foundations for explaining, predicting, and changing human behavior. Although SCT was not derived from the nursing discipline, it has demonstrated considerable social significance and a powerful theoretical impact on nursing in empirical research. SCT can be strengthened by clarifying its relational propositions, enhancing semantic consistency, and improving testability and empirical adequacy. In addition, SCT is individually focused and does not account for interdependence within

relationships. Pediatric sleep interventions have limited long-term effects and sustainability without considering the parent-child dyadic interdependency. We advance the argument that a family-centered approach is beneficial for understanding pediatric sleep health; specifically, the parent-child shared management (PCSM) perspective. PCSM is a concept that reflects the shared responsibility and interdependence that parent and child have for managing child health. It assumes that with parents' ongoing support, children's responsibility for their own health management increases over time, along with developmental progression and health-related experiences. We propose reformulating SCT by integrating PCSM in the pediatric sleep context: Social Cognitive Theory with Shared Management (SCT-SM). The proposed SCT-SM accounts for parent-child interdependence and role transition. Shared management interventions that engage parents and children in active roles in managing sleep have potential sustainable effects in improving sleep and quality of life.

Conclusion: The reformulated SCT-SM allows researchers to better understand parent-child shared management of pediatric sleep. Our research team will soon test the SCT-SM in children with juvenile idiopathic arthritis (JIA) and sleep problems, including their parents. We expect that sleep intervention guided by SCT-SM will improve sleep quality, enhance communication, and boost the capacity to manage chronic conditions in children and parents. We also anticipate that the reformulated SCT-SM has the potential to generalize to other pediatric chronic conditions by providing a framework for a better understanding of the shifting roles/responsibilities between parent-child dyads.

Key Words: Parent-Child Shared Management, Social Cognitive Theory, Theory Reformulation

Introduction

Sleep problems in childhood are highly prevalent, affecting 25% to 45% of typically-developing children and up to 80% of children with special healthcare needs (Bruni et al., 2022; McLay et al., 2020; Phillips et al., 2020). Behavioral Insomnia of Childhood (BIC), including bedtime resistance and difficulty initiating and/or maintaining sleep, is the most common sleep problem (Freeman et al., 2020; Macias & Malhotra, 2021; Owens & Moore, 2017). BIC leads to sleep deficiency (insufficient sleep duration and poor quality), low sleep efficiency, sleep fragmentation, disrupted physical and psychological health, poor school performance, and behavioral dysfunction (Hayes & Bainton, 2020; Park et al., 2022). Sleep problems also negatively impact parental and family functioning (Chang et al., 2019; Nunes et al., 2020; Williamson et al., 2019). Parents of children with BIC are more likely to report distress, fatigue, and marital conflict associated with sleep deficiency resulting from their child's sleep problems (Martin et al., 2019; Tyler et al., 2019).

Social Cognitive Theory (SCT) has been a guiding framework in health research as it is helpful for understanding people's behaviors (Bagherniya et al., 2018; Moeini et al., 2019; Tougas et al., 2015; Xiang et al., 2022; Zare et al., 2020). SCT describes the influence of individual experiences, the actions of others, and environmental factors on individual health behaviors and emphasizes the primary role that cognition plays in encoding and performing behaviors (Bandura, 1986). A key concept is reciprocal determinism, which refers to the continuous interaction of personal, environmental, and behavioral factors; these three factors continuously interact through influencing and being influenced by each other in a triangular model (Bandura, 1998). The goal of SCT is to explain how people regulate their behavior

through control and reinforcement to achieve and maintain the intended behavior (Luszczynska & Schwarzer, 2015).

In an effort to further understand SCT, advance sleep research guided by SCT, and inform pediatric sleep intervention development, we aimed to report on an analysis and evaluation of SCT in the context of pediatric sleep and propose a reformulation of SCT. A comprehensive analysis and evaluation of SCT in the context of pediatric sleep health have not yet been conducted, and this limits understanding of SCT and its potential to inform theory-driven sleep interventions for families experiencing BIC.

Methods

Theory Analysis and Evaluation Framework

We used Fawcett's framework to guide the analysis and evaluation of SCT (Fawcett & Desanto-Madeya, 2012). Fawcett's framework provides a comprehensive structure for examining middle-range and grand theories. Theory analysis entails a non-judgmental and systematic examination of what the author has presented about the theory. There are three steps in theory analysis. These steps include investigating a theory's 1) scope, 2) context, and 3) content. The sources used for analysis are the author’s writings; what others have written about the theory generally are not used in the analysis, unless necessary (for example, if the author is unclear on a particular point). Theory evaluation entails making judgments about the extent to which the theory meets six established criteria. The six criteria are 1) significance, 2) internal consistency, 3) parsimony, 4) testability, 5) empirical adequacy, and 6) pragmatic adequacy. Evaluation is based on the results of the theory analysis and may also draw on a published critique of the theory, research articles, and descriptions of the use of the theory in practice.

Results

Theory Scope

Theory scope refers to a theory's breadth and abstractness of its concepts and propositions (Fawcett & Desanto-Madeya, 2012). Grand theories have the greatest breadth and abstraction, while middle-range theories are less abstract and more applicable to clinical/social phenomena (Fawcett & Desanto-Madeya, 2012). SCT is a middle-range theory because it has specific concepts and relationships between propositions.

Theory Context

Theoretical context considers the extent to which the concepts and propositions fit within the nursing metaparadigm, its philosophical claims (also called worldview), the conceptual model that guided theory development, and antecedent knowledge from which the theorist drew (Fawcett & Desanto-Madeya, 2012).

Metaparadigm Concepts and Metaparadigm Propositions. SCT addresses the metaparadigm nursing concepts of *human beings, health behavior,* and *environment*, positing that human behavior is the product of and influenced by the dynamic interplay across personal, behavioral, and environmental factors (Bandura, 1986). A metaparadigm nursing proposition of SCT is that the behavior of human beings is *"*concerned with the patterning of human health experiences within the context of the environment" (Fawcett & Desanto-Madeya, 2012, p. 6).

Philosophical Claims. The philosophical basis of SCT is human agency and human capability. Human agency underscores that individuals can direct their own thoughts, feelings, and actions in specific ways to attain goals (Bandura, 1986). People are not simply acted upon by their environment and others' actions, but they also shape their environment to change their behavior.

Worldview. SCT does not explicitly state its worldview, but contextualism can be inferred. Contextualism originated from philosopher Stephen C. Pepper, who emphasized: "act in context." People continuously interact with the dynamic environment to change their behaviors (Morris, 1988; Zimmerman, 1983). The worldview of contextualism underpins SCT in that health behavior occurs within a social context, where a person's experiences, expectations, and perceptions are shaped.

Conceptual Model. The conceptual model of SCT is triadic determinism between *behavioral*, *environmental*, and *personal* factors (e.g., cognitions and emotions; Bandura, 1986). For example, in sleep health, children who feel more confident in soothing themselves to sleep (high self-efficacy/personal) tend to follow a consistent bedtime routine which, in turn, supports good quality sleep (behavior).

Antecedent Knowledge. Social Learning Theory (SLT), the precursor to SCT published in 1977 by Bandura, holds that a person's perceived self-efficacy, self-regulation, and observational learning significantly correlate with behavioral change (Bandura, 1977). In 1986, Bandura expanded and renamed SLT to SCT, emphasizing the importance of cognition in performing and changing behaviors (Bandura, 1986). As a result, SCT evolved from emphasizing behavior-oriented concepts in 1977 to cognitive concepts in 1986.

Theory Content

Theory content includes the concepts and propositions of a theory (Fawcett & Desanto-Madeya, 2012). According to Fawcett, concepts give meaning, enable a theory to be interpreted, and structure phenomena. Propositions include statements that describe or define concepts (nonrelational propositions) and statements about relations between two or more concepts (relational propositions)

(Fawcett & Desanto-Madeya, 2012). **Table 1** shows key concepts and propositions of SCT.

Theory Evaluation

Significance. The criterion of significance requires justification of the theory's importance to the nursing discipline through the following aspects: explicit assertion of metaparadigm concepts and propositions, derivative philosophical claims, conceptual models, or antecedent knowledge (Fawcett & Desanto-Madeya, 2012). The worldview of contextualism can be inferred from SCT. The conceptual model of triadic reciprocal interactions is clearly documented, as is the theory's antecedent knowledge. SCT is also widely applied across diverse disciplines and areas of study, including psychology, nursing, medicine, and other health professions (Glanz et al., 2015). These demonstrate the solid foundation upon which SCT was developed and have been cited throughout other SCT publications (Bandura, 1985, 1986, 1989, 2001, 2002, 2004).

Internal Consistency. Internal consistency is achieved when all theory components are consistent and coherent, its concepts demonstrate semantic clarity and consistency, and its propositions demonstrate structural consistency (Fawcett & Desanto-Madeya, 2012). Semantic clarity is evident in the definitions of SCT concepts (see **Table 1** for SCT concepts and propositions). Some elements that limit internal consistency include semantic inconsistency in interchangeable terminology, such as "observational learning" and "social modeling." Before 2004, SCT used "observational learning." However, after 2004, SCT used "social modeling" and "observational learning" interchangeably. Additionally, the relational propositions of SCT are not clearly stated. SCT primarily depends on the triadic reciprocal interactions between behavior, environment, and people. SCT does not indicate how the concepts interact (e.g., does high self-efficacy lead to high expectations or vice versa? Does goal setting promote self-efficacy?) and to what extent those key concepts impact an individual's behavior (e.g., whether some are more influential on behavior than others)? The structural inconsistency of the relational propositions of SCT reduces the internal consistency of SCT.

Parsimony. Parsimony requires a theory to be comprised of as few concepts and propositions as necessary to convey the meaning of the theory (Fawcett & Desanto-Madeya, 2012). SCT is a complex theoretical paradigm capable of accounting for all aspects of human behaviors, yet it is depicted in a simple structure. However, the theory may be oversimplified and wide-reaching without explicitly explaining all of the concepts in SCT. For example, SCT is not explicit about which concepts are contained under People, Environment, and Behavior. There is also a lack of clarity about how these concepts function differently in various contexts, such as individuals, teams, cultures, and gender. This lack of clarity diminishes parsimony and presents a challenge for intervention operations in future projects.

Testability. Testability for a middle-range theory requires observable concepts and measurable propositions (Fawcett & Desanto-Madeya, 2012). Two elements limit SCT's testability. First, SCT is unclear about which concepts are contained under People, Environment, and Behavior, which could lead to inappropriate applications of SCT. Second, SCT lacks a clear description of how the concepts interact in consistent and predictable ways toward explaining human behavior, which reduces testability and measurability. Nevertheless, many researchers have tested one or more concepts of SCT. **Table 2** shows SCT concepts and instruments tested in pediatric sleep studies. Robust statistical methods such as regression analyses, structural equation modeling, and dynamic computational modeling have been employed to test the propositions of SCT (Dewar et al., 2013; Esmaeily et al., 2014; Kanekar et al., 2015; Lubans et al., 2012; Riley et al., 2016; Torkan et al., 2018).

Empirical Adequacy. The empirical adequacy criterion assumes that the theory is congruent with empirical data (Fawcett & Desanto-Madeya, 2012). As shown in Table 2, SCT has been broadly applied across diverse disciplines. Self-efficacy, in particular, has been tested

and validated in many studies. However, concepts such as observational learning, self-regulation, and motivation have not been as widely tested. Therefore, SCT partially meets the empirical adequacy criterion.

Pragmatic Adequacy. Pragmatic adequacy refers to how the theory and research findings help enhance practice or solve problems arising from practice (Fawcett & Desanto-Madeya, 2012). SCT provides a framework for understanding and predicting behaviors, identifying and targeting pathways for changing those behaviors, improving health outcomes, and reducing disease burden (Glanz et al., 2015). **Table 3** provides examples of how SCT has been applied to pediatric sleep intervention studies. Studies are categorized based on three types of theory utilization: 1) *inform*: SCT concepts are used to guide the development of the intervention, but the theoretical constructs are not described or measured; 2) *applied*: SCT is specified as the theoretical framework for developing the intervention, and the theoretical concepts are measured in the study; and 3) *create/build*: a new theory is developed based on SCT, and concepts are measured in the study (Painter et al., 2008).

SCT and Parent-Child Shared Management

Despite the utility of SCT in explaining, predicting, and changing human behavior, SCT is individually focused and does not account for interdependence or interaction within relationships. In pediatric sleep research, it is crucial to understand parent-child interdependence to effectively manage children's sleep. Parents play critical roles in shaping children's health management skills as they are essential care providers and teachers. Pediatric sleep interventions have limited long-term effects and sustainability without considering parent-child dyadic interdependency (Kieckhefer & Trahms, 2000; Sonney et al., 2020).

This paper advances the argument that taking a family-centered approach, specifically a parent-child shared management perspective (Kieckhefer & Trahms, 2000), is beneficial for understanding pediatric sleep. Parent-child shared management is a concept that reflects the shared responsibility and interdependence (being dependent upon one another) that parent and child have for managing child health. It assumes that with parents' ongoing support, children's responsibility for their own health management increases along with developmental progression and health-related experiences (Buford, 2004; Kieckhefer & Trahms, 2000). Shared management theorists contend that childhood is an opportune time for children to learn health management responsibility in a safe environment alongside their parent(s), to maximize the child's management potential (Buford, 2004; Kieckhefer & Trahms, 2000; Schilling et al., 2006; Sonney et al., 2016). We believe that adding parent-child shared management as a central concept in SCT enhances its capacity to account for this interdependence and broadens its application to dyads.

Building on insights from the above SCT theory analysis and evaluation, we propose a reformulated Social Cognitive Theory by integrating parent-child shared management: Social Cognitive Theory with Shared Management (SCT-SM). **Figure 1** presents a conceptual model of SCT-SM. This reformulated SCT-SM acknowledges empirical evidence and has the potential to guide future sleep research on mechanisms that facilitate sleep health among children and their parents.

Reformulation

Maintaining the structure of triadic determinism, SCT-SM includes the three factors of people, behavior, and the environment but adds parent-child shared management as a central concept that influences and is influenced by each of the three factors of triadic determinism. The

sections below define parent-child shared management and the three factors of triadic determinism in SCT-SM, then describes relationships between people, behavior, environment, and parent-child shared management in the context of pediatric sleep health using the reformulated model.

Parent-Child Shared Management

Parent-child shared management is characterized by an interdependent connection, effective partnership, strategic collaboration, and role transition process within dyads. In early childhood, a child mainly depends on their parent(s) to provide care. As the child develops physically and cognitively, they are capable of assuming increasing responsibility for their health and self-management (Sonney et al., 2016). Development and capacity for self-management are highly variable among children; typically, developing adolescents will assume primary responsibility for healthy sleep behaviors, with the parent being available to consult and support them. Shared management is highly variable within families and dyads due to interpersonal and familial dynamics, the child's developmental trajectory, and self-management capacity.

People

People refers to children and their parent(s) or family caregiver(s). *People* also refers to cognitive factors, including 1) the dyad's confidence to execute healthy sleep behaviors; 2) the dyad's self-regulation, including the ability to manage their thoughts and behaviors to meet healthy sleep goals; 3) the dyad's knowledge of sleep health; and 4) the dyad's beliefs and attitudes toward sleep.

Environment

The *environment* is conceptualized from a social-ecological perspective (Bronfenbrenner & Morris, 2007). For example, family functioning, the social-physical environment, and the policy environment are contained within the *environment* concept.

Behavior

Behavior is the act people conduct with or without purpose. In sleep research, behaviors including sleep behaviors (actions directly related to sleep: bedtime, rise time, regularity of sleep timing, napping habits, sleep routine) and sleep-related behaviors (a lifestyle that may influence sleep: avoiding caffeine, tobacco, alcohol, night light exposure, as well as engaging in stress management and physical activity habits) (Hall & Nethery, 2019; McDowall et al., 2017).

