

Open Trial of the Parent Behavior Change Intervention (PBC-I): Study Protocol

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### Abstract

**Objective:** Parents have profound impacts on adolescents' health behaviors. Yet parents receive minimal training in the elements of conversations that optimally inspire their children toward engaging in healthy behaviors. The current study examines a novel interpersonal target: parent-adolescent conversations about adolescent health behavior change. Derived from advances in the science of behavior change, the Parent Behavior Change Intervention (PBC-I) contains conversational elements (e.g., behavior change techniques, positive communication strategies) hypothesized to reduce parent-adolescent coercion and conflict and facilitate upward spirals of healthy behavior change in adolescents. **Methods/Design:** The first phase of the study involves the development of the PBC-I in a small case series ( $N = 12$  dyads). The second phase involves an open trial of the PBC-I ( $N = 36$  dyads). Adolescents will receive six, 50-min sessions of the Transdiagnostic Sleep and Circadian Intervention (TranS-C) to improve sleep while their parents receive six, 50-min sessions of the PBC-I. Parent-adolescent dyads will be assessed before and after the intervention. The primary analysis will examine whether postintervention use of behavior change techniques and positive communication strategies by parents is higher than preintervention use and whether increased use by parents predicts more positive conversational behaviors, less parent-adolescent conflict, higher adolescent motivation for change, and improved adolescent sleep. **Discussion:** This research provides an initial test of the hypothesis that improving the parent-adolescent conversation will improve adolescent sleep health behavior. While sleep-related health behaviors are the focus of this study, the research is designed to be relevant to a broad range of health behavior change in young people.

**Keywords:** adolescence, sleep, parent intervention, behavior change techniques

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### **Open Trial of the Parent Behavior Change Intervention (PBC-I): Study Protocol**

Adolescence is a period of considerable risk and vulnerability (Steinberg et al., 2015). It is also when future patterns, habits, and tendencies are established. Hence, an urgent need exists to identify novel modifiable contributors to risk and vulnerability among adolescents. The goal of this article is to describe the rationale and the treatment development process for a new program of research that aims to investigate two promising intervention targets to reduce health risks and increase sustainable health behaviors in youth: parent-adolescent conversations and sleep health.

#### **Rationale for Focusing on Parent-Adolescent Conversation**

Parent-adolescent conversation is an important contributor to the health choices of adolescents, including alcohol use (Reimuller, Hussong, & Ennett, 2011), smoking experimentation (White, 2012), risk-taking behavior (Wilson & Donenberg, 2004), and sexual health behavior (Widman, Choukas-Bradley, Noar, Nesi, & Garrett, 2016). High levels of coercion and conflict within parent-adolescent dyads are associated with negative adolescent outcomes, from greater internalizing behaviors such as avoidance (e.g., Saxbe, Ramos, Timmons, Rodriguez, & Margolin, 2014) and externalizing behaviors such as aggression (e.g., Ehrlich, Dykas, & Cassidy, 2012; Klahr, Rueter, McGue, Iacono, & Alexandra Burt, 2011) to declines in academic achievement (Dotterer, Hoffman, Crouter, & McHale, 2008), whereas moderate levels of conflict are associated with more positive outcomes (Smetana, Campione-Barr, & Metzger, 2006). On the other hand, more positive parent-adolescent communication and parental warmth were associated with a broad range of health domains, including less substance use and risky behaviors (Piko & Balázs, 2012), better eating habits and less weight problems

(Pearson, Atkin, Biddle, Gorely, & Edwardson, 2010), and better sleep (Brand, Hatzinger, Beck, & Holsboer-Trachsler, 2009).

Despite this evidence, parents receive minimal training in the specific elements of conversations that optimally inspire their children to engage in healthy behaviors. Progress has been made in terms of health professionals using parents as change agents to promote adolescent sexual health and prevent unintended pregnancies (Gavin, Williams, Rivera, & Lachance, 2015; Jaccard & Dittus, 1991; Jaccard & Levitz, 2015). However, relative to preventing problem behaviors, little research is available on increasing health behaviors in adolescents, such as sleep-promoting behaviors, through parent-based interventions. Hence, the current study examines a novel interpersonal target, namely, to pinpoint the micro-mechanisms of parent-adolescent conversations about behavior change that may improve parent-adolescent conversations, lessen coercion and conflict, as a first step toward harnessing the role parents could play in promoting sustainable health behaviors in their adolescents.

### **Rationale for Focusing on Sleep as the Target Health Behavior**

On average, adolescents sleep 7 hours each night during the school year (Asarnow, McGlinchey, & Harvey, 2014), falling 2.25 hours short of the recommended 9.25 hours (Carskadon et al., 1980; Matricciani, Blunden, Rigney, Williams, & Olds, 2013). One major contributor to this sleep deprivation is the “eveningness” circadian preference, which affects approximately 40% of adolescents (Carskadon, Acebo, Richardson, Tate, & Seifer, 1997; Roenneberg et al., 2004). Eveningness refers to a delayed sleep-wake schedule; combined with early school start times, it leads to sleep deprivation and sleep variability from weekdays to weekends (Crowley, Acebo, & Carskadon, 2007; Gradisar et al., 2013). This is of concern because adequate sleep is critical for optimal brain development (Tarokh, Saletin, & Carskadon,

2016). Also, eveningness is consistently associated with problems in emotional (Gau et al., 2007), cognitive (Goldstein, Hahn, Hasher, Wiprzycka, & Zelazo, 2007; Short, Gradisar, Lack, & Wright, 2013), behavioral (e.g., Adan, Natale, Caci, & Prat, 2010; Negriff, Dorn, Pabst, & Susman, 2011), social, and physical health domains (Miller, Lumeng, & LeBourgeois, 2015; Schaal, Peter, & Randler, 2010).

