Inclusivity in insomnia: Adolescents' perspectives on the Sleep Solved app: A qualitative interview study

Sarah E. Bennett, Grace M. Lewis, Stephanie Chambers, Milly H. Johnston, James Denison-Day, Anthony Duffy, Georgia Treneman-Evans, Paula Kuberka, Nicholas Christoforou, Lee M. Ritterband, Robert Meadows, Doaa Alamoudi, Ian Nabney, Lucy Yardley

Submitted to: JMIR mHealth and uHealth
on: August 15, 2025

Table of Contents

Inclusivity in insomnia: Adolescents' perspectives on the Sleep Solved app: A qualitative interview study

Sarah E. Bennett[1] PhD; Grace M. Lewis[2] PhD; Stephanie Chambers[2] MSc; Milly H. Johnston[2] BSc; James Denison-Day[3] PhD; Anthony Duffy[4] MSc; Georgia Treneman-Evans[2] MSc; Paula Kuberka[1] MSc; Nicholas Christoforou[2] LLB; Lee M. Ritterband[5] PhD; Robert Meadows[6] PhD; Doaa Alamoudi[7] PhD; Ian Nabney[8] PhD; Lucy Yardley[1, 3] PhD

[1] School of Psychological Science University of Bristol Bristol GB
[2] Bristol Medical School University of Bristol Bristol GB
[3] School of Psychology University of Southampton Southampton GB
[4]School of Interactive Arts & Technology Digital Health Circle Lab Simon Fraser University British Columbia CA
[5]Department of Psychiatry and Neurobehavioral Sciences Center for Behavioral Health and Technology University of Virginia Health System Charlottesville US
[6] Department of Sociology University of Surrey Guildford GB
[7] Department of Management Science Yanbu Industrial College Yanbu SA
[8] School of Engineering Mathematics and Technology University of Bristol Bristol GB

Corresponding Author:
Sarah E. Bennett PhD

School of Psychological Science
University of Bristol
12A Priory Road
Bristol
GB

Abstract

Background: Adolescent sleep duration can substantially impact mood, behavior, and academic attainment. While hundreds of sleep-related apps are available to download, none have been co-created with adolescents from underserved populations in the UK.

Objective: The aim of this study was to explore adolescents' views, expectations and experiences with a novel app to improve sleep, called Sleep Solved, to understand which features were perceived as positive and helpful, and to identify ways to further enhance its usefulness. Sleep Solved is part of a larger stepped behavior change study and was co-created with adolescents from underserved groups to make the app accessible and engaging for this population.

Methods: Sixty-three participants aged 16-18 from across the UK completed semi-structured interviews after trying the app. Interviews were analyzed using inductive thematic analysis, with a particular focus on the views of individuals from underserved ethnic and socioeconomic groups.

Results: Participants perceived Sleep Solved as a useful tool that provides helpful advice regarding changeable behaviors to improve sleep hygiene. Co-created features of the app, such as the Sleep Stars gamified rewards system and the easy-read, science-based 'sleep hacks', were viewed positively by participants, who reported that it had a beneficial impact on their sleep and sleep schedule. Praise was given for the app's ease of use, and how the science of sleep was explained at an appropriate level, without being overwhelming. Compared to sleep advice on social media platforms, Sleep Solved was considered more reliable and trustworthy. Participants described better sleep hygiene, such as a regular sleep routine and a longer sleep duration, and increased feelings of improved mood and energy.

Conclusions: This study found that a co-created sleep app, designed with input from adolescents in underserved UK populations, was perceived as accessible, reliable, and effective in supporting positive sleep behavior change. Participants, particularly those from low socioeconomic status (SES) backgrounds and diverse ethnicities, reported improved sleep routines and mood, highlighting the potential of co-designed digital tools to engage and benefit adolescent users.

(JMIR Preprints 15/08/2025:82410)

DOI: https://doi.org/10.2196/preprints.82410

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http
No. Please do not make my accepted manuscript PDF available to anyone. I understand that if I later pay to participate in <a href="https:/

Original Manuscript

Original Paper

Corresponding Author: Sarah E. Bennett, PhD

School of Psychological Science

University of Bristol

Bristol BS8 1TU

United Kingdom

Phone: +44 117 455 2009

Email: sarah.bennett@bristol.ac.uk

https://orcid.org/0000-0001-7355-124X

Grace M. Lewis, PhD, School of Psychological Science, University of Bristol, Bristol, United Kingdom. https://orcid.org/0000-0002-5282-2941