Relationships Between People, Behavior, Environment, and Parent-Child Shared Management in SCT-SM

As depicted in Figure 1, the reformulated SCT-SM focuses on bidirectional and reciprocal relationships that explain how parent-child shared management mediates the multidimensional factors contributing to one's sleep health.

People and Behavior

Parent-child dyads and sleep outcomes reciprocally interact. Children's health conditions (e.g., chronic disease, mental health conditions; Johnson et al., 2016, 2018; Koyanagi & Stickley, 2015; Medic et al., 2017), self-efficacy (Bihlmaier & Schlarb, 2016; Schlarb et al., 2012), and self-regulation (Dorrian et al., 2019; Owens et al., 2016; Williams & Sciberras, 2016; Zhang & Wu, 2020) are strongly associated with sleep behaviors. Reciprocally, healthier sleep habits, sleep behaviors, and better sleep outcomes are associated with parent-child dyads' better overall physical, mental health, and life satisfaction (Blackwell et al., 2020; Dong et al., 2019; Grandner, 2017; Kaneita et al., 2009; Shanahan et al., 2014; Stranges et al., 2012), as well as sleep-related

knowledge, beliefs, self-efficacy, and self-regulation (Owens et al., 2016; Przepiórka et al., 2019). Moreover, higher maternal knowledge, beliefs, and self-efficacy about sleep are correlated with fewer children's sleep problems, depressive symptoms, and fatigue, as well as better daytime performance (Br et al., 2016; Grandner, 2017; McDowall et al., 2017; Peltz & Rogge, 2019.; Thakral et al., 2020; Werner et al., 2022).

Environment and Behavior

Family Functioning. Family functioning includes the process of communication, problem-solving, division of labor, conflict management, and a sense of attachment and engagement among family members (El‐Sheikh & Kelly, 2017). Positive family functioning includes maternal sensitivity, children's secure attachment to parents, and parents' high-quality involvement (El-Sheikh & Kelly, 2017). Negative family functioning includes marital aggression and conflict, parents' hostility towards each other, aggression between parents and children, and parental mental health conditions (Caicedo, 2014; Lewandowski et al., 2010). Children who experience positive family functioning tend to sleep longer and have better sleep quality, whereas children who experience negative family functioning tend to have sleep deficiency (Bélanger et al., 2015; Bernier et al., 2017; Bordeleau et al., 2012; El-Sheikh et al., 2012; Kelly & El-Sheikh, 2011; Mindell et al., 2009; Ragni et al., 2019; Rhoades et al., 2012).

Physical and Social Environment. Examples of the physical and social environment include housing quality and safety, noise, population density, transportation, and community cohesion (Billings et al., 2020; Hale et al., 2015; Hunter & Hayden, 2018; Johnson et al., 2018). Due to inequitable systems, predominantly live in under-resourced environments negatively affect minoritized and underrepresented populations' sleep health (Bagley et al., 2018; El-Sheikh et al., 2013; Grimes et al., 2019; Johnson et al., 2019; Mayne et al., 2021; Rosen et al., 2003; R.

Wang et al., 2017; Williams & Collins, 2001). For example, children who are living in environments with less green space, security and social cohesion, exposed to more noise, air pollution, and night light, are more likely to experience longer sleep onset latency, increased fragmented sleep, daytime sleepiness, and sleep disorders (Mayne et al., 2021). Furthermore, systemic racism has additional adverse effects on sleep health through the mechanism of psychosocial trauma, discrimination and micro-aggressions, and stereotype threats to sleep (Bailey et al., 2017). These experiences can serve as external threats and impair the ability to be vulnerable in sleep (Billings et al., 2021). People who experience micro-aggressions and racism have poorer quality sleep that result from greater racism-related vigilance and discrimination experiences (Alcántara et al., 2017; Gaston et al., 2020; Ong et al., 2017; Yip et al., 2020).

Policy Environment. Policies profoundly influence sleep health, from operational issues in local schools to national-level legislation that governs safety and health matters related to sleep. As summarized by Barnes and Drake (2015), national middle and high school instructional hours could be delayed, work hours and schedules could be better regulated, daylight savings time could be eliminated, public awareness about the impact of electronic devices on sleep could be improved, and the access to diagnostic testing for sleep disorders needs to be enhanced.

People and Environment

People live in and are influenced by their environment, and they also shape the environment (Bandura, 1986). For example, policies regulating quiet time between 9 pm to 7 am, delayed school start times based on age, and cancellation of daylight savings would promote better sleep health (Barnes & Drake, 2015). Higher sleep-related efficacy, self-regulation, knowledge, and beliefs toward sleep also contribute to a better sleep environment (e.g., no TV or

screen in the bedroom, quiet and dark sleep environment). Family engagement in healthy sleep behaviors could contribute to building communities that support sleep health.

Parent-Child Shared Management and Behavior, People, and Environment

Shared management is a dynamic process, given that parent and child responsibilities continuously evolve as the child develops. The shared management relationship could both influence and be influenced by the environment. Shared management relationships could foster positive family functioning by creating open communication channels, enhancing positive interaction and feedback, and strengthening family bonds by facing challenges and overcoming barriers as a team. In shared management relationships, parents' knowledge, awareness, attitudes, and beliefs toward sleep health profoundly impact how children perceive sleep and perform sleep-related behaviors. Partnerships within families ultimately extend to collaboration and participation within neighborhoods and communities. With more families realizing and understanding the critical role of sleep and adopting shared management in managing sleep and other health conditions, more people will advocate for optimizing policies and strive to make the community a better "healthy-sleep friendly" place.

Discussion

This is the first paper to comprehensively analyze and evaluate SCT and reformulate SCT toward parent-child shared management in pediatric sleep health. SCT provides strong theoretical foundations for explaining, predicting, and changing human behavior. Although SCT was not derived from the nursing discipline, it demonstrates the considerable social significance and has powerfully impacted empirical nursing research. However, SCT is individually focused and does not account for interdependence within relationships. Our proposed SCT-SM adds the

active role of parent and child and accounts for parent-child interdependence and role transition, providing a promising framework for promoting children's sleep health with sustained effects.

Implications for Sleep Research, Intervention, and Healthcare

Most of the literature on pediatric sleep focuses on children or parents alone, which decontextualizes pediatric sleep research by not considering connections within parent-child dyads. SCT-SM reconsiders pediatric sleep from a new theoretical perspective that includes parent-child shared management. Additionally, given that many behaviors happen in the context of relationships, SCT-SM could be informative for shared management among other types of dyadic relationships—for example, Alzheimer's disease management within a patient-informal caregiver dyad.

In addition, validated and user-friendly assessment tools need to be developed to measure parent-child shared management for use in healthcare and research settings. To date, only one known shared measurement assessment tool has been created, and it is rarely used because the tool was designed only for parental respondents(Kieckhefer et al., 2009). Moreover, systemic racism and racial discrimination significantly mediate the relationship between race and insomnia symptom severity (Cheng et al., 2020). Future research could explore whether SCT-SM could mitigate sleep health disparities among children in underserved communities by addressing drivers of inequities including racism and discrimination.

Parents typically receive little preparation for shared management of their child’s health. Guided by SCT-SM, future research interventions could add a component of parent-child shared management, including strategies for how to maximize children’s engagement in self-management. Interventions could also meet families’ needs and priorities by applying participatory design in the development stage, allowing parents and children to provide

suggestions and feedback on the intervention prototype. Leveraging mobile applications and other technology-enabled approaches may increase the accessibility and scalability of future shared management sleep health interventions.

Furthermore, healthcare professionals are critical in promoting parent-child shared management within families. SCT-SM theory has the potential to guide healthcare professionals to encourage and support the development of collaborative plans for dyadic care by increasing families' awareness of shared management, coaching their practice and monitoring their progress at each appointment.

Strengths and Limitations

This paper has some limitations. Our analysis and evaluation of SCT are limited to the sources we used, including Bandura's writings about the theory (Bandura, 1986, 1997, 1998, 2004), Glantz and colleagues' (2015) writings, and empirical research studies that have used SCT. We did not conduct a systematic review of all empirical research studies that used SCT, and the sources we used were limited to those written in English. However, the strengths of this manuscript include the application of an established theory analysis and evaluation framework (Fawcett & Desanto-Madeya, 2012), our focus on the use of SCT in pediatric sleep research, and the proposed reformulation. Reformulation is an accepted form of knowledge development (Reed & Shearer, 2017), and SCT-SM extends SCT to dyadic behavioral research concerned with shared management.

Conclusion

The reformulated SCT-SM allows researchers to better understand parent-child shared management of pediatric sleep. Our research team will soon test SCT-SM in children with juvenile idiopathic arthritis (JIA) and sleep problems, including their parents. We expect a sleep

intervention guided by SCT-SM will improve sleep quality, enhance communication, and boost the capacity to manage chronic conditions in children and parents. We also anticipate that the reformulated SCT-SM could extend to other pediatric chronic conditions by providing a framework for a better understanding of shifting roles/responsibilities between parents and children.

References

Aardoom, J. J., Loheide-Niesmann, L., Ossebaard, H. C., & Riper, H. (2020). Effectiveness of eHealth Interventions in Improving Treatment Adherence for Adults With Obstructive Sleep Apnea: Meta-Analytic Review. *Journal of Medical Internet Research*, *22*(2), e16972. https://doi.org/10.2196/16972

Alcántara, C., Patel, S. R., Carnethon, M., Castañeda, S. F., Isasi, C. R., Davis, S., Ramos, A. R., Arredondo, E., Redline, S., Zee, P. C., & Gallo, L. C. (2017). Stress and sleep: Results from the Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study. *SSM - Population Health*, *3*, 713–721. https://doi.org/10.1016/j.ssmph.2017.08.004

Bagherniya, M., Taghipour, A., Sharma, M., Sahebkar, A., Contento, I. R., Keshavarz, S. A., Mostafavi Darani, F., & Safarian, M. (2018). Obesity intervention programs among adolescents using social cognitive theory: A systematic literature review. *Health Education Research*, *33*(1), 26–39. https://doi.org/10.1093/her/cyx079

Bagley, E. J., Fuller-Rowell, T. E., Saini, E. K., Philbrook, L. E., & El-Sheikh, M. (2018). Neighborhood Economic Deprivation and Social Fragmentation: Associations With Children's Sleep. *Behavioral Sleep Medicine*, *16*(6), 542–552. https://doi.org/10.1080/15402002.2016.1253011

Bailey, Z. D., Krieger, N., Agénor, M., Graves, J., Linos, N., & Bassett, M. T. (2017). Structural racism and health inequities in the USA: Evidence and interventions. *The Lancet*, *389*(10077), 1453–1463. https://doi.org/10.1016/S0140-6736(17)30569-X

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037//0033-295x.84.2.191

Bandura, A. (1985). Model of Causality in Social Learning Theory. In M. J. Mahoney & A. Freeman (Eds.), *Cognition and Psychotherapy* (pp. 81–99). Springer US. https://doi.org/10.1007/978-1-4684-7562-3_3

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory* (pp. xiii, 617). Prentice-Hall, Inc.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, *44*(9), 1175–1184. https://doi.org/10.1037/0003-066X.44.9.1175

Bandura, A. (1997). *Self-efficacy: The exercise of control* (pp. ix, 604). W H Freeman/Times Books/ Henry Holt & Co.

Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology & Health*, *13*(4), 623–649. https://doi.org/10.1080/08870449808407422

Bandura, A. (2001). Social Cognitive Theory: An Agentic Perspective. *Annual Review of Psychology*, *52*(1), 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Bandura, A. (2002). Social cognitive theory of mass communication. In *Media effects: Advances in theory and research, 2nd ed* (pp. 121–153). Lawrence Erlbaum Associates Publishers.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior: The Official Publication of the Society for Public Health Education*, *31*(2), 143–164. https://doi.org/10.1177/1090198104263660

Barnes, C. M., & Drake, C. L. (2015). Prioritizing Sleep Health: Public Health Policy Recommendations. *Perspectives on Psychological Science*, *10*(6), 733–737. https://doi.org/10.1177/1745691615598509

Beck, L. H., Bransome, E. D., Mirsky, A. F., Rosvold, H. E., & Sarason, I. (1956). A continuous performance test of brain damage. *Journal of Consulting Psychology*, *20*(5), 343–350. https://doi.org/10.1037/h0043220

Bélanger, M.-È., Bernier, A., Simard, V., Bordeleau, S., & Carrier, J. (2015). Viii. Attachment and Sleep Among Toddlers: Disentangling Attachment Security and Dependency. *Monographs of the Society for Research in Child Development*, *80*(1), 125–140. https://doi.org/10.1111/mono.12148

Bernier, A., Tétreault, É., Bélanger, M.-È., & Carrier, J. (2017). Paternal involvement and child sleep: A look beyond infancy. *International Journal of Behavioral Development*, *41*(6), 714–722. https://doi.org/10.1177/0165025416667851

Bihlmaier, I., & Schlarb, A. A. (2016). Self-efficacy and sleep problems. *Somnologie*, *20*(4), 275–280. https://doi.org/10.1007/s11818-016-0085-1

Billings, M. E., Cohen, R. T., Baldwin, C. M., Johnson, D. A., Palen, B. N., Parthasarathy, S., Patel, S. R., Russell, M., Tapia, I. E., Williamson, A. A., & Sharma, S. (2021). Disparities in Sleep Health and Potential Intervention Models. *Chest*, *159*(3), 1232–1240. https://doi.org/10.1016/j.chest.2020.09.249

Billings, M. E., Hale, L., & Johnson, D. A. (2020). Physical and Social Environment Relationship With Sleep Health and Disorders. *Chest*, *157*(5), 1304–1312. https://doi.org/10.1016/j.chest.2019.12.002

Blackwell, C. K., Hartstein, L. E., Elliott, A. J., Forrest, C. B., Ganiban, J., Hunt, K. J., Camargo, C. A., LeBourgeois, M. K., & program collaborators for Environmental influences on Child Health Outcomes (ECHO). (2020). Better sleep, better life? How sleep quality

influences children's life satisfaction. *Quality of Life Research*, *29*(9), 2465–2474. https://doi.org/10.1007/s11136-020-02491-9

Bordeleau, S., Bernier, A., & Carrier, J. (2012). Maternal sensitivity and children's behavior problems: Examining the moderating role of infant sleep duration. *Journal of Clinical Child and Adolescent Psychology: The Official Journal for the Society of Clinical Child and Adolescent Psychology, American Psychological Association, Division 53*, *41*(4), 471–481. https://doi.org/10.1080/15374416.2012.686101

Br, I., horst, Hautzinger, M., & Schlarb, A. (2016). *Improving Psychosocial Health, Coping, and Self-Efficacy in Parents of Sleep-Disturbed Young Children*. https://doi.org/10.4172/2161-0487.1000249

Brandhorst, I., & Hautzinger, M. (2016). Improving Psychosocial Health, Coping, and Self-Efficacy in Parents of Sleep-Disturbed Young Children. *Journal of Psychology & Psychotherapy*, *06*(02). https://doi.org/10.4172/2161-0487.1000249

Bronfenbrenner, U., & Morris, P. A. (2007). The Bioecological Model of Human Development. In *Handbook of Child Psychology*. John Wiley & Sons, Ltd. https://doi.org/10.1002/9780470147658.chpsy0114

Bruni, O., DelRosso, L. M., Mogavero, M. P., Angriman, M., & Ferri, R. (2022). Chronic insomnia of early childhood: Phenotypes and pathophysiology. *Neuroscience & Biobehavioral Reviews*, *137*, 104653. https://doi.org/10.1016/j.neubiorev.2022.104653

Bub, K. L., Robinson, L. E., & Curtis, D. (2016). Longitudinal Associations between Self-regulation and Health across Childhood and Adolescence. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *35*(11), 1235–1245. https://doi.org/10.1037/hea0000401

Buford, T. A. (2004). Transfer of asthma management responsibility from parents to their school-age children. *Journal of Pediatric Nursing*, *19*(1), 3–12. https://doi.org/10.1016/j.pedn.2003.09.002

Carcea, I., & Froemke, R. C. (2019). Biological mechanisms for observational learning. *Current Opinion in Neurobiology*, *54*, 178–185. https://doi.org/10.1016/j.conb.2018.11.008

Chang, L.-Y., Wu, C.-C., Yen, L.-L., & Chang, H.-Y. (2019). The effects of family dysfunction trajectories during childhood and early adolescence on sleep quality during late adolescence: Resilience as a mediator. *Social Science & Medicine*, *222*, 162–170. https://doi.org/10.1016/j.socscimed.2019.01.010

Cheng, P., Cuellar, R., Johnson, D. A., Kalmbach, D. A., Joseph, C. L., Cuamatzi Castelan, A., Sagong, C., Casement, M. D., & Drake, C. L. (2020). Racial discrimination as a mediator of racial disparities in insomnia disorder. *Sleep Health*, *6*(5), 543–549. https://doi.org/10.1016/j.sleh.2020.07.007

Dewar, D. L., Plotnikoff, R. C., Morgan, P. J., Okely, A. D., Costigan, S. A., & Lubans, D. R. (2013). Testing Social-Cognitive Theory to Explain Physical Activity Change in Adolescent Girls From Low-Income Communities. *Research Quarterly for Exercise and Sport*, *84*(4), 483–491. https://doi.org/10.1080/02701367.2013.842454

Dong, L., Martinez, A. J., Buysse, D. J., & Harvey, A. G. (2019). A composite measure of sleep health predicts concurrent mental and physical health outcomes in adolescents prone to eveningness. *Sleep Health*, *5*(2), 166–174. https://doi.org/10.1016/j.sleh.2018.11.009

Dorrian, J., Centofanti, S., Smith, A., & McDermott, K. D. (2019). Chapter 4—Self-regulation and social behavior during sleep deprivation. In H. P. A. Van Dongen, P. Whitney, J. M.