While the biological shift toward eveningness may be difficult to modify, a novel behavioral sleep intervention—the Transdiagnostic Intervention for Sleep and Circadian Rhythms (TranS-C)—has been designed to modify psychosocial, behavioral, and cognitive contributors to eveningness, such as technology use around nighttime and irregular bedtimes and waketimes from weekdays to weekends (Harvey, 2016; Harvey & Buysse, 2017; Harvey et al., 2018). Consistent with research documenting the effectiveness of sleep interventions for youth, a recent randomized controlled trial showed that TranS-C, relative to psychoeducation, effectively reduced eveningness and improved sleep in adolescents (Dong, Gumport, Martinez, & Harvey, 2019; Harvey et al., 2018). During the initial phase of the TranS-C implementation, parents were invited to join the final 5-10 minutes of each 50-minute session to promote acceptance and reinforcement of change. It became apparent that these parent-adolescent conversations could become strikingly negative, coercive, and conflictual, which motivated the current research. One goal of the current research is to develop a parent intervention to supplement TranS-C in which parents are taught to use effective behavior change techniques (BCTs) and positive communication strategies with their adolescents to promote better sleep.

### **Theoretical Background**

Little is known about how parents shape their adolescents' sleep health behaviors through daily conversations. As adolescents take greater control of their own sleep, relative to younger

children, parent-adolescent conversations about sleep may be an important sleep-related socialization target used by parents. As shown in Figure 1 and based on prior work (Brand, Gerber, Hatzinger, Beck, & Holsboer-Trachsler, 2009; Brand, Hatzinger, et al., 2009; Erath & Tu, 2011), the Parent Behavior Change Intervention (PBC-I) is predicted to increase parental use of BCTs and positive conversational behavior and thereby improve parent-adolescent conversations about sleep, reduce coercion and conflict in parent-adolescent conversations, and promote an authoritative parenting style. Improved parent-adolescent communication is theoretically predicted to increase adolescents' motivation for making health behavior changes. Moreover, by teaching parents how to deliver BCTs and positive communication strategies, the intervention is expected to promote more positive parent-adolescent conversation about behavior change (e.g., using BCTs such as problem solving to identify and overcome barriers to change, instead of nagging or yelling) that, in turn, is hypothesized to contribute to adolescents' sustainable healthy sleep behaviors by supporting emotion regulation and self-regulation (El-Sheikh et al., 2009; Erath & Tu, 2011; Hessler & Katz, 2010; Lohaus, Vierhaus, & Ball, 2009). Several important factors are recognized in this model: (a) the predicted effect of factors such as family economic stressors as well as parent stress and psychopathology on uptake of the intervention (El-Sheikh et al., 2013; El-Sheikh, Kelly, Bagley, & Wetter, 2012); (b) the potential for reciprocal effects of teen sleep-related health behaviors on parent-adolescent conversation, coercion and conflict, and parenting style (Kerr, Stattin, & Özdemir, 2012); and (c) the detrimental effect of poor sleep on adolescent's motivation for behavior change (Beebe, 2011; Wolfson & Carskadon, 2003).

The treatment development process is based on the theoretical framework of the behavior change wheel. The behavioral model at the heart of the behavior change wheel incorporates the

key processes of the following theories and practices: theory of planned behavior, self-regulation theory, operant learning theory, relapse prevention theory, health belief model, motivational interviewing, and motivational enhancement (Michie, Atkins, & West, 2014; Michie, van Stralen, & West, 2011). An integral part of the process of applying the behavior change wheel to intervention development is to select the “active ingredients,” i.e., the BCTs likely to be effective given the understanding of the target behaviors. The extensive 93-item BCT taxonomy is useful for this purpose (Michie et al., 2013, 2015). In the current study, the behavior change wheel framework is used to conceptualize and develop the intervention for parent-level behavior change, with the aim of increasing the use of effective BCTs, positive conversational behaviors, and adolescent sleep-promoting behaviors (e.g., adhering to a bedtime routine, regularizing bedtime and wake up time from weekdays to weekend). Intervention strategies are selected from the BCT taxonomy for both parent-level and adolescent-level behavior change (Figure 1 shows examples of BCTs parents are taught to use to promote adolescent behavior change). This method has been used to develop interventions related to a wide range of health behavior change, such as smoking cessation, healthy diet, physical activities, weight management, and self-management of chronic illness (e.g., Brooksbank et al., 2019; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Michie, Churchill, & West, 2011; Walsh et al., 2019). While a few prior studies have derived parent interventions to promote sexual behavior (Schuster et al., 2008) and sedentary behaviors (St. George, Wilson, Schneider, & Alia, 2013), to the best of our knowledge there is no prior parent intervention to promote adolescent sleep health and no prior parent intervention was derived using the behavior change wheel framework with BCTs intentionally specified.