Stephanie Chambers, MSc, Bristol Medical School, University of Bristol, Bristol, United Kingdom, https://orcid.org/0009-0006-4934-9256

Milly H. Johnston, BSc, Bristol Medical School, University of Bristol, Bristol, United Kingdom, https://orcid.org/0000-0001-7852-9607

James Denison-Day, PhD, School of Psychology, University of Southampton, Southampton, United Kingdom, https://orcid.org/0000-0003-0223-0005

Anthony Duffy, MSc, Digital Health Circle Lab, School of Interactive Arts & Technology, Simon Fraser University, British Columbia, BC, Canada, https://orcid.org/0000-0002-4769-8819

Georgia Treneman-Evans, MSc, Bristol Medical School, University of Bristol, Bristol, United Kingdom, https://orcid.org/0000-0003-0707-6078

Paula Kuberka, MSc, School of Psychological Science, University of Bristol, Bristol, United Kingdom, https://orcid.org/0009-0006-2181-8057

Nicholas Christoforou, LLB, Bristol Medical School, University of Bristol, Bristol, United Kingdom. https://orcid.org/0009-0000-1912-9216

Lee M. Ritterband, PhD Center for Behavioral Health and Technology, Department of Psychiatry and Neurobehavioral Sciences, University of Virginia Health System, Charlottesville, VA, United States, https://orcid.org/0000-0001-7624-5213

Robert Meadows, PhD, Department of Sociology, University of Surrey, Guildford, United Kingdom. https://orcid.org/0000-0002-9165-1305

Doaa Alamoudi, PhD, Department of Management Science, Yanbu Industrial College, Yanbu, Kingdom of Saudi Arabia, https://orcid.org/0000-0001-6406-9742

Ian Nabney, PhD, School of Engineering Mathematics and Technology, University of Bristol, Bristol, United Kingdom. https://orcid.org/0000-0001-7382-2855

Lucy Yardley, PhD, School of Psychological Science, University of Bristol, Bristol, United Kingdom and School of Psychology, University of Southampton, Southampton, United Kingdom https://orcid.org/0000-0002-3853-883X

Inclusivity in insomnia: Adolescents' perspectives on the *Sleep Solved* app: A qualitative interview study

Abstract

Background: Adolescent sleep duration can substantially impact mood, behavior, and academic attainment. While hundreds of sleep-related apps are available to download, none have been co-created with adolescents from underserved populations in the UK.

Purpose: The aim of this study was to explore adolescents' views, expectations and experiences with a novel app to improve sleep, called Sleep Solved, to understand which features were perceived as positive and helpful, and to identify ways to further enhance its usefulness. Sleep Solved is part of a larger stepped behavior change study and was co-created with adolescents from underserved groups to make the app accessible and engaging for this population.

Methods: Sixty-three participants aged 16-18 from across the UK completed semi-structured interviews after trying the app. Interviews were analyzed using inductive thematic analysis, with a particular focus on the views of individuals from underserved ethnic and socioeconomic groups.

Results: Participants perceived Sleep Solved as a useful tool that provides helpful advice regarding changeable behaviors to improve sleep hygiene. Co-created features of the app, such as the Sleep Stars gamified rewards system and the easy-read, science-based 'sleep hacks', were viewed positively by participants, who reported that it had a beneficial impact on their sleep and sleep schedule. Praise was given for the app's ease of use, and how the science of sleep was explained at an appropriate level, without being overwhelming. Compared to sleep advice on social media platforms, Sleep Solved was considered more reliable and trustworthy. Participants described better sleep hygiene, such as a regular sleep routine and a longer sleep duration, and increased feelings of improved mood and energy.

Conclusions: This study found that a co-created sleep app, designed with input from adolescents in underserved UK populations, was perceived as accessible, reliable, and effective in supporting positive sleep behavior change. Participants, particularly those from low socioeconomic status (SES) backgrounds and diverse ethnicities, reported improved sleep routines and mood, highlighting the potential of co-designed digital tools to engage and benefit adolescent users.

Keywords: behavior change; digital intervention; insomnia; depression; anxiety; sleep; qualitative research; adolescents.

Background

Adolescents in the UK report significant insomnia symptoms, with prevalence rates from 4% [1] to 23.8% [2]. This is a major public health concern as sleep difficulties can lead to poor academic results [3, 4], reduced school attendance [5], and impacts on mood and social and family life [6].