Hinson, K. A. Honn, & M. W. L. Chee (Eds.), *Progress in Brain Research* (Vol. 246, pp. 73–110). Elsevier. https://doi.org/10.1016/bs.pbr.2019.03.010

El-Sheikh, M., Bagley, E. J., Keiley, M., Elmore-Staton, L., Chen, E., & Buckhalt, J. A. (2013). Economic adversity and children's sleep problems: Multiple indicators and moderation of effects. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *32*(8), 849–859. https://doi.org/10.1037/a0030413

El-Sheikh, M., & Kelly, R. J. (2017). Family Functioning and Children's Sleep. *Child Development Perspectives*, *11*(4), 264–269. https://doi.org/10.1111/cdep.12243

El-Sheikh, M., Kelly, R. J., Bagley, E. J., & Wetter, E. K. (2012). Parental depressive symptoms and children's sleep: The role of family conflict. *Journal of Child Psychology and Psychiatry*, *53*(7), 806–814. https://doi.org/10.1111/j.1469-7610.2012.02530.x

Esmaeily, H., Peyman, N., Taghipour, A., KHorashadizadeh, F., & Mahdizadeh, M. (2014). A Structural Equation Model to predict the Social-Cognitive Determinants related to Physical Activity in Iranian women with Diabetes Mellitus. *Journal of Research in Health Sciences*, *14*(4), Article 4. https://doi.org/10.34172/jrhs141482

Fawcett, J., & Desanto-Madeya, S. (2012). *Contemporary Nursing Knowledge: Analysis and Evaluation of Nursing Models and Theories*. F. A. Davis Company. http://ebookcentral.proquest.com/lib/washington/detail.action?docID=1109626

Freeman, D., Sheaves, B., Waite, F., Harvey, A. G., & Harrison, P. J. (2020). Sleep disturbance and psychiatric disorders. *The Lancet Psychiatry*, *7*(7), 628–637. https://doi.org/10.1016/S2215-0366(20)30136-X

Gaston, S. A., Feinstein, L., Slopen, N., Sandler, D. P., Williams, D. R., & Jackson, C. L. (2020). Everyday and major experiences of racial/ethnic discrimination and sleep health in a

multiethnic population of U.S. women: Findings from the Sister Study. *Sleep Medicine*, *71*, 97–105. https://doi.org/10.1016/j.sleep.2020.03.010

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3 1/2-7 years old on a Stroop-like day-night test. *Cognition*, *53*(2), 129–153. https://doi.org/10.1016/0010-0277(94)90068-x

Glanz, K., Rimer, B. K., & Viswanath, K. (2015). *Health Behavior: Theory, Research, and Practice*. John Wiley & Sons.

Golem, D., Eck, K. M., Delaney, C. L., Clark, R. L., Shelnutt, K. P., Olfert, M. D., & Byrd-Bredbenner, C. (2019). "My stuffed animals help me": The importance, barriers, and strategies for adequate sleep behaviors of school-age children and parents. *Sleep Health*, *5*(2), 152–160. https://doi.org/10.1016/j.sleh.2018.11.003

Grandner, M. A. (2017). Sleep, Health, and Society. *Sleep Medicine Clinics*, *12*(1), 1–22. https://doi.org/10.1016/j.jsmc.2016.10.012

Grimes, M., Camerota, M., & Propper, C. B. (2019). Neighborhood deprivation predicts infant sleep quality. *Sleep Health*, *5*(2), 148–151. https://doi.org/10.1016/j.sleh.2018.11.001

Gunn, H. E., O'Rourke, F., Dahl, R. E., Goldstein, T. R., Rofey, D. L., Forbes, E. E., & Shaw, D. S. (2019). Young adolescent sleep is associated with parental monitoring. *Sleep Health*, *5*(1), 58–63. https://doi.org/10.1016/j.sleh.2018.09.001

Hale, L., Emanuele, E., & James, S. (2015). Recent Updates in the Social and Environmental Determinants of Sleep Health. *Current Sleep Medicine Reports*, *1*(4), 212–217. https://doi.org/10.1007/s40675-015-0023-y

Hall, W. A., & Nethery, E. (2019). What does sleep hygiene have to offer children's sleep problems? *Paediatric Respiratory Reviews*, *31*, 64–74. https://doi.org/10.1016/j.prrv.2018.10.005

Hammersley, M. L., Okely, A. D., Batterham, M. J., & Jones, R. A. (2019). An Internet-Based Childhood Obesity Prevention Program (Time2bHealthy) for Parents of Preschool-Aged Children: Randomized Controlled Trial. *Journal of Medical Internet Research*, *21*(2), e11964. https://doi.org/10.2196/11964

Haraldstad, K., & Stea, T. H. (2021). Associations between pain, self-efficacy, sleep duration, and symptoms of depression in adolescents: A cross-sectional survey. *BMC Public Health*, *21*(1), 1617. https://doi.org/10.1186/s12889-021-11680-1

Hayes, B., & Bainton, J. (2020). The impact of reduced sleep on school related outcomes for typically developing children aged 11–19: A systematic review. *School Psychology International*, *41*(6), 569–594. https://doi.org/10.1177/0143034320961130

Hunter, J. C., & Hayden, K. M. (2018). The association of sleep with neighborhood physical and social environment. *Public Health*, *162*, 126–134. https://doi.org/10.1016/j.puhe.2018.05.003

Johnson, D. A., Billings, M. E., & Hale, L. (2018). Environmental Determinants of Insufficient Sleep and Sleep Disorders: Implications for Population Health. *Current Epidemiology Reports*, *5*(2), 61–69. https://doi.org/10.1007/s40471-018-0139-y

Johnson, D. A., Jackson, C. L., Williams, N. J., & Alcántara, C. (2019). Are sleep patterns influenced by race/ethnicity – a marker of relative advantage or disadvantage? Evidence to date. *Nature and Science of Sleep*, *11*, 79–95. https://doi.org/10.2147/NSS.S169312

Johnson, D. A., Lisabeth, L., Lewis, T. T., Sims, M., Hickson, D. A., Samdarshi, T., Taylor, H., & Roux, A. V. D. (2016). The Contribution of Psychosocial Stressors to Sleep among African Americans in the Jackson Heart Study. *Sleep*, *39*(7), 1411–1419. https://doi.org/10.5665/sleep.5974

Kaneita, Y., Yokoyama, E., Harano, S., Tamaki, T., Suzuki, H., Munezawa, T., Nakajima, H., Asai, T., & Ohida, T. (2009). Associations between sleep disturbance and mental health status: A longitudinal study of Japanese junior high school students. *Sleep Medicine*, *10*(7), 780–786. https://doi.org/10.1016/j.sleep.2008.06.014

Kanekar, A., Sharma, M., & Bennett, R. (2015). Using Social Cognitive Theory to Predict Safer Sex Behaviors in College Students. *American Journal of Health Studies*, *30*(2), Article 2. https://doi.org/10.47779/ajhs.2015.174

Kelly, R. J., & El-Sheikh, M. (2011). Marital conflict and children's sleep: Reciprocal relations and socioeconomic effects. *Journal of Family Psychology : JFP : Journal of the Division of Family Psychology of the American Psychological Association*. https://doi.org/10.1037/a0023789

Khor, S. P. H., McClure, A., Aldridge, G., Bei, B., & Yap, M. B. H. (2021). Modifiable parental factors in adolescent sleep: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *56*, 101408. https://doi.org/10.1016/j.smrv.2020.101408

Kieckhefer, G. M., & Trahms, C. M. (2000). Supporting development of children with chronic conditions: From compliance toward shared management. *Pediatric Nursing*, *26*(4), 354–363.

Kieckhefer, G. M., Trahms, C. M., Churchill, S. S., & Simpson, J. N. (2009). Measuring parent-child shared management of chronic illness. *Pediatric Nursing*, *35*(2), 101–108, 127.

Kim, E., Lee, R., & Cain, K. C. (2017). Cosleeping, sleep disturbances, children's behavioral problems, and parenting self-efficacy among Korean American families. *Journal of Child and Adolescent Psychiatric Nursing, 30*(2), 112–120. https://doi.org/10.1111/jcap.12182

Koyanagi, A., & Stickley, A. (2015). The Association between Sleep Problems and Psychotic Symptoms in the General Population: A Global Perspective. *Sleep, 38*(12), 1875–1885. https://doi.org/10.5665/sleep.5232

Lubans, D. R., Plotnikoff, R. C., Morgan, P. J., Dewar, D., Costigan, S., & Collins, C. E. (2012). Explaining dietary intake in adolescent girls from disadvantaged secondary schools. A test of Social Cognitive Theory. *Appetite, 58*(2), 517–524. https://doi.org/10.1016/j.appet.2011.12.012

Luszczynska, A., & Schwarzer, R. K. (2015). *Social cognitive theory*. McGraw Hill. https://acuresearchbank.acu.edu.au/item/87306/social-cognitive-theory

Macias, M. I., & Malhotra, S. (2021). Behavioral Insomnia of Childhood. *American Journal of Respiratory and Critical Care Medicine*, *203*(8), P20–P21. https://doi.org/10.1164/rccm.2038P20

Martin, C. A., Papadopoulos, N., Chellew, T., Rinehart, N. J., & Sciberras, E. (2019). Associations between parenting stress, parent mental health and child sleep problems for children with ADHD and ASD: Systematic review. *Research in Developmental Disabilities, 93,* 103463. https://doi.org/10.1016/j.ridd.2019.103463

Mayne, S. L., Mitchell, J. A., Virudachalam, S., Fiks, A. G., & Williamson, A. A. (2021). Neighborhood environments and sleep among children and adolescents: A systematic review. *Sleep Medicine Reviews, 57,* 101465. https://doi.org/10.1016/j.smrv.2021.101465

McDowall, P. S., Galland, B. C., Campbell, A. J., & Elder, D. E. (2017). Parent knowledge of children's sleep: A systematic review. *Sleep Medicine Reviews*, *31*, 39–47. https://doi.org/10.1016/j.smrv.2016.01.002

McLay, L., Sutherland, D., Machalicek, W., & Sigafoos, J. (2020). Systematic Review of Telehealth Interventions for the Treatment of Sleep Problems in Children and Adolescents. *Journal of Behavioral Education*, *29*(2), 222–245. https://doi.org/10.1007/s10864-020-09364-8

Medic, G., Wille, M., & Hemels, M. E. (2017). Short- and long-term health consequences of sleep disruption. *Nature and Science of Sleep*, *9*, 151–161. https://doi.org/10.2147/NSS.S134864

Mindell, J. A., Telofski, L. S., Wiegand, B., & Kurtz, E. S. (2009). A Nightly Bedtime Routine: Impact on Sleep in Young Children and Maternal Mood. *Sleep*, *32*(5), 599–606.

Moeini, B., Bashirian, S., Soltanian, A. R., Ghaleiha, A., & Taheri, M. (2019). Examining the Effectiveness of a Web-Based Intervention for Depressive Symptoms in Female Adolescents: Applying Social Cognitive Theory. *Journal of Research in Health Sciences*, *19*(3), e00454.

Moorman, J. D., & Harrison, K. (2019). Beyond Access and Exposure: Implications of Sneaky Media Use for Preschoolers' Sleep Behavior. *Health Communication*, *34*(5), 529–536. https://doi.org/10.1080/10410236.2017.1422103

Morris, E. K. (1988). Contextualism: The world view of behavior analysis. *Journal of Experimental Child Psychology*, 289–323.

Nunes, S., Campbell, M. K., Klar, N., Reid, G. J., & Stranges, S. (2020). Relationships between sleep and internalizing problems in early adolescence: Results from Canadian National

Longitudinal Survey of Children and Youth. *Journal of Psychosomatic Research*, *139*, 110279. https://doi.org/10.1016/j.jpsychores.2020.110279

Ong, A. D., Cerrada, C., Lee, R. A., & Williams, D. R. (2017). Stigma consciousness, racial microaggressions, and sleep disturbance among Asian Americans. *Asian American Journal of Psychology*, *8*(1), 72–81. https://doi.org/10.1037/aap0000062

Owens, J. A., Dearth-Wesley, T., Lewin, D., Gioia, G., & Whitaker, R. C. (2016). Self-Regulation and Sleep Duration, Sleepiness, and Chronotype in Adolescents. *Pediatrics*, *138*(6), e20161406. https://doi.org/10.1542/peds.2016-1406

Owens, J. A., & Moore, M. (2017). Insomnia in Infants and Young Children. *Pediatric Annals*, *46*(9), e321–e326. https://doi.org/10.3928/19382359-20170816-02

Painter, J. E., Borba, C. P. C., Hynes, M., Mays, D., & Glanz, K. (2008). The Use of Theory in Health Behavior Research from 2000 to 2005: A Systematic Review. *Annals of Behavioral Medicine*, *35*(3), 358–362. https://doi.org/10.1007/s12160-008-9042-y

Panadero, E. (2017). A Review of Self-regulated Learning: Six Models and Four Directions for Research. *Frontiers in Psychology*, *8*. https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00422

Park, J., Kim, S. Y., & Lee, K. (2022). Effectiveness of behavioral sleep interventions on children's and mothers' sleep quality and maternal depression: A systematic review and meta-analysis. *Scientific Reports*, *12*(1), Article 1. https://doi.org/10.1038/s41598-022-07762-8

Peltz, J. S., & Rogge, R. D. (n.d.). The Moderating Role of Parents' Dysfunctional Sleep-Related Beliefs Among Associations Between Adolescents' Pre-Bedtime Conflict, Sleep Quality,

and Their Mental Health. *Journal of Clinical Sleep Medicine*, *15*(02), 265–274. https://doi.org/10.5664/jcsm.7630

Phillips, N. L., Moore, T., Teng, A., Brookes, N., Palermo, T. M., & Lah, S. (2020). Behavioral interventions for sleep disturbances in children with neurological and neurodevelopmental disorders: A systematic review and meta-analysis of randomized controlled trials. *Sleep*, *43*(9), zsaa040. https://doi.org/10.1093/sleep/zsaa040

Przepiórka, A., Błachnio, A., & Siu, N. Y.-F. (2019). The relationships between self-efficacy, self-control, chronotype, procrastination and sleep problems in young adults. *Chronobiology International*, *36*(8), 1025–1035. https://doi.org/10.1080/07420528.2019.1607370

Qiu, L., Chhikara, A., & Vakharia, A. (2021). Multidimensional Observational Learning in Social Networks: Theory and Experimental Evidence. *Information Systems Research*, *32*(3), 876–894. https://doi.org/10.1287/isre.2021.0993

Ragni, B., De Stasio, S., Barni, D., Gentile, S., & Giampaolo, R. (2019). Parental Mental Health, Fathers' Involvement and Bedtime Resistance in Infants. *Italian Journal of Pediatrics*, *45*(1), 134. https://doi.org/10.1186/s13052-019-0731-x

Reed, P. G., & Shearer, N. B. C. (2017). *Nursing Knowledge and Theory Innovation, Second Edition: Advancing the Science of Practice*. Springer Publishing Company.