Importantly, this research is designed following the experimental therapeutic approach, which is a framework advocated by the National Institute of Mental Health and other federal agencies for psychosocial intervention research that requires not only quantifying treatment efficacy but also explaining the mechanism of change (Insel, 2015). As shown in Figure 2, following the experimental medicine approach, the PBC-I focuses on a novel intervention target: parent-adolescent communication. The target engagement will be verified by use of several measures and coding procedures.

### **Aims and Hypotheses**

The current article describes the rationale and process involved in developing a parent intervention to promote better sleep behavior change in adolescents. The first aim is to develop and refine a novel intervention—the PBC-I—to improve parent use of BCTs and positive communication in a case series of 12 parent-adolescent dyads. The PBC-I will be delivered to parents while their teen is receiving TranS-C. The second aim is to conduct a small open trial ( $N = 36$  dyads) to test the PBC-I. There are two hypotheses. First, relative to before the intervention, postintervention parent-adolescent conversations will be characterized by more parent use of BCTs, less negative and more positive parent conversational behaviors, less parent-adolescent coercion and conflict, more teen motivation, more youth engagement in sleep-promoting behavior, and improved sleep. Second, increased parent use of BCTs from before to after the PBC-I will be associated with less negative and more positive parent conversational behaviors, less parent-adolescent coercion and conflict, more teen motivation, more youth engagement in sleep-promoting behavior, and improved sleep. The third aim is to conduct exploratory analyses on whether the primary outcomes for parent conversational behavior, parent-adolescent coercion and conflict, and teen motivation for behavior change mediate the relationship between BCT

frequency and the primary sleep outcomes. Whether parent use of BCTs is moderated by age, gender, and race/ethnicity of the adolescent and gender of the parent will also be investigated.

## **Proposed Methods**

### **Study Design and Setting**

The current study is being conducted in a U.S. university psychological clinic. The study has two phases. The first phase is a pilot phase in which a case series ( $N = 12$ ) is conducted to develop and refine the PBC-I treatment. The second phase of the study is an open trial with a one-group pre-test/post-test design to test the PBC-I in 36 parent-adolescent dyads, in which the parent will receive PBC-I and the teen will receive TranS-C in parallel sessions. We considered but decided against adding a control group because (a) we already know the effect size of the TranS-C intervention from a prior NICHD-funded R01 randomized controlled trial ( $N = 176$ ) and (b) we will learn more about the new parent intervention in 36 dyads ( $N$  in an open trial) than in 18 dyads ( $N$  of the experimental group in a 1:1 randomized controlled trial) because it will provide greater variation as well as a larger dataset.

### **Open Science Plans**

Consistent with open science, preregistration of the study design, eligibility criteria, and outcome measures are available at ClinicalTrials.gov ([NCT03926221](https://clinicaltrials.gov/ct2/show/study/NCT03926221)) since this study meets National Institute of Health's definition of a clinical trial. An Open Science Framework page has been created for this study (<https://doi.org/10.17605/OSF.IO/NPM5G>) and data used for the analysis (i.e., preregistered variables) will be uploaded, including raw and derived 7-day sleep diary and actigraphy variables, questionnaire measures, BCT coding data, conversation behavior coding data, and coding reliability data. Recordings and transcripts of the parent-adolescent conversations will not be shared to protect participants' privacy. A GitHub page will be created

to share codes used for statistical analysis (including version control). Preprint will be posted on psyarxiv.com and the manuscript will be open access when published.

### **Participants and Procedures**

A total of 48 parent-adolescent dyads (12 dyads for the pilot phase and 36 dyads for the open trial) are being recruited through multiple methods, including in schools, in the community, and through online e-mail discussion and interest groups in the U.S. San Francisco Bay Area. Interested parents and adolescents are first screened separately by phone to determine the adolescent's eligibility according to the inclusion and exclusion criteria.

The inclusion criteria for the adolescents are as follows: (a) age between 10 and 18 years (age 10 was based on the start age of adolescence defined by the WHO; Sawyer, Azzopardi, Wickremarathne, & Patton, 2018) and residence with a parent or guardian; (b) lowest quartile of the Children's Morningness-Eveningness Preferences (CMEP) scale (score  $\leq 27$ ); (c) self-reported weekday sleep onset time for the past month later than 10:40 pm for 10–13-year-olds, 11:00 pm for 14–16-year-olds, and 11:20 for 17–18-year-olds at least three nights per week and total sleep time  $\leq 8$  hours for at least three nights per week; (d) English language fluency; (e) able and willing to give informed assent; and (f) participation in all study sessions by at least one parent or primary caregiver living in the same household as the adolescent at least 50% of the week.