The transition from childhood to adolescence has been described by Carskadon (2011) as a 'perfect storm' of biological, psychological and socio-cultural factors, starting in late childhood, limiting the quantity of sleep that adolescents are able to achieve [7].
Environmental factors such as social pressures, exams and anxiety surrounding academic performance can affect adolescents' sleep [1, 2]. Social pressure, poor social skills and a lack of parental supervision may drive problematic social media use, where adolescents can face peer pressure to stay up late and engage with friends into the early hours of the morning [3-6].

Lower socioeconomic status (SES) has been strongly associated with poorer sleep outcomes in adolescents. In a systematic review, adolescents from low SES families, those on lower incomes or with more indicators of poverty were more likely to develop sleep disorders, including difficulty initiating or maintaining sleep, and were significantly more likely to develop insomnia [7]. Factors such as lower neighborhood safety and greater worries about community violence have been linked to a bigger risk of developing sleep problems in adolescence [8-10], whereas neighborhood contentedness, living in a safer environment or more affluent area, has been associated with a longer sleep duration [9, 11, 12]. Within the home, low SES adolescents may also face difficulties with family overcrowding, a lack of structure or routine, or high levels of sensory stimuli, such as noise, factors which can also lead to poorer sleep quality and increased sleepiness [13, 14].

Research has also shown potential sleep differences across different ethnic groups. White participants have had better sleep outcomes, compared to minority groups. Black, Asian and Hispanic participants tended to have shorter sleep duration, and problems with waking and sleep onset [15]. In a similar study of sleep duration, Black and African American participants reported an average of 15.1 minutes less sleep compared to White participants [16, 17]. Contextual factors, such as ethnicity or SES, will be important elements to consider when examining the effectiveness of any new sleep intervention.

A key factor in the success of any intervention is participant engagement. Having a low SES has been linked to reduced participant engagement with app-based interventions [18], such as mHealth apps that target healthy eating or physical activity [19, 20]. Adolescents with low SES are also at higher risk of poorer physical health behaviors, such as low levels of physical activity, smoking, high-energy food intake and drug misuse, compared to children from families with a higher SES [21-24]. They may have lower English language skills, compared to children with a higher SES [25]. In addition, research has indicated that young people, immigrants, those with a basic education, on a low income, and receiving government benefits are significantly more likely to have poor health literacy and potentially worse health outcomes [26]. Therefore, to mitigate any potential user difficulties with lower literacy levels, lower health literacy and reduced participant engagement, attention to the needs of those from lower SES regions was considered a vital factor in the design and co-creation of Sleep Solved. The app was carefully refined throughout to be at an easy-read level, at an approximate reading age of 9-10 years (Flesch-Kincaid score of 90-100, age 10-11 years old, or a 5th

grade level, as measured by the Readability Scoring System v2.0) [27]. Difficult concepts such as hormone changes or circadian rhythms were explained through simple language and pictures, to reflect different learning styles and improve engagement. Based on PPI feedback and behaviour change theory, a social modelling element was created, where audio clips from users with different regional accents explained how the Sleep Solved app had worked for them [28, 29].

Research has indicated a bidirectional link between sleep difficulties in adolescence, and mental health problems such as anxiety and depression [15]. Adolescents with low SES have been shown to have higher rates of depressive symptoms and medication use and were more likely to receive a mental health diagnosis through adolescence and into adulthood [30]. The highest prevalence of mental health diagnoses has been found in adolescent boys with low SES, whereas adolescent girls of medium to high SES have been shown to have the lowest prevalence [31]. With embarrassment and discomfort potentially acting as a barrier to seeking formal mental health support [16-18], offering accessible sleep hygiene advice to adolescents through mHealth apps and their own smartphones may be a less stigmatizing way to provide support. This is particularly true as an estimated 99% of adolescents in the UK have access to the internet, and 90% of those aged over 11 years own a smartphone [19].

To create relevant and applicable interventions for adolescents that are also engaging, it is vital to involve the perspectives and lived experience of underserved communities in research, including those from low income or minority ethnic families [32, 33]. To ensure that research interventions have the best chance of being effective, a wide variety of different people need to be recruited to take part in research, especially from groups that are not involved in research as often [32, 34]. This also ensures that any findings from the research could be more generalisable to a broader population. While many apps that promise to aid sleep are available to be downloaded, few have been co-created with input from adolescents themselves [35, 36]. Co-creating with the people who will be using them is intended to ensure that the app is relevant, meets their needs, is accessible and engaging, and therefore will be more likely to be used successfully [37].