Rhoades, K. A., Leve, L. D., Harold, G. T., Mannering, A. M., Neiderhiser, J. M., Shaw, D. S., Natsuaki, M. N., & Reiss, D. (2012). Marital hostility and child sleep problems: Direct and indirect associations via hostile parenting. *Journal of Family Psychology: JFP: Journal of the Division of Family Psychology of the American Psychological Association (Division 43)*, *26*(4), 488–498. https://doi.org/10.1037/a0029164

Riley, W. T., Martin, C. A., Rivera, D. E., Hekler, E. B., Adams, M. A., Buman, M. P., Pavel, M., & King, A. C. (2016). Development of a dynamic computational model of social cognitive theory. *Translational Behavioral Medicine*, *6*(4), 483–495. https://doi.org/10.1007/s13142-015-0356-6

Robinson, M. J., & Knobloch-Westerwick, S. (2017). Bedtime Stories that Work: The Effect of Protagonist Liking on Narrative Persuasion. *Health Communication*, *32*(3), 339–346. https://doi.org/10.1080/10410236.2016.1138381

Robinson, M. J., & Knobloch-Westerwick, S. (2020). Seeking Inspiration through Health Testimonials: Improving Mothers' Self-Efficacy, Outcome Expectations, and Behavior in Handling Children's Sleep Behavior. *Health Communication*, *35*(12), 1455–1465. https://doi.org/10.1080/10410236.2019.1652065

Rosen, C. L., Larkin, E. K., Kirchner, H. L., Emancipator, J. L., Bivins, S. F., Surovec, S. A., Martin, R. J., & Redline, S. (2003). Prevalence and risk factors for sleep-disordered breathing in 8- to 11-year-old children: Association with race and prematurity. *The Journal of Pediatrics*, *142*(4), 383–389. https://doi.org/10.1067/mpd.2003.28

Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development*, *72*(5), 1394–1408. https://doi.org/10.1111/1467-8624.00355

Schilling, L. S., Knafl, K. A., & Grey, M. (2006). Changing Patterns of Self-Management in Youth with Type I Diabetes. *Journal of Pediatric Nursing*, *21*(6), 412–424. https://doi.org/10.1016/j.pedn.2006.01.034

Schlarb, A. A., Kulessa, D., & Gulewitsch, M. D. (2012). Sleep characteristics, sleep problems, and associations of self-efficacy among German university students. *Nature and Science of Sleep*, *4*, 1–7. https://doi.org/10.2147/NSS.S27971

Schwarzer, R., & Renner, B. (2000). Social-cognitive predictors of health behavior: Action self-efficacy and coping self-efficacy. *Health Psychology*, *19*(5), 487–495. https://doi.org/10.1037/0278-6133.19.5.487

Shanahan, L., Copeland, W. E., Angold, A., Bondy, C. L., & Costello, E. J. (2014). Sleep problems predict and are predicted by generalized anxiety/depression and oppositional defiant disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *53*(5), 550–558. https://doi.org/10.1016/j.jaac.2013.12.029

Sonney, J. T., Gerald, L. B., & Insel, K. C. (2016). Parent and child asthma illness representations: A systematic review. *Journal of Asthma*, *53*(5), 510–516. https://doi.org/10.3109/02770903.2015.1116088

Sonney, J. T., Thompson, H. J., Landis, C. A., Pike, K. C., Chen, M. L., Garrison, M. M., & Ward, T. M. (2020a). Sleep intervention for children with asthma and their parents (SKIP Study): A novel web-based shared management pilot study. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *16*(6), 925–936. https://doi.org/10.5664/jcsm.8374

Sonney, J. T., Thompson, H. J., Landis, C. A., Pike, K. C., Chen, M. L., Garrison, M. M., & Ward, T. M. (2020b). Sleep intervention for children with asthma and their parents (SKIP Study): A novel web-based shared management pilot study. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *16*(6), 925–936. https://doi.org/10.5664/jcsm.8374

Stranges, S., Tigbe, W., Gómez-Olivé, F. X., Thorogood, M., & Kandala, N.-B. (2012). Sleep problems: An emerging global epidemic? Findings from the INDEPTH WHO-SAGE study among more than 40,000 older adults from 8 countries across Africa and Asia. *Sleep, 35*(8), 1173–1181. https://doi.org/10.5665/sleep.2012

ten Brink, M., Lee, H. Y., Manber, R., Yeager, D. S., & Gross, J. J. (2021). Stress, Sleep, and Coping Self-Efficacy in Adolescents. *Journal of Youth and Adolescence, 50*(3), 485–505. https://doi.org/10.1007/s10964-020-01337-4

Thakral, M., Von Korff, M., McCurry, S. M., Morin, C. M., & Vitiello, M. V. (2020). Changes in dysfunctional beliefs about sleep after cognitive behavioral therapy for insomnia: A systematic literature review and meta-analysis. *Sleep Medicine Reviews, 49,* 101230. https://doi.org/10.1016/j.smrv.2019.101230

Tinker, E. C., Garrison, M. M., & Ward, T. M. (2020). Development of the Sleep Health in Preschoolers (SHIP) intervention: Integrating a theoretical framework for a family-centered intervention to promote healthy sleep. *Families, Systems, & Health, 38*(4), 406–417. https://doi.org/10.1037/fsh0000546

Torkan, N., Kazemi, A., Paknahad, Z., & Bahadoran, P. (2018). Relationship of Social Cognitive Theory Concepts to Dietary Habits of Pregnant Women. *Iranian Journal of Nursing and Midwifery Research*, *23*(2), 125–130. https://doi.org/10.4103/ijnmr.IJNMR_157_16

Tougas, M. E., Hayden, J. A., McGrath, P. J., Huguet, A., & Rozario, S. (2015). A Systematic Review Exploring the Social Cognitive Theory of Self-Regulation as a Framework for Chronic Health Condition Interventions. *PLOS ONE, 10*(8), e0134977. https://doi.org/10.1371/journal.pone.0134977

Tyler, D., Donovan, C. L., Scupham, S., Shiels, A. L., & Weaver, S. A. (2019). Young Children's Sleep Problems: The Impact of Parental Distress and Parenting Style. *Journal of Child and Family Studies*, *28*(8), 2098–2106. https://doi.org/10.1007/s10826-019-01429-1

Wang, J.-S., Gamble, J. H., & Yang, Y.-T. C. (2020). Mobile sensor-based community gaming for improving vocational students' sleep and academic outcomes. *Computers & Education*, *151*, 103812. https://doi.org/10.1016/j.compedu.2020.103812

Wang, R., Dong, Y., Weng, J., Kontos, E. Z., Chervin, R. D., Rosen, C. L., Marcus, C. L., & Redline, S. (2017). Associations among Neighborhood, Race, and Sleep Apnea Severity in Children. A Six-City Analysis. *Annals of the American Thoracic Society*, *14*(1), 76–84. https://doi.org/10.1513/AnnalsATS.201609-662OC

Werner, A., Mayer, A., & Lohaus, A. (2022). Sleep-related parenting self-efficacy and parent-reported sleep in young children: A dyadic analysis of parental actor and partner effects. *Sleep Health*, *8*(1), 54–61. https://doi.org/10.1016/j.sleh.2021.11.004

Williams, D. R., & Collins, C. (2001). Racial residential segregation: A fundamental cause of racial disparities in health. *Public Health Reports*, *116*(5), 404–416.

Williams, K. E., & Sciberras, E. (2016). Sleep and Self-Regulation from Birth to 7 Years: A Retrospective Study of Children with and Without Attention-Deficit Hyperactivity Disorder at 8 to 9 Years. *Journal of Developmental & Behavioral Pediatrics*, *37*(5), 385–394. https://doi.org/10.1097/DBP.0000000000000281

Williamson, A. A., Mindell, J. A., Hiscock, H., & Quach, J. (2019). Sleep Problem Trajectories and Cumulative Socio-Ecological Risks: Birth to School-Age. *The Journal of Pediatrics*, *215*, 229-237.e4. https://doi.org/10.1016/j.jpeds.2019.07.055

Wilson, K. E., Miller, A. L., Bonuck, K., Lumeng, J. C., & Chervin, R. D. (2014). Evaluation of a Sleep Education Program for Low-Income Preschool Children and Their Families. *Sleep*, *37*(6), 1117–1125. https://doi.org/10.5665/sleep.3774

Xiang, B., Wong, H. M., & McGrath, C. P. J. (2022). The efficacy of peer-led oral health programs based on Social Cognitive Theory and Health Belief Model among Hong Kong adolescents: A cluster-randomized controlled trial. *Translational Behavioral Medicine*, *12*(3), 423–432. https://doi.org/10.1093/tbm/ibab142

Yeager, D. S., Lee, H. Y., & Jamieson, J. P. (2016). How to Improve Adolescent Stress Responses: Insights From Integrating Implicit Theories of Personality and Biopsychosocial Models. *Psychological Science*, *27*(8), 1078–1091. https://doi.org/10.1177/0956797616649604

Yip, T., Cheon, Y. M., Wang, Y., Cham, H., Tryon, W., & El-Sheikh, M. (2020). Racial Disparities in Sleep: Associations With Discrimination Among Ethnic/Racial Minority Adolescents. *Child Development*, *91*(3), 914–931. https://doi.org/10.1111/cdev.13234

Zare, S., Ostovarfar, J., Kaveh, M. H., & Vali, M. (2020). Effectiveness of theory-based diabetes self-care training interventions; a systematic review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 423–433. https://doi.org/10.1016/j.dsx.2020.04.008

Zhang, M. X., & Wu, A. M. S. (2020). Effects of smartphone addiction on sleep quality among Chinese university students: The mediating role of self-regulation and bedtime procrastination. *Addictive Behaviors*, *111*, 106552. https://doi.org/10.1016/j.addbeh.2020.106552

Zimmerman, B. J. (1983). Social Learning Theory: A Contextualist Account of Cognitive Functioning. In C. J. Brainerd (Ed.), *Recent Advances in Cognitive-Developmental*

Theory: Progress in Cognitive Development Research (pp. 1–50). Springer. https://doi.org/10.1007/978-1-4613-9490-7_1

Figure 3.1 SCT-SM towards Sleep Health

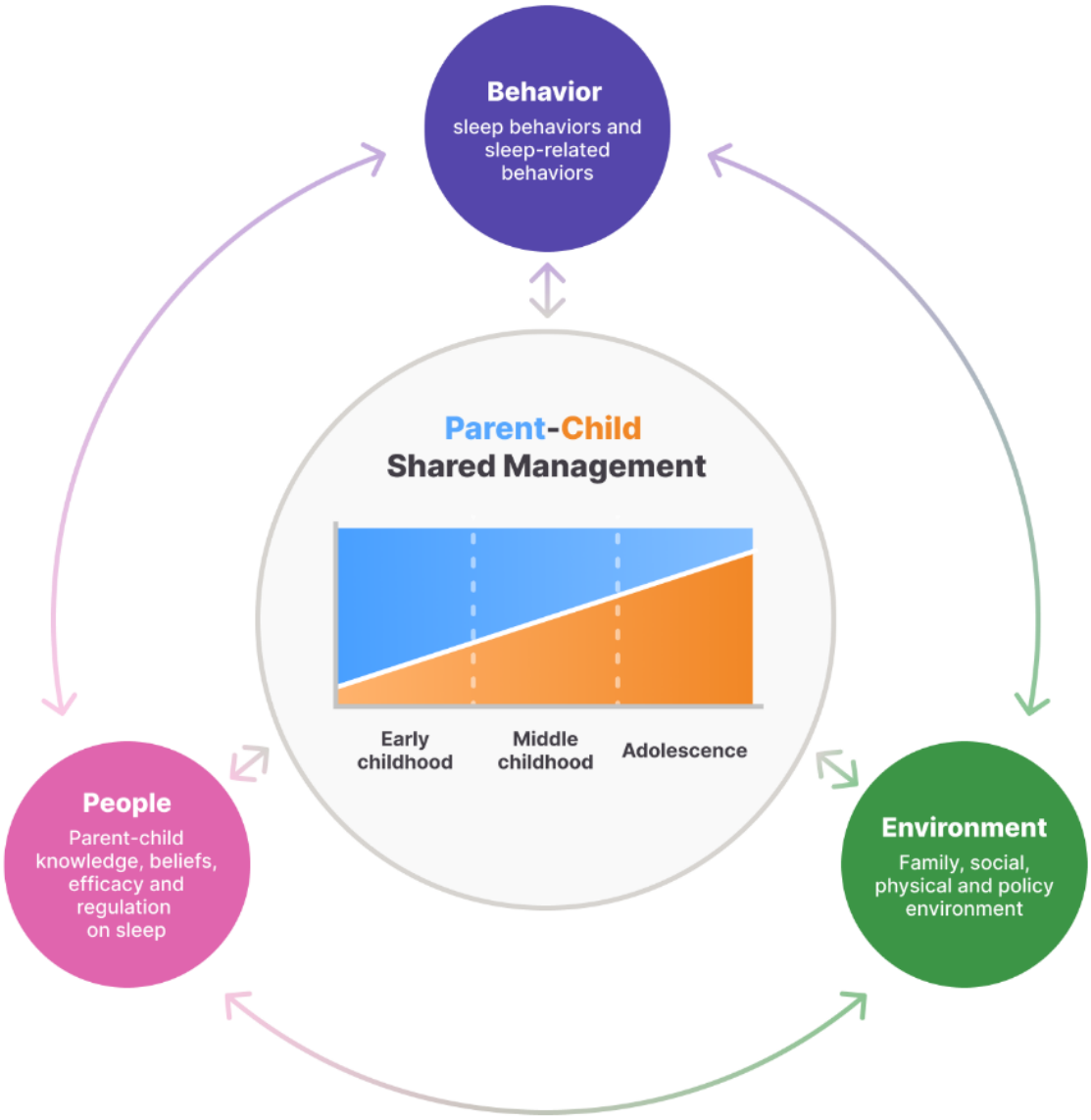


Table 3.1 Social Cognitive Theory Concepts

Concept	Nonrelational Proposition	Example in Pediatric Sleep Health	Relational Proposition with Respect to Health Behaviors
Reciprocal determinism	Environmental factors impact people. People also influence their environment and adjust their behavior (Bandura, 1977, 1986)	Children's sleep is a product of and reciprocally influences their own and their parents' knowledge, attitudes, and beliefs about sleep; parents' rewards or incentives for their child's sleep behaviors; and parental modeling of sleep behaviors.	Dynamic, mutual, and continuous interaction among the person (an individual with learned experiences), environment, and behavior factors (Glanz et al., 2015).
Self-efficacy	"Self-efficacy is the belief in the personal ability to perform behaviors that bring desired outcomes." (Bandura, 1986)	People base their self-efficacy upon mastery experiences (e.g., interpretation of actual daily sleep behavior), vicarious (modeled) experiences (e.g., sibling modeling), forms of social persuasion by others (e.g., "I know you can sleep really well through the night"), and physiological index (e.g., "I am feeling relaxed when I think about sleep"; Bandura, 1997)	Within a social cognitive system of triadic reciprocity, self-efficacy is hypothesized to influence behaviors and environments and, in turn, is affected by them. Higher self-efficacy is likely to result in better outcomes (Bandura, 1986, 1997)
Outcome expectation	Outcome expectation is the belief about the likelihood and value of the consequences of behavioral choices (Bandura, 1986)	Outcome expectation is a source of motivation. It includes external outcomes (e.g., "if I have a consistent sleep routine, I will sleep better") and internal outcomes (e.g., "If I had a good night's sleep, I would feel great"). People form outcome expectations about the likely results of given actions based on experience and observations of a model.	Outcome expectations sustain behaviors for a long time when people believe their actions will bring preferred outcomes. Higher outcome expectation is associated with better outcomes (Aardoom et al., 2020; Gunn et al., 2019; Khor et al., 2021).
Observational learning	People learn to perform new behaviors that they had not learned previously by modeling the behaviors of	Observational learning takes four component processes: attention (observe the model, e.g., observe sibling/parent going to bed consistently each day and waking up refreshed), retention (cognitively organizing and transforming information for storage in memory, e.g., observing behavior daily and	Observational learning is a process of learning by watching the behavior of others. The targeted behavior is observed and mimicked. For example, children learn to respond to others by observing how their caregivers interact