The exclusion criteria for the adolescents are as follows: (a) an active, progressive physical illness directly related to the onset and course of the sleep disturbance; (b) evidence of sleep apnea, restless legs, or periodic limb movements; (c) significantly impairing pervasive developmental disorder per parent report; (d) history of substance dependence in the past 6 months; (e) suicide risk per youth report; (f) bipolar disorder or schizophrenia or another current

Axis I disorder if there is a significant risk of harm and/or decompensation if treatment of that comorbid condition is delayed as a function of participating in any stage of this study; or (g) new (unestablished) medication use ( $\leq 4$  weeks). Eligible parent-adolescent dyads are then invited for an in-person pretreatment assessment. During the pretreatment assessment, eligibility is further confirmed by assessing the presence of suicide risk using the Columbia-Suicide Severity Rating Scale (C-SSRS) (Shahid, Wilkinson, Marcu, & Shapiro, 2011), certain sleep disorders (included in the exclusion criteria) using relevant sections of the Duke Structured Interview for Sleep Disorders (Edinger et al., 2009), and substance use using relevant modules on alcohol and substance use from the Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS) (Kaufman et al., 1997). A flowchart of the study design is presented in supplemental material A. Pretreatment and posttreatment assessments include questionnaire measures, behavioral tasks, and 7-day sleep diary and actigraphy collection. Recommendations for Interventional Trials (SPRIT 2013) Checklist and Figure are provided in supplemental material B and C.

## Measures

The primary and secondary outcomes are presented in Table 1 and the measures are described below.

**Hot Topics Task** (Eisenberg et al., 2008; Hetherington, 2008). This task is administered before and after treatment. The task integrates two assays from the Science of Behavior Change (SOBC) research network: Couples Conflict Task and Rapid Marital Interaction Coding System. In prior research, intraclass correlations based on coding of this task have ranged from .71 to .93 (Eisenberg et al., 2008). The parent and adolescent each rate 44 topics of frequent disagreement and the intensity of anger for each topic by using the Issue Checklist (Prinz, Foster, Kent, &

O’Leary, 1979). Based on the responses, the two topics with the highest anger intensity are chosen. The parent-adolescent dyad are then left alone to have two 8-minute conversations about these two topics. The researchers specify that one of the topics is about sleep (either “bedtime” or “getting up in the morning” from the Issue Checklist, whichever has the highest anger intensity rating); the other is a topic rated as most conflict-generating. If the anger intensity is the same for parent and adolescent but for different topics, the topic will be chosen at random. The conversations are videotaped and later transcribed verbatim. The videotapes and transcriptions are used by two coding teams to code for the parent’s use of BCTs as well as the parent’s positive and negative conversational behaviors, respectively. The sleep-related conversation ensures the conversations are comparable across dyads in terms of the BCTs and positive and negative conversational behaviors; the non-sleep-related conversation allows for an index of the broader (beyond sleep) impacts of parental use of BCTs and conversational behaviors.

**End-of-Session Conversation.** After the 45-minute session with the therapist, the parent will be invited to join their adolescent. The adolescent coach will read the dyad an instruction about this task and leave the room to allow the dyad to have a 5-min conversation. The instruction for the dyad specifies that the conversation is to “discuss the teen’s sleep goals for this week and how the teen will achieve these goals” and encourages the dyad to stay on topic. The purpose of this task is for the adolescent to tell their parent the collaboratively devised plan for improving the teen’s sleep for the week ahead and for the parent to apply the BCTs along with positive communication strategies to support the teen’s sleep goal(s). The Conversations will be audiotaped and transcribed verbatim, and the tapes will be coded for parent use of BCTs and positive and negative conversational behaviors. In addition, about 2 to 3 times during the course of the treatment, the PBC-I therapist will review the End-of-Session Conversation from

the previous session and provide the parent constructive feedback in the next session on their use of BCTs and communication strategies.

**Coercion and conflict.** Two measures are used to assess parent-adolescent coercion and conflict. The Issues Checklist (IC) assesses 44 topics on which parents and adolescents may have disagreements (Prinz et al., 1979). The measure is given to both parent and adolescents. The frequency and intensity of each topic are rated. The outcome variables derived from the IC are the mean anger intensity and the number of conflicts. Reliability is well established. In addition, parent and adolescent versions of the Conflict Behavior Questionnaire are administered to the parent-adolescent dyad (Prinz et al., 1979). The study will use the 20-item version (Robin & Foster, 1989). The questionnaire contains 20 true-false scale items and assesses perceived communication conflict between parent-adolescent dyads. It has adequate reliability (Cronback's  $\alpha = 0.88-0.95$ ) and validity data (Prinz et al., 1979; Robin & Foster, 1989).

**Teen motivation for behavior change.** Two measures are used to assess adolescent motivation for behavior change. The Decisional Balance Worksheet is a measure of motivation to change (Collins, Carey, & Otto, 2009; Collins, Eck, Torchalla, Schröter, & Batra, 2010). It has adequate predictive, convergent, and discriminant validity. The targeted behavior is "improving sleep." The counts of pros and cons of change are obtained and converted into the decisional balance proportion  $[(\text{proS}_{\text{change}} + \text{conS}_{\text{no-change}})/(\text{proS}_{\text{change}} + \text{conS}_{\text{change}} + \text{proS}_{\text{no-change}} + \text{conS}_{\text{no-change}})]$  representing the decisional balance toward change. DBP scores between 0 and 0.5 indicate a balance tipped towards maintenance of the current behavior, a score of 0.5 indicates an even balance between changing versus maintaining behavior, and scores between 0.5 to 1 indicate a balance tipped towards behavior change.