The purpose of Sleep Solved was to serve as an accessible first step of a stepped program of support. Adolescents shown to have more persistent sleep difficulties, anxiousness or low mood could then be guided toward the extensive support provided by existing apps: Sleep Healthy Using the Internet (SHUTi)[38], Bite Back [39] and Project YES [39]. There are some notable examples of apps co-created with young people, such as the Smile for Life (SMILE) app [35] and Sleep Ninja for adolescents with insomnia [36]. The only example from the UK is Sleep SSI (single session intervention), a one-off intervention co-created with 11 adolescents, based on the Project YES (Youth Empowerment and Support) app [40, 41]. However, none of these sleep apps have been co-created with adolescents from underserved ethnic groups, or from areas of social disadvantage. In addition, only small groups have provided feedback on their user experience. There is a need for all users to recognize people like themselves, and their social and cultural experiences, to engage with, and feel included in an accessible app [42, 43]. The involvement of a wider range of underserved populations in app development is therefore vital.

Person-centered methodologies, or ‘co-approaches’ such as co-production, co-design and co-creation [44] are methods used to bring people together as active and equal partners in research [45]. A principal element in the person-based approach, co-creation involves academics working collaboratively to produce interventions that are relevant and acceptable to stakeholders, perceived

as useful, and are therefore more likely to be adopted in ‘real world’ settings [31]. In this study, the co-creation of the Sleep Solved app by and for adolescents in the UK, using the person-based approach [46], has been published previously [28, 29]. Our prior paper detailed how the app was successfully co-created and optimized in partnership with adolescents, to co-produce an app that was accessible, representative, and easily understood, but without requiring extensive engagement for users to benefit from a range of sleep hygiene advice and support.

The purpose of this paper is to understand users' experiences of the Sleep Solved app while taking part in a large feasibility trial. It was important to explore how the app was perceived, how users engaged with the content, determine which co-created features of the app were enjoyed and considered helpful, and identify ways in which its usefulness might be further improved.

Methods

Study design

This paper explores adolescents (aged 16-18) perspectives of a new, co-created stepped digital intervention to support sleep hygiene behaviors and wellbeing. In-depth qualitative interviews were conducted, focusing particularly on a diverse range of adolescents from across the UK.

Ethical considerations

Ethics approval for the study was granted by the North-West – Greater Manchester Central Research Ethics Committee (Reference: 23/NW/0129). All methods were completed in accordance with applicable guidelines and regulations.

Participant recruitment

Adolescents aged 16-18 were recruited to a non-randomized feasibility trial carried out in collaborations with 33 schools and colleges from across the UK. Participants were invited to participate if they were aged between 16 and 18 and owned a smartphone. Those receiving treatment for insomnia or a diagnosed mental health condition were excluded from the study, as they were receiving treatment. Participating schools and colleges received a ‘welcome pack’ on enrolling in the study, featuring a study poster, digital presentation explaining the study, staff and student information videos, and a document outlining the most effective ways to recruit students. Participants could express their interest in taking part by scanning a QR code, or by following a direct link on the poster, presentation, or videos to the participant information sheet and consent form.

For the interviews, purposive sampling was used to better reach underserved populations in research. All those who had expressed an interest in being interviewed were purposively sampled

based on ethnicity and levels of socioeconomic deprivation.

Data collection

Interview participants provided written consent to take part in a one-on-one interview using televideo software. Participants were allocated a unique identification number, and the data was anonymized, whereby all identifying information was removed. Participants were informed about the purpose of the study, the benefits and possible downsides of participating, the apps, what would be required of them, how their data would be stored, and who was funding the research, and had the opportunity to ask questions. Talking with the research team about the study in a one-to-one interview was entirely optional, and only those who consented to be contacted about an interview, and for the interview to be recorded, were invited to participate. Participants were reminded that they could stop participating at any time, without giving a reason. Names and corresponding identification numbers and consent forms were kept separately and securely on a password protected server. In compensation for their time, interview participants were offered a digital voucher of £40 (approximately US $52.75), which was financed through the study budget.

A semi-structured interview topic guide was used to guide discussions, developed by members of the research team (SB, MJ, GTE, PK, LY and RM). Open-ended questions explored participants' reasons for participating, sleep experiences before, and after trying the apps offered, as well as their knowledge of sleep hygiene advice and any prior experiences of sleep advice. Participants were asked about app use, app content, use of social support, and whether they were likely or not to continue to use the app. To ensure relevance of the questions to adolescents, they were further refined after the first 10 interviews for clarity and to capture any new factors. A relationship with participants was not established prior to the commencement of the study.