	others (Bandura, 1986)	cognitively accepting the behavior), production (translating cognitive conceptions into behavior, e.g., establishing consistent sleep routines and schedules), and motivation (choosing to learn actions believed to result in the desired outcome, e.g., believing that consistent sleep routines and sufficient sleep will lead to physical and mental health; Bandura, 1986).	with others (Carcea & Froemke, 2019; Qiu et al., 2021).
Self-regulation	Refers to the processes people use to activate and sustain behaviors, cognitions, and affects, which are systematically oriented toward attaining goals (Bandura, 1986)	People motivated to attain goals (e.g., healthy sleep) will likely engage in effective self-regulatory activities (e.g., maintaining consistent sleep routines, recording sleep time, modifying the bedroom environment). Throughout the self-regulatory process, people's cognition (personal influences) directs their behaviors, and external feedback (behavior and environmental factors) can affect their cognition.	People regulate their behaviors through self-control, small attainable goal-setting, problem-solving, feedback, self-reward, self-reflection, and enlisting social support. Effective self-regulatory activities (e.g., implementing a strategy, monitoring performance, adjusting one's approach as needed, reflecting on progress, and sustaining motivation) enhance self-efficacy of learning and support self-regulation (Panadero, 2017).

Table 3.2 Tests and Measures of Key Social Cognitive Theory Concepts

Concept	Studies	Target Area	Instruments
Self-efficacy	• Bihlmaier & Schlarb, 2016 • ten Brink et al., 2021 • Brandhorst & Hautzinger, 2016 • Haraldstad & Stea, 2021 • Kim et al., 2017 • Hammersley et al., 2019	• Children with chronic insomnia • Adolescent sleep • Parents of children with sleep disturbances • Adolescents with pain and sleep problems • Parents of children with sleep disturbances • Childhood Obesity Prevention	• Bandura's General Self-Efficacy Scale (Chen et al., 2001) • Coping Self-Efficacy(Yeager et al., 2016). • General Self-Efficacy Scale (Schwarzer & Renner, 2000) • General Self-Efficacy Scale (Schwarzer & Renner, 2000) • Parenting Self-Efficacy Scale Questionnaire (Choe & Chung, 2010)
Self-regulation	• Bub et al., 2016	• Children and adolescents	• Self-imposed waiting task (Mischel, 1974) • Children's Stroop Task (Gerstadt et al., 1994) • Continuous Performance Task (Beck et al., 1956) • Child Behavior Questionnaire(Rothbart et al., 2001)
Outcome expectation	• Robinson & Knobloch-Westerwick, 2020	• Mothers of children with sleep problems	• Participants were asked to indicate their agreement that the five sleep assertions placed in a story would improve sleep hygiene on a scale from 1 = totally incorrect to 7 = totally correct (Robinson & Knobloch-Westerwick, 2017)
Observational learning	• Golem et al., 2019	• School-age children and their parents	• Focus group interview

Table 3.3 Examples of SCT Related Interventions

Pediatric Sleep Research	Employed Concepts	Use of the Theory	Population of Research	Sample size	Findings
Sleep health in preschoolers intervention (Tinker et al., 2020)	• Self-efficacy • Self-regulation • Outcome expectation	Inform	Parents of preschool-age children (2.5 to 5 years) with a behavioral sleep problem	433 parent-child dyads	Ongoing
Sleep education (Wilson et al., 2014)	• Self-efficacy • Knowledge and attitude	Applied	Parents of preschool children with sleep problems	152 parents	Parents' knowledge, attitudes, and self-efficacy improved after the intervention; children in the intervention group significantly improved their weeknight sleep duration
Sleep health and academic functioning (Wang et al., 2020)	• Reciprocal determinism • Self-efficacy • Behavior capacity • Outcome expectation • Expectancies • Observational learning • Reinforcement	Applied	High school students	144 high school students	Students in the intervention group had decreased daytime sleepiness, less insomnia, and higher academic achievements
Sleep health in children with asthma (Sonney et al., 2020)	• Goal setting • Action planning • Self-monitoring	Inform	Children and their parents	25 parent-child dyads (children 6-11 years of age)	The sleep intervention was feasible, acceptable, and effective in improving the child's and parent's sleep outcomes, except for total sleep time
Sleep behavior and media	• Environment • Observational learning	Inform	Parents of preschoolers	278 parents	Quantity of media use, screen media in the bedroom, and

use (Moorman & Harrison, 2019)					sneaky media use associated with shorter nightly sleep and longer daily napping

Chapter 4: Evaluating Behavioral Intervention Technologies: Integrating Human-Centered Design and Implementation Science Outcomes

Abstract

Background: Behavioral intervention technologies (BITs) have been the tools for advanced health solutions by increasing access to cost-effective care by reducing barriers. However, BITs often show reduced impacts in community settings and are rarely sustained, limiting the capacity to fulfill their promising benefit. Human-Centered Design (HCD) is an approach that can address these implementation challenges by incorporating the stakeholders' needs, making the content and functionality contextually appropriate. Implementation Science (IS) helps researchers to understand barriers and facilitators, develop strategies that overcome obstacles, and enhance the uptake and sustainability of BITs in real-world settings. HCD and IS shared common goals to improve BITs' usability and implementation by applying iterative and contextual design processes, engaging stakeholders as the design partner, involving a multidisciplinary design team, and conducting iterative testing and evaluation as early and frequently as possible. In this study, we proposed a heuristic model that can maximize the potential of BITs' success. We aimed to 1) synthesize the HCD and IS outcomes, integrate them into an evaluation model for BITs' design, development, and testing process; 2) apply the integrated evaluation model to a case study, Sleep Shared-Management Intervention for Children with Juvenile Idiopathic Arthritis and Their Parents.

Methods: We conducted a narrative literature review centered on HCD and implementation outcomes on BITs from the PubMed, CINAHL, and Web of Science databases (2000-2023). Article inclusion criteria are as follows: 1) published through the search date of January 11,

2023, 2) focused on usability constructs or implementation outcomes, and 3) related to evidence-based practices (e.g., intervention, services, policy) in healthcare.

Results: Informed by evolved frameworks of HCD and IS outcomes, we proposed a heuristic model that can guide the development and evaluation of BITs: USIS model, in which Usability and IS are combined. We categorized the outcomes into five domains 1) User-Centeredness (empathy, engagement, and equity), 2) Efficiency (cost, timeliness, and rapidity), 3) Feasibility (learnability, memorability, error reduction, and low cognitive load), 4) Satisfaction (acceptability, appropriateness), and 5) Fidelity (adoption, penetration, sustainability). USIS conceptualized constructs to reflect key outcomes of BIT's usability and implementation, address the missing piece of user-focused outcomes like equity, accessibility, empathy, and engagement, and implementation outcomes such as timeliness and rapidity. Guided by the USIS model, we found the strengths and areas for improvement for the SLEEPSMART project.

Conclusion: USIS model offers specific tools to design better BITs and evaluate existing BITs to improve health innovations' translation into practice. With the USIS model, HCD and IS practitioners can use a common language to enhance implementation and health outcomes for broader communities, support researchers in identifying multilevel barriers to implementation, and guide evaluating the BITs. We believe the USIS model offers a pathway for improving innovation advancement by incorporating the processes and tools from HCD and IS.

Key words: Behavioral intervention technologies, Human-Centered Design, usability, Implementation Science

Introduction

Behavioral intervention technologies (BITs) refer to evidence-based behavioral and psychological interventions delivered via various technology media, including smartphone applications, computer programs, virtual reality, wearable technology, and electronic messaging (Michie et al., 2017; Wray et al., 2019). In the past few decades, BITs have been the tools for advanced health solutions by increasing accessibility by reducing barriers such as transportation, scheduling, stigma, and high healthcare costs (Bausback & Bunge, 2021; Hermes et al., 2019; Lee et al., 2018; Mohr et al., 2013; Mohr et al., 2014; Stiles-Shields et al., 2019; Wray et al., 2019). However, the research-practice gap remains (Bauer & Kirchner, 2020; Onken, 2022). BITs often show reduced impacts in community settings and are rarely sustained once implementation support ends, thus limiting the capacity to fulfill their promising benefit for the populations of interest (Hermes et al., 2019; Onken, 2022).

Human-Centered Design (HCD) is an increasingly recognized approach that can address these implementation challenges early in development by incorporating the stakeholders' needs, and learning styles. HCD is an iterative and non-linear design process to make the services highly usable by centering users' needs (ISO, 1999). HCD includes multiple steps: 1) empathize: also referred to as user research, where designers and researchers conduct comprehensive observation, communication, and investigation with users on their needs, behavior, habits, and why. 2) Define: based on the information gathering in the first stage, this is where designers synthesize findings, define users' problems, and formulate the problem statement. 3) Ideate: with a solid understanding of the users and a clear problem statement, this phase is where creative

solutions are generated by thinking outside of the box. 4) Prototype: the transition from ideas into tangible actions that will be tested on real users. A prototype can be low fidelity (e.g., a sketch) or high fidelity (e.g., a model). 5) Test: in this stage, real users will try the prototype and report their perceptions on what works and what needs to change/improve to function better. The testing results often inform the designers and researchers about whether they need to return to the first stage and undergo several rounds of ideation before testing again. The "trial-and-error" application is unique to HCD, with each iteration resulting in a more usable, contextually appropriate, and innovative solution (Melles et al., 2021; Norman et al., 2021).

One ultimate goal of HCD is to achieve the *usability* of the solution. Usability was initially defined only as "ease of use" (Hartson, 1998) and was modified to "usefulness, ease of learning, and satisfaction" (Lund, 2001). Usability considers the extent to which the target users can adopt a product to reach their goals with effectiveness, efficiency, and satisfaction (ISO, 1998; Lyon & Koerner, 2016). Maximizing usability ensures new products, tools, or processes have intuitive interfaces, require little learning, and can be easily adopted by users for ease of use and align with the contextualized needs of the users (Lyon, Brewer, et al., 2020).

Even though HCD can enhance content and functionality, there is still a challenge in implementing BIT in real-world situations in terms of adoption and sustainability. Thus, Implementation Science (IS) can be a powerful tool to fill the gap. IS helps researchers to understand barriers (what hinders the implementation) and facilitators (what supports the implementation) across multiple levels of context and determinants, develop strategies that overcome obstacles, and enhance the uptake and sustainability of innovations in real-world settings (Bauer & Kirchner, 2020). Emerging studies have paid more attention to BITs' design characteristics strongly influence interventions' adoption, implementation, and sustainability in

healthcare settings (Hooley et al., 2020; Klaic et al., 2022; Powell et al., 2012, 2017; Waltz et al., 2015, 2019). For example, the design problems that affect implementation success could be too complicated to use (e.g., low learnability and memorability), too challenging to understand and navigate (e.g., high cognitive burden and low flexibility), and not fit for delivery context (e.g., not consider context factors) (Dopp et al., 2019a; Hermes et al., 2019; Wray et al., 2019).

HCD and IS contributed to enhancing BIT's effectiveness differently and complement each other. They shared common goals to improve intervention usability and implementation by applying iterative and contextual design processes, engaging stakeholders as the design partner, involving a multidisciplinary design team, and conducting iterative testing and evaluation as early and frequently as possible. HCD considers primarily the content and functionality, with the rationale that a well-designed and compelling innovation is much more likely to be adopted and sustained, whereas IS focuses mainly on the context, including the organizations and settings, to ensure it is more conducive to the innovations. Integrating HCD and IS in designing, developing, and evaluating BITs has promising outcomes in the following ways. Implementation practitioners could incorporate HCD principles in existing leadership and collaboration strategies, incorporate the HCD process to identify barriers/facilitators and co-create solutions with stakeholders. HCD practitioners may integrate IS outcomes into each design iteration and make designs more feasible and sustainable for complex and large-scale health needs in the long run (Lyon, Brewer, et al., 2020; Norman et al., 2021).

Despite the potential to improve effectiveness and adoption in BITs using HCD and IS, little work has been done to conceptualize and apply the integration of HCD and IS in a step-by-step guide to do so. In this study, we propose a heuristic model (Moustakas, 1990) that can guide the design, development, and evaluation efforts to maximize the potential of success in BITs'

implementation. To develop the model, we will 1) synthesize the HCD and IS outcomes, integrate them into an evaluation model for BITs' design, development, and testing process; 2) apply the integrated evaluation model to a case study - SLEEPSMART – Sleep Shared-Management Intervention for Children with Juvenile Idiopathic Arthritis and Their Parents.

Methods

We conducted a narrative literature review (Grant & Booth, 2009) centered on usability constructs and implementation outcomes on BITs from the PubMed, CINAHL, and Web of Science databases (2000-2023). Article inclusion criteria are as follows: 1) published through the search date of January 11, 2023, 2) focused on usability constructs or implementation outcomes, and 3) related to evidence-based practices (e.g., intervention, services, policy) in healthcare. Articles were excluded if they did not include conceptualization of usability or if they described implementation strategies to improve specific outcomes on products outside the healthcare field. With the evidence we gathered, we summarized the key constructs of usability and implementation outcomes, synthesized the shared principles outcomes, and incorporated outcomes into the HCD stage evaluation model. We then applied the newly developed model to a sleep BIT to illustrate how it works.

Results

Usability Outcomes

Usability was initially conceptualized as learnability, efficiency, memorability, error frequency/severity, and satisfaction (Nielsen, 1994). Later, more factors were identified and added, including functional minimalism, low cognitive load, less training required, exploitation of the natural constraints, and clear feedback to users (Maguire, 2001; Tognazzini, 2014). In

2016, Lyon and his team redefined and broadened the usability constructs specific to behavioral and psychological science and offered a comprehensive guideline on designing and evaluating the BITs (Lyon & Koerner, 2016). The seven principles include 1) Learnability: Intervention design should have high learnability, which means users should be able to understand and learn to use the intervention fast; 2) Efficiency: Users should spend minimal time, cost, and effort in using the intervention to solve their problems; 3) Memorability: the design of the intervention should allow users to remember and successfully operate in the interface and conduct the function of the intervention without much support; 4) Error Reduction: users can be prevented or allowed quick recovery from error clicks to reduce mishandling the process; 5) Satisfaction: high acceptability and value to users, even after comparing other existing intervention or tools within a similar context; 6) Low Cognitive Load: the design only requires users' minimal thinking to complete the intervention tasks, and usually is associated with the simplified structure of the intervention; 7) Exploit Natural Constraints: a successful intervention should address the destination context's static properties that limit intervention use. The primary goal of applying HCD in BIT is to improve BIT's usability, which is theorized to be one determinant of implementation outcomes and influence BITs' adoption and penetration (Lyon & Bruns, 2019).