The Intrinsic Motivation Inventory assesses intrinsic motivation related to a target activity (“participating in sleep coaching sessions”) (McAuley, Duncan, & Tammen, 1989). This measure is factor analytically coherent and stable across a variety of tasks, conditions, and settings (Deci, Eghrari, Patrick, & Leone, 1994), has good internal consistency (Cronbach’s  $\alpha = 0.85$ ), and has demonstrated strong temporal stability (McAuley et al., 1989). Three subscales are administered: interest/enjoyment (7 items), perceived competence (6 items), and effort/importance (5 items).

**Sleep-promoting behavior and sleep.** Sleep promoting behaviors refer to a set of sleep health recommendations covered in TranS-C, such as regularizing bedtime and wake up time, adhering to a bedtime routine (e.g., dim light, eliminate screen time before going to bed) and rise-up routine that promotes optimal sleep. Sleep-promoting behaviors are measured using a 7-day sleep diary and actigraphy. A sleep diary is considered the gold standard (Carney et al., 2012) and more than 5 days of sleep diary data can yield reliable estimates of sleep in adolescents (Short, Arora, Gradisar, Taheri, & Carskadon, 2017). Actigraphy is obtained via the Actiwatch Spectrum activity monitor (Philips Respironics), which continuously measures movement (sampled in 60-s epochs). Actigraphy is strongly correlated with polysomnography (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992) and has been validated in adolescents (Johnson et al., 2007; Sadeh, Sharkey, & Carskadon, 1994). Regularity in sleep midpoint will be derived from the sleep diary and actigraphy.

Global sleep functioning is measured by using the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). The PSQI is a 19-item questionnaire that yields a global score ranging from 0 to 21, with higher scores indicating greater sleep problems in the past month. The PSQI is widely used and has been validated in youth as a global measure of sleep. The total score had

good convergent and divergent validity and moderate reliability (Cronbach's alpha = 0.72) in a sample of adolescents and young adults (de la Vega et al., 2015). Eveningness preference is measured using the CMEP scale (Carskadon, Vieira, & Acebo, 1993), a self-report measure of the degree of eveningness. Scores range from 10 (extreme evening preference) to 43 (extreme morning preference). Prior studies reported that the CMEP scores have good reliability (Cronbach's alpha = 0.78-0.82) (Carskadon, Seifer, & Acebo, 1991; Díaz-Morales, de Leon, & Sorroche, 2007) and good convergent validity (Kim, Dueker, Hasher, & Goldstein, 2002).

### **Coding Procedures**

**Coding for BCTs.** All coders completed the online training and obtained certificates for BCT coding ([www.bct-taxonomy.com](http://www.bct-taxonomy.com)). Coding is conducted in pairs. Two coders independently code a Hot Topics Task or End-of-Session Conversation by first reading the transcription line by line and listening to the video- and audiotapes twice and then marking the exact words signifying a BCT and assigning it a label from the existing taxonomy. Coders then meet to compare the codes and resolve discrepancies through discussion. We will report percent agreement, kappa, and prevalence-adjusted and bias-adjusted (PABAK) for inter-rater reliability.

**Coding for positive and negative conversational behaviors.** Parent's positive and negative conversational behaviors used during the Hot Topics Task and End-of-Session Conversation will be coded by use of a codebook developed for this study. It was adapted from the Interaction Behavior Code (Prinz & Kent, 1978), which is designed to assess parent-adolescent communication through consensus coding from several raters who review and code the audio- and videotapes and transcripts of the conversations. In our coding manual (see supplemental material D), codes 1 to 23 are rated "yes" (1 point) if the behaviors occurred at all during the conversation; otherwise, they are rated "no" (0 point). A coding team separate from

the BCT coding team will review and code the audio- or video-tapes and transcripts of the conversations. Coders are blind to the session number for the end-of-session conversation and assessment time point (pre or post-treatment) for the Hot Topic task. Each tape or transcript is independently coded by a group of three coders, and then resolve discrepancy through discussion.

### **Treatment Development Process**

The PBC-I components were derived through three parallel phases (for details see Dong, Fine, & Harvey, 2019). Phase 1 involved identifying BCTs to be delivered for parents to use with their adolescent children (for adolescent sleep behavior change) and for therapists to use with parents (for parent conversation behavior change). The treatment development team (LD, EF, AGH), who has expertise in Trans-C and psychological treatment development, met weekly for the first pilot phase of the study to conceptualize behavior change at the parent and adolescent level using the Behaviour Change Wheel framework (Michie et al., 2014; Michie, van Stralen, et al., 2011). On the basis of this, each BCT from the BCT taxonomy (Michie et al., 2013) was evaluated by the treatment development team for inclusion in the PBC-I. Team members first created scenarios of how each BCT could be applicable to the PBC-I, and independently rated each BCT as either high or low in terms of the priority for inclusion in the PBC-I. The team met to discuss and resolve discrepancies. As part of the rating process, the team also identified BCTs that would potentially contribute to conflict and coercion in parent-adolescent conversation (e.g., punishment, remove reward). This process resulted in a list of BCTs for parents to use with their adolescent children to promote sleep change and for therapists to use with parents to promote BCT use respectively (see supplemental material E). This list serves as the basis of drafting the PBC-I manual (see supplemental material F, also available at

<https://doi.org/10.17605/OSF.IO/8U457>). For example, the PBC-I prioritizes teaching parents BCTs related to goals and planning (e.g., problem solving, reviewing behavior goals), feedback and monitoring (e.g., feedback on behavior), social support, restructuring the physical and social environment, rewards, and comparison of outcomes (e.g., pros and cons). Therapists are encouraged to use BCTs such as goals and planning (e.g., problem solving, action planning) repetition and substitution (e.g., behavioral practice/experiment), shaping knowledge (e.g., behavioral experiment, instruction of how to perform behavior), comparison of outcomes (e.g., pros and cons) with parents to promote parent behavior change.