Interviews were carried out by televideo between November 2023 and April 2025 by five women members of the research team: Research Fellow Dr Sarah Bennett, PhD; Senior Research Associate Dr Grace Lewis, PhD; Research Associate Ms. Paula Kuberka, MSc; Research Assistant Ms. Stephanie Chambers, MSc and Peer Researcher Ms. Milly H Johnston, BSc. All had prior experience of conducting in-depth qualitative interviews. Interviews were conducted on televideo, enabling participants to see the characteristics of the interviewer. Interviews were recorded, transcribed verbatim and checked for correctness. Data collection concluded at 63 interviews where no additional factors were identified from the data and a rich awareness of the issues raised had been achieved [47].

Data analysis

Qualitative analysis was conducted iteratively by three women members of the research team (SEB, GML, SC) using a pragmatic inductive thematic analysis approach [48]. NVivo 14 was used to manage the data [49]. The codes, which were inductively derived from the data, were combined to form themes, and this process continued until a series of overarching themes or key findings were recognized. Preliminary results and a thematic map were shared and discussed with the wider research team to further refine the themes identified [48]. Data saturation was considered to have

been realized when no further aspects were identified from the data [47]. This was achieved at 55 interviews, and continued to 63 participant interviews, to ensure that no new ideas were introduced. These results have been reported in line with COREQ reporting guidelines (Consolidated Criteria for Reporting Qualitative Research; see Multimedia Appendix) [50].

Results

Overview

A total of 63 participants took part in semi-structured interviews, self-identified gender indicated 44 (69.84%) women, 17 (26.9%) men; (one of whom identified as female to male transgender), 1 (1.58%) “prefer not to say”, 1 (1.58%) “no response”. The mean age of the participants was 16.90 years (range 16-18, SD: 0.75).

Table 1 compares self-defined ethnicity of those interviewed for this study (n=63) to the high-level ethnic groups in England and Wales recorded in the 2021 UK Census [51], indicating a good relative ethnic heterogeneity of participants across those interviewed, compared to national data.

Table 1: Self-defined ethnicity in this sample (n=63), compared to the 2021 UK Census data.

Self-defined ethnicity	Interviewed participants (n=63)	2021 UK Census Data: High-level ethnic groups in England and Wales [51]
White English, Welsh, Scottish, Northern Irish or British	53.96% (34/63)	74.4% (44.4 million)
Asian or Asian British	28.57% (18/63)	9.3% (5.5 million)
Black, Black British, African or Caribbean	4.76% (3/63)	4.0% (2.4 million)
Mixed or multiple ethnic groups	4.76% (3/63)	2.9% (1.7 million)
Other ethnic group	1.58% (1/63)	2.1% (1.3 million)

The mean duration of the interviews was 40.34 minutes (SD: 10.579; minimum 22, maximum 67) minutes. The levels of relative regional deprivation were estimated using contributors’ postcodes against the 2019 English Indices of Deprivation Data [52, 53]. The IMD considers seven subsections of deprivation- income, employment, education, health, crime, access to housing and services, and living environment [53]. The Indices of Deprivation are a measure of deprivation at small local level areas (Lower-layer Super Output Areas: LSOAs). These LSOAs are a standard statistical geography designed to contain a similar population size; approximately 650 households, equating to around 1500 residents [54]. Most of the participants interviewed for this study (45/63, 71.42%) lived in the 50% most deprived regions of the UK. Levels of relative deprivation in our sample varied from 10% of most deprived neighborhoods (11/63, 17.46%), to 10% of the least deprived (2/63, 3.17%).

Three overarching themes are presented below:

1. Reasons for participating and expectations of the Sleep Solved app
2. Experiences of Sleep Solved
3. Perceived benefits of Sleep Solved

1. Reasons for participating and expectations of the Sleep Solved app

The majority of those interviewed described having a poor sleep schedule, such as an erratic sleep pattern, as their reason for taking part. Many cited that they had “nothing to lose” in participating, and that they were willing to "give it a try” to find out if Sleep Solved made any difference to their sleep. Some participants described being told about the Sleep Solved app by friends and classmates, who were taking part in the study too, whereas others were recommended to the app by perceived authority figures, such as college teaching or wellbeing staff.