Implementation Outcomes

Numerous frameworks in IS can be categorized into three types: Process (Chinman et al., 2008; Graham et al., 2006), Determinant (Aarons et al., 2011; Damschroder et al., 2009; G. Harvey & Kitson, 2015; Stirman et al., 2013; Wiltsey Stirman et al., 2019), and Evaluation (Glasgow et al., 1999; Proctor et al., 2011). This paper focuses on the evaluation framework where all outcomes come together to affect the ultimate implementation.

Proctor's team was one of the first to develop a conceptual model of implementation research that encompasses three distinct but interrelated domains: implementation outcomes (acceptability, adoption, appropriateness, costs, feasibility, fidelity, penetration, and sustainability), service outcomes (efficiency, safety, effectiveness, equity, patient-centeredness, and timeliness) and client outcomes (satisfaction, function, and symptomatology) (Proctor et al., 2009). Later, Proctor et al. further explored and defined eight outcomes for implementation science that have been broadly adopted (Proctor et al., 2011). In 2019, Hermes and colleagues re-characterized the implementation outcomes specific to BIT study use (Hermes et al., 2019). Eight BIT implementation outcomes were recharacterized to better meet the unique aspects of BITs and include 1) Acceptability: how agreeable or satisfactory to users on the BITs; 2) Adoption: users' intention or initiation for using the BITs; 3) Appropriateness: users' perception of fit of BITs; 4) Feasibility: the extent in which BITs can be successfully used or conducted within a context; 5) Fidelity: the extent of BITs being delivered as intended; 6) Implementation Cost: cost associated with implementing BITs; 7) Penetration: the incorporation of the BIT within any services setting (organization or family); 8) Sustainability: the degree in which a BIT practice is maintained and integrated into a setting for a long-term and stable operations. The recharacterized outcomes expanded our understanding of factors related to successful implementation and enabled us to identify the areas that need more work.

A conceptual evaluation model in BITs: USIS model

Informed by these evolved frameworks of usability and IS outcomes, we propose a heuristic model that can guide the development and evaluation of BITs: USIS model, in which Usability and IS are combined. We analyzed HCD and IS outcomes and summarized the conceptual similarities with overlapping goals. Moreover, we added additional components to

make USIS more comprehensive and practical in healthcare settings. We seek to advance BIT's effectiveness, adoption, and sustainability by synthesizing the HCD and IS outcomes and integrating them into one evaluation model in the continuous BIT design, development, and testing process.

We categorized the outcomes into five domains 1) User-Centeredness (empathy, engagement, and equity), 2) Efficiency (cost, timeliness, and rapidity), 3) Feasibility (learnability, memorability, error reduction, and low cognitive load), 4) Satisfaction (acceptability, appropriateness), and 5) Fidelity (adoption, penetration, sustainability). USIS conceptualized constructs to reflect key outcomes of BIT's usability and implementation, address the missing piece of user-focused outcomes like equity, accessibility, empathy, and engagement, and implementation outcomes such as timeliness and rapidity. **Table 4.1** shows the proposed USIS constructs and definitions.

Domain 1. User-Centeredness. Focusing on the users' needs throughout the whole design process is the foundation of HCD and the premise of the success of IS. We propose empathy, user engagement, and equity fall under this domain. *1) Empathy* is the most critical element in the human-centric design as we can see the world through users' eyes, feel what they feel, and experience things as they do as close as possible (Norman et al., 2021; Surma-aho & Hölttä-Otto, 2022). Empathy can be achieved by putting our preconceptions aside and choosing to understand users' ideas, thoughts, and needs. *2) User engagement* is another method to stay connected to users' interests, motivations, and goals. Active, enabled, and engaged users are the foundation of every successful product, and improved user engagement enables building better products, optimizing user communication, and retaining users (Birnbaum et al., 2015; Göttgens & Oertelt-Prigione, 2021). *3) Equity* allows the voices of minoritized or disadvantaged communities to

directly impact how the solution will address the inequity by purposefully involving them throughout a design process (Kwak, 2020). The equitable design acknowledges that equity doesn't happen by chance but with intent and focus (Kwak, 2020). It includes teams (users and researchers), content, and implementation (Liu et al., 2019). The users need to be diverse and representative of the target user. The research team needs to involve collaboration among multidisciplinary teams. Carefully identifying representative user needs can correct this bias and enhance product quality (Lyon, Dopp, et al., 2020). The content of the intervention needs to be contextually appropriate and culturally relevant. A successful intervention should address and fit the destination context's static properties that limit intervention use. For the implementation aspect, equity was considered with accessibility, uptake, adherence, and effectiveness (Lyon, Dopp, et al., 2020; Richardson et al., 2022; Veinot et al., 2018). Accessibility is for those with disabilities and low digital health literacy. Design with accessibility enables people with various abilities and disabilities to perceive, understand, navigate, interact, and contribute to the products/services. Uptake considers those who are not computer savvy, do not trust technology, or are exposed through informal social networks. Adherence considers intervention usability, literacy burden, access to money, time, and coping skills. Finally, effectiveness considers different groups of people and their access (Veinot et al., 2018).

Domain 2. Efficiency. Efficiency reflects that users should spend minimal time, cost, and effort using the intervention to solve their problems. Efficiency can be realized by rapid iteration and prototyping, making ideas tangible to quickly test and improve based on feedback. Timeliness refers to designing technology-enabled services that must account for ongoing iteration, evolving, and fast updating of the technology and service over time (Graham et al., 2019; Mohr et al., 2018).

Domain 3. Feasibility is constructed with learnability, memorability, error reduction, and low cognitive load. Feasibility refers to the extent in which the intervention can be done or carried out as designed. A product with low-complex functions and user-friendly interfaces enhances learnability, memorability, and error reduction. It lowers users' cognitive load, increasing the chance of adoption of the innovation among target users (Munson et al., 2022).

Domain 4. Satisfaction. Satisfaction refers to users perceiving it as highly acceptable, helpful, and valuable for solving problems, including appropriateness and acceptability. Appropriateness is the innovation's perceived fit, relevance, or compatibility (Hermes et al., 2019; E. Proctor et al., 2011). Acceptability is how well an intervention being received by the target population and the extent to which the new intervention meet the needs of the target population (Hermes et al., 2019; Proctor et al., 2011).

Domain 5. Fidelity. Fidelity refers to the extent to which the protocols deliver core components of interventions as intended (Proctor et al., 2011). Intervention adoption, penetration, and sustainability can be advanced via adherence and enhancing intervention fidelity, which can be achieved by developing intervention manuals or protocols and training interventionists (Toomey et al., 2020; Walton et al., 2020). Adoption is the actual use of the intervention by users, penetration is the extent of integration of intervention within a context, and a sustainability is the extent of the intervention's practice and effect is maintained and long lasting (Hermes et al., 2019; Proctor et al., 2011).

USIS Model in HCD Process

When developing and evaluating the BITs guided by the HCD approach, having a clear road map of which particular outcomes occur in which HCD stage is beneficial for researchers and designers. We propose a USIS model by locating specific USIS outcomes to each HCD stage

to maximize the potential of success in BITs' implementation. **Table 4.2** shows the USIS stage model in the context of BITs design, development, and evaluation. 1) Throughout the HCD process, as the foundation and core element, user-centeredness constructed with empathy, engagement, and equity should be prioritized and penetrated in each operation. 2) In stages of ideate & prototype, usability testing, and pilot testing, designers and researchers' teams should focus primarily on efficiency, including cost, timeliness, and rapidity. The mantra, "fail early and often," conveys the spirit of rapid prototyping and iteration, the inexpensive exploration of novel ideas, and making ideas tangible to quickly test and improve. Additionally, feasibility should be taken into account during these stages. When generating new ideas, it is helpful to create a "low-fidelity" version of a product to model the innovation. Low-fidelity prototyping is a simple and quick way to translate design ideas to testable artifacts, such as paper sketch. 3) During the stages of usability testing and pilot testing, users' satisfaction is a vital indicator. The designer and researcher team take the opportunity to refine and adjust the BIT in response to users' perception of if the products are acceptable, useful, and enjoyable to use in terms of their content, complexity level, delivery method, and credibility. 4) In the pilot testing and future testing in community/clinical settings, fidelity must be considered. Further improvement and refinement of the intervention may be needed based on users' feedback.

Case Study: The Sleep Intervention for Children and Their Parents

This case study is based on an internet-delivered Sleep Shared-Management Intervention (SLEEPSMART) for children with juvenile idiopathic arthritis (JIA) and their parents. The research team used the HCD approach for intervention development and pilot testing. We demonstrate how to use the USIS model to evaluate SLEEPSMART.

About SLEEPSMART. Sleep deficiency, which includes insufficient sleep duration and poor sleep quality, is highly comorbid in children with JIA. A multidisciplinary research team developed and pilot-tested SLEEPSMART for children with JIA and their parents (Ward et al., 2020b). SLEEPSMART was designed to improve a child's sleep by modifying the child/parent's negative beliefs, increasing outcome expectations and self-efficacy, facilitating change in the social and physical environments, and encouraging child/parent activation. In the SLEEPSMART program, children partnered with their parents. They learned through six interactive educational modules (voice-over slide show), completed quizzes and activities after each module, and were supported by a sleep coach throughout the program.

SLEEPSMART development with HCD. The evaluation was based on the data collected in the SLEEPSMART development process at each HCD stage.

Stage I. Discover & define. The research team conducted in-depth interviews with six parent-child dyads. Designers and researchers partnered together and developed an interview protocol. Data were collected on JIA children's and their parent's perceptions, needs, preferences, and daily behaviors regarding sleep habits, routines and perceptions, JIA management, mobile/web habits, and information-seeking behaviors. All interview questions were user-centered and aimed to identify the users' true needs and preferences. Based on users' feedback, designers made the design decisions in SLEEPSMART in the following ways. For content, used age-appropriate language (4^{th}-grade reading level or above) with simple and sufficient information and avoided overwhelming amounts of texts. For design, the interface is engaging (themes in space, animal, or sports), easy to navigate, and interactive; the learning module has fun interaction and rewards, incorporating accessibility functionality – fonts are easy to read for individuals with dyslexia.

Stage II. Ideate & prototype. Four parent and child dyads were invited to participate in the participatory design (PD) session. PD is an approach to actively design collaboratively via a think-aloud protocol, which is method that participants verbally describing what they are doing while they work through the product flow (Ward, 2020). The components of the PD sessions included brainstorming to generate ideas about the intervention design, iterative ideation phases, design activities to brainstorm, and group discussions to generate and evaluate ideas (Kang et al., 2015). In the PD session, designers used generative and evaluative techniques to better understand: 1) What content types are most engaging for and appealing for 9 to 11-year-old children (as well as to their parents), 2) What theme/design is most engaging for and appealing to 9 to11-year-old children, 3) What will help motivate 9 to 11-year-old children (with arthritis and sleep issues) to go through a sequence of learning modules. In addition, low-cost and rapid iterative user personas and wireframes were used to model users' behaviors before usability testing. Persona is an approach to model and synthesis from observation of many targeting people (Bhattacharyya et al., 2019); Wireframe refers to a illustration of a interface's space location and content layout(Göttgens & Oertelt-Prigione, 2021). Based on users' input, the design and contents featured in SLEEPSMART include numerous aspects. For content, explanations are detailed; children take a quiz after each learning module; digital rewards are be provided upon quiz completion; portals are provided for file upload; balanced number of images, texts, and videos are incorporated; and information on arthritis. For designs, SLEEPSMART used many visuals, separated text with images, used bright colors, enabled audio playing to improve accessibility, used an empathetic tone, and ensured multiple ways for assignment submission.

Stage III. Usability testing & refinement. Two usability testing sessions were conducted with two parent-child dyads between June and August 2019. The goals of the usability testing focused on 1) assessing the overall usability of each of the three platforms that the user must navigate in the learning module process (email, SLEEPSMART website, REDCap Site); 2) assessing the overall usability of navigating between the three platforms in the learning module process (email → SLEEPSMART website → REDCap site); 3) assess task comprehension of the first learning module; 4) determine the level of ease in completing the core tasks required by each platform in the learning module; 5) identify obstacles to completing key tasks. The research and design teams identified what worked well and opportunities for improvement, repeated the iterative process, discussed potential solutions to the problems, and revised the design for the intervention website, the content of the email, and REDCap. Based on users' feedback in this stage, designers kept the succinct text in the SLEEPSMART website and included each of the steps at the beginning of the website. For example, in step 1, review the overview of the weekly lesson; in step 2, listen to the slide show; in step 3, take a quiz; and in step 4, complete your weekly activities and have your parent upload it to REDCap. For the design, designers used Use bold/underlining to highlight the essential information in the email; created sub-sections within each step; resized the slideshow (or video) to fit within the screen size; added a play button or arrow for the slideshow.

Stage IV. Pilot testing. From 2019 to 2021, to evaluate the feasibility, acceptability, and efficacy of SLEEPSMART, we enrolled 50 children, 8 to13 years, with JIA and sleep deficiency, and their parents in the SLEEPSMART study. They were randomized to either the SLEEPSMART group or the control group. Data were collected on their perception of the feasibility and acceptability of SLEEPSMART and outcomes in sleep and shared management.

After intervention completion, researchers conducted exit interviews with 12 parent-child dyads to understand their perceptions of what they liked and found useful/acceptable/helpful in the SLEEPSMART intervention and identify the areas/gaps they did not like and need to change for refinement. In summary, based on users' feedback, parent-child dyads found the following five aspects most satisfied: 1) learning modality: the flexibility of self-paced online access learning; 2) intervention content and structure: the content was informative and reliable; 3) research team: research team was highly responsive, informative and accessible; 4) empowered children: children could assume responsibility and take control to improve their sleep; 5) parent-child shared management: the intervention partnered parent and child together toward the same goal. Dyads also reported their suggestions for SLEEPSMART, which is reported in the evaluation section.

Data analysis. All sessions were audiotaped after the families provided consents and assents. To evaluate SLEEPSMART, we analyzed and coded SLEEPSMART development process data in deductive coding methods using the USIS model. According to each USIS outcome, we coded the SLEEPSMART design data under each HCD process as the research questions, user feedback, and design decisions. For example, for the user-centeredness outcome, under the discover and define stage, we summarized the design/research questions on parent-child dyads' sleep, JIA, mobile/web behaviors, dyads' feedback to these questions, and the design decisions around dyads' input including content and design features.

Evaluation. Guided by the USIS model, we found the strengths and areas for improvement for the SLEEPSMART project. The strengths include 1) the intervention content was well structured: a clear and purposeful structure consisting of must-have milestones with the right direction throughout the design and development life cycle, ensuring the final high-quality

delivery (design and product), and solving the right problem. 2) user-centeredness was prioritized throughout the HCD process. Research questions were comprehensively explorative and closely tied to identify users' needs, users' feedback was fully transcribed and documented, and each design decision was based on users' input and needs. 3) The researcher and designer team applied various HCD methods that enhanced USIS outcomes. Specifically, the team used in-depth interviews to empathize with users, applied participatory design methods (stickies and big picture activity) to empower "co-design" and users' engagement, and adopted user persona and wireframe to model users' behaviors in a low-cost and rapid iterative way. They applied two usability testing sessions as opportunities to improve the intervention's learnability, memorability, error reduction, and cognitive burden and examine users' satisfaction with the intervention. The research team also pilot-tested the intervention to assess the feasibility, acceptability, and preliminary efficacy and identified areas for refinement. 4) the design decision was consistently maintained and consolidated across the HCD process. For example, design decisions made in the discover & define stage were well preserved and expanded in the ideate & prototype stage, and the decision became more concrete in the test & refine stage.