Phase 2 involved a review of literature to identify the communication skills that promote positive parent-child interaction and may support the optimal delivery of BCTs. . Phase 3 involved a review of evaluations of parent and family interventions to consider additional components used to address adolescent problem behaviors. The initial PBC-I contents were tested with a small number of pilot cases ( $N = 12$ ) in an iterative process. Treatment manuals for therapists and handouts for parents (included as a supplemental material and also available at: <https://doi.org/10.17605/OSF.IO/8U457>) were developed on the basis of this work and modified after piloting as needed. PBC-I has two main components. The first component involves BCTs that therapists teach parents to use to promote adolescents' health behavior change as well as BCTs that therapists use with parents to change their behavior (i.e., increase the use of effective BCTs in supporting their adolescent to change health behavior). The second component involves positive communication strategies (e.g., focusing on strengths, use open ended questions, take turns speaking) for parents to use when delivering the BCTs.

The PBC-I consists of six, 50 min sessions. Each session follows a general structure, including agenda setting, homework review, introducing and practicing skills (e.g., specific

BCTs, positive communication strategies), eliciting feedback, setting homework, and end-of-session conversation. Additionally, session 1 includes psychoeducation on the importance of parent involvement and monitoring; session 6 includes deriving a plan to maintain intervention gains. The PBC-I encourages parent coaches to use role-play, behavioral experiments, and behavioral rehearsal techniques to practice using new BCTs combined with positive communication strategies to support the adolescent's behavior change. Homework is assigned weekly for parents to practice skills at home and track their progress.

### **Data Analysis**

The sample size was determined based on feasibility considerations, including the limits of time (2 years) and resources. Data analysis will be completed in Stata 16.0. Data will be double entered if not directly entered by participants. Data will be audited for quality and completeness. Variable distributions will be evaluated to ensure that assumptions of planned analyses are met. For aim 1 (PBC-I development), the results of process evaluation (qualitative data) from the treatment development process will be reported. For aim 2 hypothesis 1 (whether there is pre-post change in outcomes of interest), the main effect of time will be investigated by evaluating pretreatment to post-treatment changes on outcomes of interest, using repeated-measures ANOVA. The outcome variables (each will be tested separately) will be the primary and secondary outcomes listed in Table 1. For aim 2 hypothesis 2 (whether pre-post change in BCT usage predicts pre-post change in other parent and adolescent outcomes), linear regression will be used to examine whether pre-post changes in BCT usage predict pre-post changes in parent conversational behavior, parent-adolescent coercion and conflict, more teen motivation, more youth engagement in sleep-promoting behavior, and improved sleep. We will also test for potential curvilinear relationship between BCT usage and parent conversational behavior and

parent-adolescent coercion and conflict. The independent variables will be the number of BCTs used and types of BCTs used by parent. The outcome variables (each will be tested separately) will be the number of negative and positive communication behaviors, parent and youth perceived general conflict, youth decisional balance proportion, youth self-reported motivation, youth sleep midpoint via sleep-dairy and actigraphy, youth subjective sleep quality, and youth eveningness. For aim 3, exploratory analysis will be conducted to examine the potential indirect effects of BCT usage on improved sleep via improved parent-adolescent conversation. Data visualization and stratified analysis will be used to explore possible effect modification by age and gender of the adolescent and gender of the parent.

### **Discussion**

The current article describes the rationale and development of a parent intervention that aims to promote better sleep by improving parent-adolescent conversations about adolescents' health behavior change. The current article also describes the protocol of an open trial that tests the PBC-I. The premise of this program of research is that parents have a massive impact on their adolescents. Training parents in effective conversation strategies may reduce parent-adolescent conflict and facilitate adolescents' health behavior change. The results of the study will provide preliminary data on whether improved parent-adolescent conversation about health behavior change is a promising mechanism to improve adolescent motivation to change, increase the uptake of sleep-promoting behavior, and improve adolescent sleep.

This research program provides an example of how the experimental medicine approach and recent advances in the science of behavior change can be applied in the development of an intervention, which is in turn tested empirically to further our understanding of the behavioral change mechanisms. Specifically, the PBC-I will be the first application of the behavior change

wheel and the BCT taxonomy in parent-adolescent conversations about adolescents' sleep behavior change. The current article also illustrates how the implementation of the experimental medicine approach embraces open science by preregistration and prespecification of the study protocol. While the current research focuses on parent use of BCTs to promote adolescent sleep changes, future studies could explore whether these BCTs might be generalized for other adolescent health behaviors and how best to help parents transfer skills learned in PBC-I to promote other health behavior change in their adolescent children.