“I talked to like a member of [Wellbeing] *staff before because I was having a lot of trouble with sleeping and she mentioned it to me…what made me kind of want to use it because she kind of explained everything about it and asked if I wanted to do it. And I thought it would be quite interesting…I have like a regular meeting with her and she mentioned it during one of them.” [006, White, young woman, 17, 40% least deprived]*

“I was referred to the Wellbeing team at my college and I spoke to a woman who mentioned the Sleep study and said that I'd probably be beneficial…As in my case would be helpful…How I can sleep better? How I can stop stressing about sleeping? Like how I can stop worrying about my sleep?... The woman who recommended [Sleep Solved] *to me said that there's a few of the people that tried it and it helped them…it'll give me more of a peace of mind to the fact that I'm not alone in it, and there's more people around the world and even near me, like at college that struggle with it as well.” [038, White, young woman, 18, 30% least deprived].*

The multi-retailer voucher offered to participants was described as “a good incentive” to taking part, as was the fact that the study seemed both “interesting” and trustworthy, as it was based at a university.

Of those interviewed, the majority were unaware of what Sleep Solved could do for them, or the potential benefits. However, some anticipated that the Sleep Solved app would provide them with helpful advice and tips on how to improve their sleep and their sleep hygiene:

“I just I was expecting like an app which it was and be like tips to help me which it was! So yeah, it did meet all my expectations.” [003, White, young woman, 18, 30% least deprived]

“I just wanted... tips and how could get to sleep faster and how I could also have, quality sleep and not just quantity.” [019, Asian or Asian British: Indian, young man, 16, 20% most deprived]

Participants suggested that improved sleep could be achieved through developing a better sleep routine and getting sustained, better-quality sleep. Others described more negative preconceptions that engaging with the app would be a long, drawn-out activity, or that as the study was ‘science-based’ that they would be forced to talk with large groups of people.

"I think I was expecting this long lengthy process where I have to talk with loads of people on a meeting, and be like a science experiment or something! (laughs)… It was a lot easier than I thought it would be...I thought that I'd have to talk to quite a few people, but it's a lot easier than I thought." [014, White, young woman, 18, 20% most deprived]

However, many participants were pleasantly surprised at how easy the app was to use, and the ways that their sleep schedule changed as a result of using Sleep Solved:

"I wasn't expecting anything to be perfectly honest with you. I was like when it says something about sleep, I thought like it's just going to, like improved it for a little bit? I wasn't expecting any like, huge results or anything, but once I got into the study itself, and I actually did what like the app was telling me to do. I was like, surprised by ...how that impacts my sleeping schedule...I was surprised. Yeah, I was amazed!" [013, Asian British (Other), young woman, 18, 40% most deprived]

2. Experiences of Sleep Solved

Participants described the app as quick, accessible, enjoyable, and easy to navigate. They found that the sleep-based science presented and explained in the app was pitched at an appropriate level and was easy to understand, compared to other apps they had tried: "Just the right amount of information…[to] benefit from it, without getting overwhelmed." [038, White British, young woman, 18, 30% least deprived]. Although some participants had feared that the science-based nature of the app might be overwhelming or complicated, many were pleased to find the explanations provided to be simple and easy to understand.

"Perfect the way it is, and it's very simplified. Like, it doesn't go into a long, detailed explanation like a whole paragraph... Easy to understand, wish I … found this sooner. I think it's really simplified. It's just really good and it's helped me massively." [034, White British, young woman, 16, 30% most deprived]

"I thought that would be like a biology lesson, to be honest with you, always frightening. Well... it actually did make sense. And like with the graph, all this kind of stuff, because I thought 'Oh, it's a biology lesson. No thank you!' I would never be able to understand it, but that was very brave. Like, I understood everything." [013, Asian or Asian British: Any other Asian background), young woman, 18, 40% most deprived]

Of our sample, around a quarter of those interviewed had no experience of the sleep advice presented in Sleep Solved before using the app, and often found the advice to be novel, "interesting", and presented in ways they hadn't encountered before.

"I did feel more confident. And like with all the information I learned a few things. Which is nice. I don't think- if I hadn't joined Sleep Solved, I don't think I ever would have got around to doing that. (laughs)" [018, Black, Black British, Caribbean or African: African, young woman, 16, 20% most deprived]

The sleep hygiene advice presented in Sleep Solved was perceived as more trustworthy and "reliable", compared to other sources of information, like social media.