We also found several areas for further improvement. First, the participants were not diversely representative. All participants were White with middle to high social-economic status. Future studies should include diverse participants with diverse population with various socioeconomic, cultural, ethnic, and geographic background backgrounds to reflect the equity principle. Moreover, building on the current long video presentation mode module, multiple methods could enhance learnability. The interventional module video could be divided into smaller sections. Indeed, accounting for JIA children's physical symptoms and age-appropriate short-time attention span, each learning module needs to be shortened (e.g., less than 7 minutes)

and gamified with more interactive features (e.g., learning through play-based activity). The knowledge needs to be delivered in a more storytelling way and develop an actual rewarding system (e.g., children will receive physical awards after completing each milestone). Furthermore, the concept of error reduction could be further improved. Currently, participants must always go back to email to find the next steps and have multiple platforms to complete the tasks (e.g., intervention website for intervention, REDCap for surveys, and a separate link for online sleep diary), which increases the chance of operational error. Instead, participants will find it more convenient and easier to follow through if structurally organizing all tasks in one dashboard. Participants only need to go to this dashboard, check out daily tasks and track their progress with tools. Participants will stay on track quickly and self-monitor their completion status, potentially motivating them to follow through with the intervention program. Lastly, fidelity (Adoption, Penetration, and sustainability) should be considered in the early stages of BIT development to maximize the program implementation success. Several strategies to maintain fidelity (Toomey et al., 2020; Walton et al., 2020): 1) develop the intervention standard operating protocols (SOP); 2) provide training sessions to research teams; 3) establish an implementation team to support research team; 4) ensure implementational problems could be discussed regularly and solved in time; and 5) build a system for monitoring implementation.

Discussion

To date, little work has been done to directly integrate HCD and IS in designing, developing and evaluating BITs to maximize the potential of success in BITs' implementation. Our work is one of the first to dissect and incorporate usability and IS outcomes into a next-level practical guiding framework for evidence-based practices (e.g., intervention, services, policy). In this initial exploratory model development study, 1) our work builds on the existing work for

HCD-focused implementation: the usability constructs (Lyon & Koerner, 2016; Maguire, 2001; Nielsen, 1994; Tognazzini, 2014) and IS outcomes (Hermes et al., 2019) that adapted from previous works (Proctor et al., 2011; Proctor et al., 2009). We found usability was considered primarily in the program design and development phases but had conceptual and functional overlap with the early stages of implementation. Usability is regarded as a key determinant of implementation outcomes, as less complex innovations with lower cognitive burdens are more likely to be well-adopted and sustained (Dopp et al., 2020; Lyon, Dopp, et al., 2020). 2) We incorporated IS outcomes into the HCD stage evaluation model. HCD offers theoretically based, robustly mapped processes that seek to improve outcomes through active engagement, respect for end-user views, and support for iterative idea refinement in response to testing and feedback (Beres et al., 2019; Melles et al., 2021). 3) We proposed the USIS model as a new conceptual framework based on the interlinkages and partnerships among key outcomes of HCD and IS. Integration of usability and IS allow researchers to embed implementation research earlier in the pipeline and expand the resources that increase evidence uptake (e.g., change design features, context, and culturally appropriate considerations, diverse stakeholders). And 4) We offered a "how-to" guide to the framework with a case study.

Some pioneer works include formally introducing HCD language and strategies to IS research field to build the collaboration foundation via shared languages (Dopp et al., 2019a), reframed implementation outcomes specifically for BITs (Graham et al., 2020; Hermes et al. 2019), applied HCD to enhance intervention design (R. Bartlett et al., 2021; Beres et al., 2019; Göttgens & Oertelt-Prigione, 2021; Norman et al., 2021; Pillsbury et al., 2021), redefined HCD usability constructs and proposed usability is a fundamental determinant of implementation research (Lyon et al., 2019; Lyon & Koerner, 2016), characterized the potential for collaboration

between HCD and implementation research (Dopp et al., 2019b, 2020; Lyon, Brewer, et al., 2020; Lyon, Dopp, et al., 2020; Lyon et al., 2019; Lyon & Bruns, 2019). While these studies are foundational, our study made a substantial and concrete step toward integrating HCD and IS into the HCD process model and locating which outcomes need to focus on which stage.

Limitation

As a preliminary study, this study has limitations and left unanswered questions for future exploration. First, we did not systematically review all empirical research studies that focused on HCD and implementation research, and the sources we used were limited to those written in English. Second, when analyzing the core elements of usability and implementation research outcomes, we only rely on the published work, which can be heterogeneous. We conducted several peer discussions and debriefing rounds to ensure the best interpretation. Third, this model remains largely conceptual and heuristic, and we need more empirical evidence to test it. Finally, applying the USIS model can be challenging for HCD and IS scientists to shoulder the learning efforts of incorporating two disciplines into one new research approach. However, we must leverage key insights from the new area and surmount roadblocks to advance the knowledge.

We believe the current USIS model will inform other researchers about another possibility of HCD-IS research, stimulate more collaboration between HCD and IS fields and offer a new perspective to advance BITs and healthcare innovations. The USIS model draws on the strengths of the HCD process, usability constructs, and IS outcomes and offers significant insights into developing streamlined and effective BITs and implementation strategies. Integrating usability constructs into IS outcomes has strong potential to improve the degree to which innovations are compelling, learnable, and implementable.

Implications

Additional research will be necessary to understand better the potential for increasingly interdisciplinary collaborations in applying the USIS model to best support BITs innovations and disseminate the USIS model to broader research communities. First, good design is a prerequisite for effective science. Health technologies and practices must be better designed to be applied and contribute to a broad population. Second, we urge researchers and developers to consider and blend the HCD approach early in research planning. For example, building long-term collaboration with developers, researchers, and user experience designers. Additionally, including the end-user's input from the beginning through to the whole design and development process. Third, strengthen the infrastructure supporting the application of HCD approaches by partnering with HCD and implementation professionals (Dopp et al. 2019b). In future research, our next research agenda is bridging the gap between implementation research and design approach. The USIS model should be tested empirically and tried in development and evaluation, determining what and how to adjust to better advance the innovations.

Conclusion

In sum, the USIS model offers specific tools to design better BITs and evaluate existing BITs to improve health innovations' translation into practice. With the USIS model, HCD and IS practitioners can use a common language to enhance implementation and health outcomes for broader communities, support researchers in identifying multilevel barriers to implementation, and guide evaluating the BITs. We believe the USIS model offers a pathway for improving innovation advancement by incorporating the processes and tools from HCD and IS.

Reference

Aarons, G. A., Hurlburt, M., & Horwitz, S. M. (2011). Advancing a Conceptual Model of Evidence-Based Practice Implementation in Public Service Sectors. *Administration and Policy in Mental Health and Mental Health Services Research*, *38*(1), 4–23. https://doi.org/10.1007/s10488-010-0327-7

Bartlett, R., Boyle, J. A., Simons Smith, J., Khan, N., Robinson, T., & Ramaswamy, R. (2021). Evaluating human-centred design for public health: A case study on developing a healthcare app with refugee communities. *Research Involvement and Engagement*, *7*(1), 32. https://doi.org/10.1186/s40900-021-00273-2

Bauer, M. S., & Kirchner, J. (2020). Implementation science: What is it and why should I care? *Psychiatry Research*, *283*, 112376. https://doi.org/10.1016/j.psychres.2019.04.025

Bausback, K. B., & Bunge, E. L. (2021). Meta-Analysis of Parent Training Programs Utilizing Behavior Intervention Technologies. *Social Sciences*, *10*(10), Article 10. https://doi.org/10.3390/socsci10100367

Beres, L. K., Simbeza, S., Holmes, C. B., Mwamba, C., Mukamba, N., Sharma, A., Munamununguu, V., Mwachande, M., Sikombe, K., Bolton Moore, C., Mody, A., Koyuncu, A., Christopoulous, K., Jere, L., Pry, J., Ehrenkranz, P. D., Budden, A., Geng, E., & Sikazwe, I. (2019). Human-Centered Design Lessons for Implementation Science: Improving the Implementation of a Patient-Centered Care Intervention. *Journal of Acquired Immune Deficiency Syndromes (1999)*, *82*(3), S230–S243. https://doi.org/10.1097/QAI.0000000000002216

Birnbaum, F., Lewis, D. M., Rosen, R., & Ranney, M. L. (2015). Patient engagement and the design of digital health. *Academic Emergency Medicine : Official Journal of the Society for Academic Emergency Medicine*, *22*(6), 754–756. https://doi.org/10.1111/acem.12692

Booker, Q. S., Austin, J. D., & Balasubramanian, B. A. (2021). Survey strategies to increase participant response rates in primary care research studies. *Family Practice*, *38*(5), 699–702. https://doi.org/10.1093/fampra/cmab070

Chinman, M., Hunter, S. B., Ebener, P., Paddock, S. M., Stillman, L., Imm, P., & Wandersman, A. (2008). The Getting To Outcomes Demonstration and Evaluation: An Illustration of the Prevention Support System. *American Journal of Community Psychology*, *41*(3), 206–224. https://doi.org/10.1007/s10464-008-9163-2

Damschroder, L. J., Aron, D. C., Keith, R. E., Kirsh, S. R., Alexander, J. A., & Lowery, J. C. (2009). Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implementation Science*, *4*(1), 50. https://doi.org/10.1186/1748-5908-4-50

de Koning, R., Egiz, A., Kotecha, J., Ciuculete, A. C., Ooi, S. Z. Y., Bankole, N. D. A., Erhabor, J., Higginbotham, G., Khan, M., Dalle, D. U., Sichimba, D., Bandyopadhyay, S., & Kanmounye, U. S. (2021). Survey Fatigue During the COVID-19 Pandemic: An Analysis of Neurosurgery Survey Response Rates. *Frontiers in Surgery*, *8*. https://www.frontiersin.org/articles/10.3389/fsurg.2021.690680

Dopp, A. R., Parisi, K. E., Munson, S. A., & Lyon, A. R. (2019a). Integrating implementation and user-centred design strategies to enhance the impact of health services: Protocol from a concept mapping study. *Health Research Policy and Systems*, *17*(1), 1. https://doi.org/10.1186/s12961-018-0403-0

Dopp, A. R., Parisi, K. E., Munson, S. A., & Lyon, A. R. (2019b). A glossary of user-centered design strategies for implementation experts. *Translational Behavioral Medicine*, *9*(6), 1057–1064. https://doi.org/10.1093/tbm/iby119

Dopp, A. R., Parisi, K. E., Munson, S. A., & Lyon, A. R. (2020). Aligning implementation and user-centered design strategies to enhance the impact of health services: Results from a concept mapping study. *Implementation Science Communications*, *1*(1), 17. https://doi.org/10.1186/s43058-020-00020-w

Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: The RE-AIM framework. *American Journal of Public Health*, *89*(9), 1322–1327. https://doi.org/10.2105/AJPH.89.9.1322

Göttgens, I., & Oertelt-Prigione, S. (2021). The Application of Human-Centered Design Approaches in Health Research and Innovation: A Narrative Review of Current Practices. *JMIR MHealth and UHealth*, *9*(12), e28102. https://doi.org/10.2196/28102

Graham, A. K., Lattie, E. G., Powell, B. J., Lyon, A. R., Smith, J. D., Schueller, S. M., Stadnick, N. A., Brown, C. H., & Mohr, D. C. (2020). Implementation Strategies for Digital Mental Health Interventions in Health Care Settings. *The American Psychologist*, *75*(8), 1080–1092. https://doi.org/10.1037/amp0000686

Graham, A. K., Wildes, J. E., Reddy, M., Munson, S. A., Taylor, C. B., & Mohr, D. C. (2019). User-centered design for technology-enabled services for eating disorders. *The International Journal of Eating Disorders*, *52*(10), 1095–1107. https://doi.org/10.1002/eat.23130

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions*, *26*(1), 13. https://doi.org/10.1002/chp.47

Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, *26*(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Hartson, H. (1998). Human-computer interaction: Interdisciplinary roots and trends. *J. Syst. Softw.* https://doi.org/10.1016/S0164-1212(98)10026-2

Harvey, G., & Kitson, A. (2015). *Implementing Evidence-Based Practice in Healthcare: A Facilitation Guide*. Routledge. https://doi.org/10.4324/9780203557334

Hermes, E. D., Lyon, A. R., Schueller, S. M., & Glass, J. E. (2019). Measuring the Implementation of Behavioral Intervention Technologies: Recharacterization of Established Outcomes. *Journal of Medical Internet Research*, *21*(1), e11752. https://doi.org/10.2196/11752

Hooley, C., Amano, T., Markovitz, L., Yaeger, L., & Proctor, E. (2020). Assessing Implementation Strategy Reporting in the Mental Health Literature: A Narrative Review. *Administration and Policy in Mental Health and Mental Health Services Research*, *47*(1), 19–35. https://doi.org/10.1007/s10488-019-00965-8

ISO. (1998). ISO. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/01/68/16883.html

ISO. (1999). *ISO*. ISO. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/05/20/52075.html

Klaic, M., Kapp, S., Hudson, P., Chapman, W., Denehy, L., Story, D., & Francis, J. J. (2022). Implementability of healthcare interventions: An overview of reviews and development of a conceptual framework. *Implementation Science : IS*, *17*, 10. https://doi.org/10.1186/s13012-021-01171-7

Kwak, J. (2020, November 30). *How Equity-Centered Design Supports Anti-Racism in the Classroom*. Every Learner Everywhere. https://www.everylearnereverywhere.org/blog/how-equity-centered-design-supports-anti-racism-in-the-classroom/

Lee, J.-A., Choi, M., Lee, S. A., & Jiang, N. (2018). Effective behavioral intervention strategies using mobile health applications for chronic disease management: A systematic review. *BMC Medical Informatics and Decision Making*, *18*(1), 12. https://doi.org/10.1186/s12911-018-0591-0

Liu, C., Lee, J. H., Gupta, A. J., Tucker, A., Larkin, C., Turimumahoro, P., Katamba, A., Davis, J. L., & Dowdy, D. (2022). Cost-effectiveness analysis of human-centred design for global health interventions: A quantitative framework. *BMJ Global Health*, *7*(3), e007912. https://doi.org/10.1136/bmjgh-2021-007912

Liu, F. F., Cruz, R. A., Rockhill, C. M., & Lyon, A. R. (2019). Mind the Gap: Considering Disparities in Implementing Measurement-Based Care. *Journal of the American Academy of Child & Adolescent Psychiatry*, *58*(4), 459–461. https://doi.org/10.1016/j.jaac.2018.11.015

Lund, A. (2001). Measuring Usability with the USE Questionnaire. *Usability and User Experience Newsletter of the STC Usability SIG*, *8*.