One major limitation of the current study is that the initial version of the PBC-I will be tested in an open trial, without a control group. This decision was made to prioritize the treatment development process given the exploratory nature of this study and the limited time and resources. However, if the results are encouraging, we will propose a randomized controlled trial to establish the efficacy of the intervention. In addition, the current study only assesses direct communication between parent and adolescent. It would be important for future research to also examine indirect communication to fully understand the parent-adolescent communication about adolescent's health behaviors. Future steps of this program of research may include applying the PBC-I contents to address other health behavior changes in adolescents. For example, the active ingredients of the PBC-I (e.g., behavior change techniques and conversation strategies) may be tested to promote a broad range of youth health behavior, such as dental hygiene, diet, and exercise. Given that this project is the first (to our knowledge) to apply the Behavior Change Wheel framework to derive a parent intervention for adolescent behavior change, future research should also determine which BCTs are most effective when used by parents to promote adolescent behavior change.

### **Authors' contributions**

AGH, LD, QZ, and SM conceived of and designed the study and acquired the funding. AGH, LD, EF, AM, CAM, HH, and MT are responsible for the acquisition of data. LD, EF, and AGH are responsible for treatment development. LD, CAM, and HH are responsible for coding. LD and CAM are responsible for data management. LD and AGH drafted the manuscript. LD is responsible for the data analysis and results interpretation. All authors were involved in revising the manuscript. All authors read and approved the final manuscript.

### **Ethics approval and consent to participate**

The University of California, Berkeley, Committee for the Protection of Human Subjects (CPHS) approved the study (protocol 2018-05-11121). Verbal informed consent/assent is obtained from the parent/guardian and the adolescent during the initial eligibility assessment over the telephone. This is followed by written informed consent obtained from the parent/guardian as well as verbal assent from the adolescent at the beginning of the preassessment, which confirms eligibility, by a member of the assessment team. See Supplemental Material. Adverse events and other unintended effects will be report to the CPHS and the NIH, following the rules stipulated by these two oversight bodies. If important protocol modifications are made, these will be reviewed by the CPHS and reported on the trial's ClinicalTrials.gov registration web page.

### **Availability of data and materials**

De-identified data concerning primary and secondary outcomes used in the final data analysis will be available at our Open Science Framework at the end of the trial. Besides this, other than the authors and compliance with data-sharing agreements stipulated by the NIH, no other entities have contractual agreements with regard to access to the final dataset.