"I felt like it would like I could really connect to it. I could relate to it because, it was like, the tips

and then everything was like kind of tailored to like people my age. I think that was so much better than what I've seen in like social media and stuff" [058, Asian or Asian British: Indian, young woman, 18, 50% least deprived]

"When there's … a 14-year-old on TikTok telling you they're doing this before you go to sleep is going to help. Whereas if it's like a trusted study that shows that actually getting 8 hours of sleep and not using your phone or blue light or anything actually does improve your sleep, it's a lot more easy to identify [as trustworthy]*" [039, Mixed ethnic group: White and Black Caribbean, young woman, 17, 40% least deprived]*

Users found the app enjoyable to use and the content interesting and appealing.

"I thought it was quite interesting. Like I remember like clicking on them like the sleep advice like how to do better sleep...then like just being, like, intrigued by them. And it was just a bit quirky, like just different, you know, like just the quirkiness. And like you don't actually see that often." [004, White, young woman, 17, 30% most deprived]

Participants in this intervention had the option to earn 'Sleep Stars' when using the Sleep Solved app, an optional gamification element co-created with adolescents. Users who tried collecting Sleep Stars during the study described them as a "fun" and appealing challenge and a good incentive for them to keep engaging with Sleep Solved.

"I'm such an easily entertained person. The fact that you can click [a] *star and it turns blue is more than enough for me to do it every day. And so, yeah, I definitely think…It's more of an incentive to do it, rather than just clicking a button that says, 'Yes, I've used the hacks' and going on with my day. " [032, White British, young woman, 18, 30% most deprived]*

Some in our sample explained taking advantage of social support, comparing their scores with friends and setting themselves challenges to improve their sleep.

"I've got 2 gold stars, and I'm working to get my third. I quite like it, it feels like a challenge to sleep well…I quite like that. I'm a very competitive person, so I'm determined to beat all my friends, so I've got making sure I get more stars than they do! We've made it into a little bit of a challenge, almost." [012, White British, young woman, 17, 20% least deprived]

A small number of interviewed participants (9/63, 14.3%, 8 of Asian British ethnicity, 1 of Black British ethnicity) did not engage with Sleep Solved. Reasons for non-engagement included forgetting to use the app, so the inclusion of app notifications and reminders may mitigate some of these barriers to participation in future versions of Sleep Solved. For some, Sleep Solved was less relevant, as they already slept well, but they felt that the app could be useful for those with poor sleep.

"Nothing made me not want to use it…I think it was quite beneficial, but of course it's beneficial for people who like need it, I guess." [037, Asian or Asian British: Pakistani, young woman, 17, 20% most deprived]

Table 2 provides an overview of the content provided in each of the sections of the Sleep Solved app, with selected participant quotes.

Table 2: Sleep Solved app content, and representative quotations from participants.

Sleep Solved content	Description	Selected quotes
App content overall: Science-based learning about sleep	Participants enjoyed the 'science based' information provided by Sleep Solved. They described the scientific elements presented as easy to read and understand, and accessible, compared to more difficult ideas they had encountered in the past.	o *"I mean, they pulled out a lot of science and that made sense, credit to them, they explain the kind of science elements very well. It wasn't … really health jargony. It was very straightforward… and I, I got it."* [030, White British, young woman, 18, 30% most deprived] o *"Having the 'why' right next to the to the solution was nice…Because, like people would say, 'Don't use caffeine before bed'…And I'd say, 'But why though?' …So, then I wouldn't listen because I'm like, 'Well, you didn't know what you're talking about. So why should I listen?' But with the app, it definitely sounded like the tips knew what they were saying, because there was the reason."* [013, Asian British (Other), young woman, 18, 40% most deprived]
Sleep hack: "How can less time in bed help me sleep better?"	The 'spending less time in bed to sleep better' hack explained the 'three kinds of sleep' (deep sleep, dreaming sleep, light sleep), recommended that participants spent less time in bed in order to sleep, using their bed for sleeping, rather than for being on their phone, planning for the next day, or eating. Participants agreed that this made sense, and that the hack had been an easy change to make. Needing 5-6 hours of deep or dreaming sleep to sleep well also made sense as a target.	o *"At first I was like, 'That feels a bit counter-intuitive' and my skeptical brain kicked in, but then I remember like it was about like cortisol levels and like, training your brain that you bed is a place to sleep and not do other things, which I was like, 'OK, that makes sense'."* [018, Black, Black British, Caribbean or African: African, young woman, 16, 20% most deprived] o *"Of all the hacks…that has been my godsend …not crawling into bed to sit on my phone. I'll do anything. I've been sitting on my desk more and I think it's made it a lot easier for me to actually fall asleep. That's definitely my fave hack."* [012, White, young woman, 17,