Lyon, A. R., Brewer, S. K., & Areán, P. A. (2020). Leveraging human-centered design to implement modern psychological science: Return on an early investment. *The American Psychologist*, *75*(8), 1067–1079. https://doi.org/10.1037/amp0000652

Lyon, A. R., & Bruns, E. J. (2019). User-Centered Redesign of Evidence-Based Psychosocial Interventions to Enhance Implementation—Hospitable Soil or Better Seeds? *JAMA Psychiatry*, *76*(1), 3–4. https://doi.org/10.1001/jamapsychiatry.2018.3060

Lyon, A. R., Dopp, A. R., Brewer, S. K., Kientz, J. A., & Munson, S. A. (2020). Designing the Future of Children's Mental Health Services. *Administration and Policy in Mental Health and Mental Health Services Research*, *47*(5), 735–751. https://doi.org/10.1007/s10488-020-01038-x

Lyon, A. R., & Koerner, K. (2016). User-Centered Design for Psychosocial Intervention Development and Implementation. *Clinical Psychology : A Publication of the Division of Clinical Psychology of the American Psychological Association*, *23*(2), 180–200. https://doi.org/10.1111/cpsp.12154

Lyon, A. R., Munson, S. A., Renn, B. N., Atkins, D. C., Pullmann, M. D., Friedman, E., & Areán, P. A. (2019). Use of Human-Centered Design to Improve Implementation of Evidence-Based Psychotherapies in Low-Resource Communities: Protocol for Studies Applying a Framework to Assess Usability. *JMIR Research Protocols*, *8*(10), e14990. https://doi.org/10.2196/14990

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies*, *55*(4), 587–634. https://doi.org/10.1006/ijhc.2001.0503

Melles, M., Albayrak, A., & Goossens, R. (2021). Innovating health care: Key characteristics of human-centered design. *International Journal for Quality in Health Care*, *33*(Supplement_1), 37–44. https://doi.org/10.1093/intqhc/mzaa127

Michie, S., Yardley, L., West, R., Patrick, K., & Greaves, F. (2017). Developing and Evaluating Digital Interventions to Promote Behavior Change in Health and Health Care: Recommendations Resulting From an International Workshop. *Journal of Medical Internet Research*, *19*(6), e7126. https://doi.org/10.2196/jmir.7126

Mohr, D., Burns, M., Schueller, S., Clarke, G., & Klinkman, M. (2013). Behavioral Intervention Technologies: Evidence review and recommendations for future research in mental health. *General Hospital Psychiatry*, *35*. https://doi.org/10.1016/j.genhosppsych.2013.03.008

Mohr, D. C., Riper, H., & Schueller, S. M. (2018). A Solution-Focused Research Approach to Achieve an Implementable Revolution in Digital Mental Health. *JAMA Psychiatry*, *75*(2), 113–114. https://doi.org/10.1001/jamapsychiatry.2017.3838

Mohr, D. C., Schueller, S. M., Montague, E., Burns, M. N., & Rashidi, P. (2014). The Behavioral Intervention Technology Model: An Integrated Conceptual and Technological Framework for eHealth and mHealth Interventions. *Journal of Medical Internet Research*, *16*(6), e3077. https://doi.org/10.2196/jmir.3077

Moustakas, C. E. (1990). *Heuristic research: Design, methodology, and applications* (p. 130). Sage Publications, Inc.

Munson, S. A., Friedman, E. C., Osterhage, K., Allred, R., Pullmann, M. D., Areán, P. A., Lyon, A. R., & UW ALACRITY Center Researchers. (2022). Usability Issues in Evidence-

Based Psychosocial Interventions and Implementation Strategies: Cross-project Analysis. *Journal of Medical Internet Research*, *24*(6), e37585. https://doi.org/10.2196/37585

Nielsen. (1994). *Usability Inspection Methods: Book by Jakob Nielsen*. Nielsen Norman Group. https://www.nngroup.com/books/usability-inspection-methods/

Norman, M. K., Hamm, M. E., Schenker, Y., Mayowski, C. A., Hierholzer, W., Rubio, D. M., & Reis, S. E. (2021). Assessing the application of human-centered design to translational research. *Journal of Clinical and Translational Science*, *5*(1), e130. https://doi.org/10.1017/cts.2021.794

Onken, L. (2022). Implementation Science at the National Institute on Aging: The Principles of It. *Public Policy & Aging Report*, *32*(1), 39–41. https://doi.org/10.1093/ppar/prab034

Pillsbury, M. K. M., Mwangi, E., Andesia, J., Njuguna, B., Bloomfield, G. S., Chepchumba, A., Kamano, J., Mercer, T., Miheso, J., Pastakia, S. D., Pathak, S., Thakkar, A., Naanyu, V., Akwanalo, C., & Vedanthan, R. (2021). Human-centered implementation research: A new approach to develop and evaluate implementation strategies for strengthening referral networks for hypertension in western Kenya. *BMC Health Services Research*, *21*(1), 910. https://doi.org/10.1186/s12913-021-06930-2

Powell, B. J., Beidas, R. S., Lewis, C. C., Aarons, G. A., McMillen, J. C., Proctor, E. K., & Mandell, D. S. (2017). Methods to Improve the Selection and Tailoring of Implementation Strategies. *The Journal of Behavioral Health Services & Research*, *44*(2), 177–194. https://doi.org/10.1007/s11414-015-9475-6

Powell, B. J., McMillen, J. C., Proctor, E. K., Carpenter, C. R., Griffey, R. T., Bunger, A. C., Glass, J. E., & York, J. L. (2012). A Compilation of Strategies for Implementing Clinical

Innovations in Health and Mental Health. *Medical Care Research and Review*, *69*(2), 123–157. https://doi.org/10.1177/1077558711430690

Proctor, E. K., Landsverk, J., Aarons, G., Chambers, D., Glisson, C., & Mittman, B. (2009). Implementation Research in Mental Health Services: An Emerging Science with Conceptual, Methodological, and Training challenges. *Administration and Policy in Mental Health*, *36*(1), 10.1007/s10488-008-0197–4. https://doi.org/10.1007/s10488-008-0197-4

Proctor, E., Silmere, H., Raghavan, R., Hovmand, P., Aarons, G., Bunger, A., Griffey, R., & Hensley, M. (2011). Outcomes for implementation research: Conceptual distinctions, measurement challenges, and research agenda. *Administration and Policy in Mental Health*, *38*(2), 65–76. https://doi.org/10.1007/s10488-010-0319-7

Richardson, S., Lawrence, K., Schoenthaler, A. M., & Mann, D. (2022). A framework for digital health equity. *Npj Digital Medicine*, *5*(1), Article 1. https://doi.org/10.1038/s41746-022-00663-0

Stiles-Shields, C., Crowe, A. N., Driscoll, C. F. B., Ohanian, D. M., Stern, A., Wartman, E., Winning, A. M., Wafford, Q. E., Lattie, E. G., & Holmbeck, G. N. (2019). A Systematic Review of Behavioral Intervention Technologies for Youth With Chronic Health Conditions and Physical and Intellectual Disabilities: Implications for Adolescents and Young Adults With Spina Bifida. *Journal of Pediatric Psychology*, *44*(3), 349–362. https://doi.org/10.1093/jpepsy/jsy097

Stirman, S. W., Miller, C. J., Toder, K., & Calloway, A. (2013). Development of a framework and coding system for modifications and adaptations of evidence-based interventions. *Implementation Science*, *8*(1), 65. https://doi.org/10.1186/1748-5908-8-65

Surma-aho, A., & Hölttä-Otto, K. (2022). Conceptualization and operationalization of empathy in design research. *Design Studies*, *78*, 101075. https://doi.org/10.1016/j.destud.2021.101075

Tognazzini, B. (2014, March 6). First Principles of Interaction Design (Revised & Expanded). *AskTog*. https://asktog.com/atc/principles-of-interaction-design/

Toomey, E., Hardeman, W., Hankonen, N., Byrne, M., McSharry, J., Matvienko-Sikar, K., & Lorencatto, F. (2020). Focusing on fidelity: Narrative review and recommendations for improving intervention fidelity within trials of health behaviour change interventions. *Health Psychology and Behavioral Medicine*, *8*(1), 132–151. https://doi.org/10.1080/21642850.2020.1738935

Veinot, T. C., Mitchell, H., & Ancker, J. S. (2018). Good intentions are not enough: How informatics interventions can worsen inequality. *Journal of the American Medical Informatics Association*, *25*(8), 1080–1088. https://doi.org/10.1093/jamia/ocy052

Walton, H., Spector, A., Williamson, M., Tombor, I., & Michie, S. (2020). Developing quality fidelity and engagement measures for complex health interventions. *British Journal of Health Psychology*, *25*(1), 39–60. https://doi.org/10.1111/bjhp.12394

Waltz, T. J., Powell, B. J., Fernández, M. E., Abadie, B., & Damschroder, L. J. (2019). Choosing implementation strategies to address contextual barriers: Diversity in recommendations and future directions. *Implementation Science*, *14*(1), 42. https://doi.org/10.1186/s13012-019-0892-4

Waltz, T. J., Powell, B. J., Matthieu, M. M., Damschroder, L. J., Chinman, M. J., Smith, J. L., Proctor, E. K., & Kirchner, J. E. (2015). Use of concept mapping to characterize relationships among implementation strategies and assess their feasibility and

importance: Results from the Expert Recommendations for Implementing Change (ERIC) study. *Implementation Science*, *10*(1), 109. https://doi.org/10.1186/s13012-015-0295-0

Ward, T. M., Skubic, M., Rantz, M., & Vorderstrasse, A. (2020). Human-centered approaches that integrate sensor technology across the lifespan: Opportunities and challenges. *Nursing Outlook*, *68*(6), 734–744. https://doi.org/10.1016/j.outlook.2020.05.004

Wiltsey Stirman, S., Baumann, A. A., & Miller, C. J. (2019). The FRAME: An expanded framework for reporting adaptations and modifications to evidence-based interventions. *Implementation Science*, *14*(1), 58. https://doi.org/10.1186/s13012-019-0898-y

Wray, T. B., Kahler, C. W., Simpanen, E. M., & Operario, D. (2019). User-centered, interaction design research approaches to inform the development of health risk behavior intervention technologies. *Internet Interventions*, *15*, 1–9. https://doi.org/10.1016/j.invent.2018.10.002

Table 4.1 USIS Constructs and Definition

Constructs	Concepts	Definition
User centeredness	Empathy Engagement Equity	**Equity**: the practice of purposefully involving minoritized or disadvantaged communities throughout a design; it acknowledges that equity happens with intent and focus. It includes teams (users and researchers), content, and implementation. - Team and Content: 1) diverse and inclusive users, multidisciplinary researcher team; 2) contextually appropriate and culturally relevant to fit users and their context of the use - Implementation: 1) accessibility for those with disabilities and low digital health literacy; 2) uptake: users who are not computer savvy, do not trust technology, or who are exposed through informal social networks; 3) adherence: intervention usability, literacy burden, access of money, time and coping skills; 4) effectiveness: different groups of people, focus on groups of people, and access. **Empathy**: the efforts to understand the users without judgment: their behavior and why, physical and emotional needs, and what is meaningful to them. **Engagement**: users' involvement in BIT development to equip, enable and empower user-centered design decisions
Efficiency	Cost Timeliness Rapidity	**Cost**: the cost related to user spend and BIT implementation. **Rapidity**: rapid iteration and prototyping to quickly test and make improvements. **Timeliness**: accounts for ongoing iteration, evolving and fast updates over time.
Feasibility	Learnability Memorability error reduction low cognitive load	**Learnability**: users can rapidly understand and use BITs. **Memorability**: users can remember and successfully operate. **Error reduction**: prevent or rapid recovery from errors **Low cognitive load**: users only need minimum efforts to complete learning and task with simplified functions.
Satisfaction	Acceptability Appropriateness	**Acceptability**: how well the intervention being received by target populations and the extent to which the intervention meet the needs of the target populations **Appropriateness**: fit and relevance to users' problems
Fidelity	Adoption Penetration Sustainability	**Adoption**: actual use (e.g., log-in timestamp) of the BIT by users **Penetration**: the extent of integration of BITs within a context. **Sustainability**: The extent of BIT's practice and effect is maintained and long lasting.

Table 4.2 USIS HCD Stage Model

USIS Constructs	Concepts	HCD Process			
		Discover & define	Ideate & Prototype	Test & refine	Pilot testing
User centeredness	Empathy Engagement Equity	X	X	X	X
Efficiency	Cost Timeliness Rapidity		X	X	X
Feasibility	Learnability Memorability error reduction low cognitive load		X	X	X
Satisfaction	Acceptability Appropriateness		X	X	X
Fidelity	Adoption Penetration Sustainability		X	X	X

Chapter 5: Conclusions and Implications

Contributions of the Three Studies

This dissertation comprised three innovative pieces of work that advance pediatric sleep health research. SLEEPSMART is the first technology-enabled pilot randomized controlled trial that targeted sleep as a primary outcome among children with JIA and their parents. The preliminary findings suggest SLEEPSMART to be highly feasible and acceptable by children with JIA and their parents, and improved children's and parents' sleep and shared management skills. It is an example for future behavioral pediatric sleep interventions to consider in the context of engaging children and parents as a team and targeting self-efficacy, motivation, problem solving and working through setbacks. Additionally, SLEEPSMART is unique in that the HCD method was applied to center stakeholders (parents and children) throughout the design and development that enhanced their satisfaction and intervention adoption. Furthermore, it is crucial to account for parent-child interdependence to effectively manage children's sleep in pediatric sleep research. Parents play critical roles in shaping children's health management skills as they are essential caregivers and teachers.

In Study 2, SCT was comprehensively analyzed and evaluated in the context of pediatric sleep. With a deeper understanding of SCT, we reformulated SCT by integrating the PCSM concept. The reformulated SCT-SM accounts for parent-child interdependence and role transition, providing a promising framework to support children's sleep health with sustained effects. SCT-SM also offers the opportunity of reconsidering pediatric sleep from new theoretical perspectives.

In Study 3, given that intervention design characteristics strongly influence implementation, adoption, and sustainability in healthcare settings, we integrated HCD and Implementation Science (IS) outcomes into a next-level practical evaluation framework for

evidence-based practices (e.g., intervention, services, policy). We recognized that HCD and IS shared common goals to improve intervention usability and implementation by applying iterative and contextual design processes, engaging stakeholders, involving a multidisciplinary design team, and conducting iterative testing and evaluation as early and frequently as possible. Our proposed USIS model can guide the design, development, and evaluation of interventions. The USIS model generates the opportunity for researchers to embed implementation research earlier in the pipeline and expand the various resources that increase the uptake of evidence (e.g., change design features, context, culturally appropriate considerations, and diverse stakeholders) and maximize the potential of BITs' success in implementation.

Study Limitations and Implications for Future Research

The overall limitations including the sample size in was relatively small and limited to the participants mainly living in greater Seattle area, predominantly White and middle class (Study 1), did not include a systematic review of all related empirical research studies, and our sources were limited to those written in English (Study 2 and 3).

Drawing from the three papers of this dissertation, my future research focuses on pediatric sleep health disparities among socially marginalized and historically underrepresented populations. Sleep health disparities are critical but often underrecognized contributors to health inequities as people with minoritized ethnic and racial backgrounds and from low-income households experience a disproportionately greater burden of sleep-related chronic illnesses (Billings et al., 2021; Grandner et al., 2016). Pediatric sleep disparities require innovative and urgent interventions to establish a foundation of lifelong healthy sleep (Billings et al., 2021). Specifically, my goals are to 1) understand the mechanisms of socioeconomic status, racism, discrimination, neighborhood segregation, geography, social patterns, and access to health care

as well as by cultural beliefs that contribute to sleep health disparities; 2) use the SCT-SM model to guide the development of a culturally- and language-tailored sleep intervention for dyads; and 3) design and develop sleep intervention with the USIS model, leverage digital health tools and other technology-enabled solutions to increase the accessibility and scalability of future sleep health interventions to improve sleep health equity among marginalized populations.

Reference

Billings, M. E., Cohen, R. T., Baldwin, C. M., Johnson, D. A., Palen, B. N., Parthasarathy, S., Patel, S. R., Russell, M., Tapia, I. E., Williamson, A. A., & Sharma, S. (2021). Disparities in Sleep Health and Potential Intervention Models. *Chest*, *159*(3), 1232–1240. https://doi.org/10.1016/j.chest.2020.09.249

Grandner, M. A., Williams, N. J., Knutson, K. L., Roberts, D., & Jean-Louis, G. (2016). Sleep disparity, race/ethnicity, and socioeconomic position. *Sleep Medicine*, *18*, 7–18. https://doi.org/10.1016/j.sleep.2015.01.020