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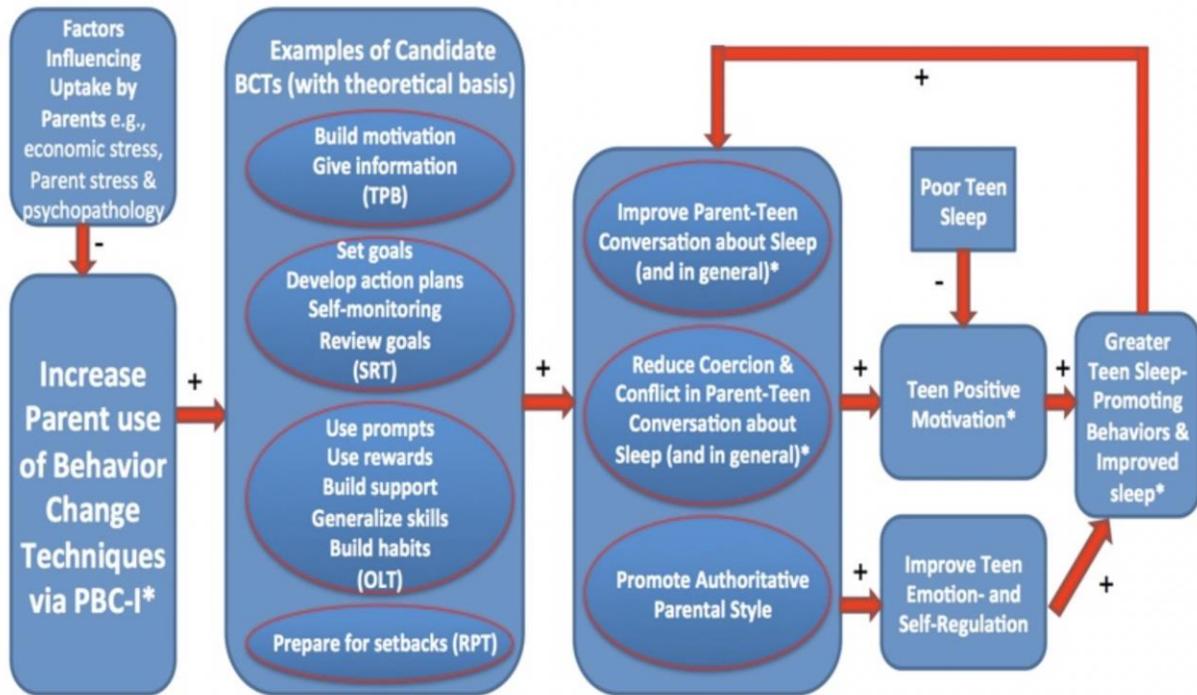
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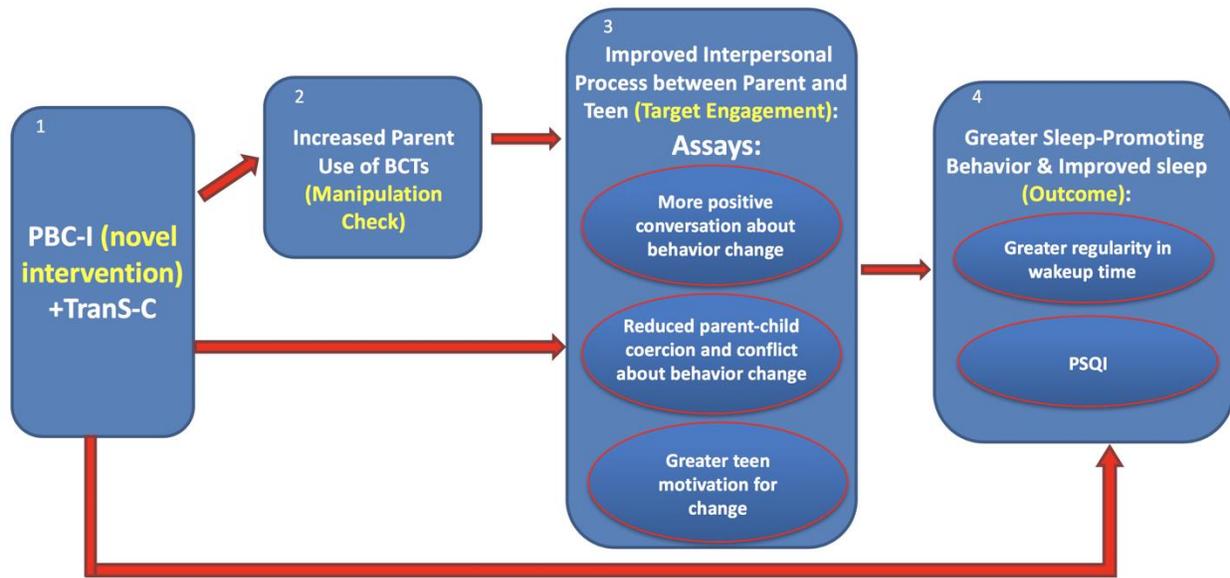
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*Figure 1.* Predicted outcomes of the Parent Behavior Change Intervention (PBC-I) on teen sleep-promoting behavior. \*Denotes the predictions tested in the proposed 2-year trial. BCT = behavior change technique; TPB = theory of planned behavior; SRT = self-regulation theory; OLT = operant learning theory; RPT = relapse prevention theory. Examples of candidate BCTs based on Michie, Hardeman, Fanshawe et al. (2008) (and in general) refer to the Hot Topics Task assessment, which will index the broader impacts, beyond sleep, of the PBC-I.



*Figure 2.* Summary of the experimental medicine approach. PBC-I = Parent Behavior Change Intervention; TranS-C = Transdiagnostic Sleep and Circadian Intervention; BCT = behavior change technique; PSQI = Pittsburgh Sleep Quality Index.

Table 1

*Summary of Primary and Secondary Outcomes*

| Domains                              | Primary outcomes  | Secondary outcomes   |
|--------------------------------------|---|--|
| Parent-adolescent communication      | <ul style="list-style-type: none"> <li>Number of BCTs used by parent coded from the Hot Topics Task (parent)</li> </ul>   | <ul style="list-style-type: none"> <li>Type of BCTs used by parent coded from the Hot Topics Task (parent)</li> <li>Number of negative and positive communication behaviors coded from the Hot Topics Task (parent)</li> </ul> |
| Coercion and conflict questionnaires | <ul style="list-style-type: none"> <li>Parent perception of general conflict between parent and child measured with Conflict Behavior Questionnaire (parent)</li> </ul> | <ul style="list-style-type: none"> <li>Youth's perception of general conflict between parent and child measured with Conflict Behavior Questionnaire (youth)</li> </ul>  |
| Teen motivation questionnaires       | <ul style="list-style-type: none"> <li>Decisional balance proportion measured with Decision Balance Worksheet (youth)</li> </ul>  | <ul style="list-style-type: none"> <li>Youth self-reported motivation for participating in TranS-C and for making sleep behavior changes measured with the Intrinsic Motivation Questionnaire (youth)</li> </ul>               |
| Sleep-promoting behaviors            | N/A   | <ul style="list-style-type: none"> <li>Regularity in sleep midpoint across the week measured with daily sleep diary (youth)</li> <li>Regularity in sleep midpoint across the week measured with actigraphy (youth)</li> </ul>  |
| Sleep and circadian functioning      | <ul style="list-style-type: none"> <li>Subjective sleep quality measured with Pittsburgh Sleep Quality Index global score (youth)</li> </ul>                            | <ul style="list-style-type: none"> <li>Morningness/eveningness preference measured with Children's Morningness-Eveningness Preference Scale (youth)</li> </ul>   |

*Note.* BCT = behavior change technique; TranS-C = Transdiagnostic Sleep and Circadian Intervention; N/A = not applicable.