		20% least deprived]
Sleep hack: "Why could sleeping in make me feel bad?"	**Cortisol:** Facts about sleep hormones, including the 'get up and go' hormone 'cortisol' which helps you to feel alert, including how getting up at the same time every day trains the brain to release cortisol at the 'right' time. Participants understood the links between changes in their sleep schedule, and later feelings of hunger, overeating or low mood to be related to cortisol. The page was described as easy to understand, with praise for the simple graph and easy-read science.	o *"It was a good explanation. It kind of made sense, cause when I wake up later, a lot of the time I feel worse. Yeah. So, it's part of the reason why I've been trying to wake up more consistently earlier… I knew about the effects of it, but I didn't know that was linked with cortisol."* [008, White, young woman, 18, 50% most deprived] o *"That's quite a good visual representation of it. …with the graphs, like, it does kind of captivate you a bit and make you want to kind of look at it more…[a] visual aid can just make it more like interesting to read because you'll see something… like with graphs and things and you just want to read what it's about."* [028, White British, young woman, 17, 30% most deprived]
	Is it OK to nap when I'm tired? Participants were advised to only nap before 3pm, keeping the curtains open, and limiting their napping to 20 minutes or less. Many had not heard this advice before, using this as an opportunity to either reduce the amount of time they were napping for, or to stop napping during the day entirely, due to their newfound awareness of the effect on their sleep later in the evening. For others, this advice was less relevant as they did not nap during the day.	o *"I thought it was actually really good because for me I sometimes accidentally take naps like I'm just sitting and I slowly start slipping away into the sleep. And I didn't realize… So, when I go to bed later, I'm not able to go to sleep. I forgot to mention that cause I stopped napping altogether because I felt like it wasn't helpful… when I did nap earlier in the day, I don't even know what times I would nap, I just felt like no matter when I slept, I could never sleep better at night."* [018, Black, Black British, Caribbean or African: African, young woman, 16, 20% most deprived]
Sleep Hack: "How can I stop worrying in bed?"	**Getting up after 20 minutes if unable to sleep**: Many described a range of activities they had tried when using this sleep hack, including getting warm drinks, reading books or craft activities.	o *"The advice did work quite a bit cause I used* [to] *like walk downstairs and sit on the sofa, spend time with my family, and that then went up to bed. It did work. I got to sleep a lot quicker than normal."* [020, White British, young man, 17, 10% most deprived]

	For some, leaving their bed was too much of a challenge, whereas others were concerned about waking up family members or pets in the house. They described limiting activities to their bedroom, rather than going downstairs to avoid disturbing others.	o *"Yeah, because I don't want to wake up anyone else in the house… not if I've got on my phone. But if I start walking through the house and stuff. Get something to eat or drink… if I wake the dog then he'll start being annoying to my parents."* [005, White, young woman, 16, 10% least deprived]
Training your brain to be calm: Military sleep hack, relaxing music and sounds	The 'Military Sleep Hack' encouraged progressive muscle relaxation "*tensing and then relaxing every muscle in your body really does help you fall asleep*" and relaxing music in order to get to sleep more easily.	o " [The Military Sleep Hack] *I've definitely been using at least four times a week now to go to sleep, if not more… I'm just able to relax and I just go to sleep after that, like within minutes, which is really nice. And I do realize how useful it was until I've tried it…it definitely relaxes my body really fast and really nicely.*" [056, White: Any other White Background, young man, 17, 10% most deprived]

Suggestions by participants to improve usability and engagement with Sleep Solved included widening the current age range (14-18 years) to include older and younger participants, as people can experience sleep problems at any age.

"Doesn't matter what your age is, you can suffer from poor sleep. So, like, a little toddler could suffer from poor sleep, old women could suffer from sleep? And I think, like, it should be promoted more because there is a lot of people in the world who do, like, suffer from sleep [problems]. *So, if the app is made, the app could help them more than, like, usual tips I guess." [021, Asian or Asian British: Pakistani, young woman, 17, 10% most deprived]*

A minority of those interviewed suggested improving the notifications and reminders that participants received to re-engage with the app, as forgetting to use and engage with Sleep Solved was listed as one of the most common reasons for not using the app while being enrolled in the study.

"I tried to do the one week challenge, but yeah I didn't get any notifications from the app… you know, Duolingo, they've got like a fairly interactive user interface. And then the reminders are very like fun…I think that could motivate me to open… the app and do more stuff as well" [025, Asian or Asian British: Any other Asian background, young woman, 17, 30% most deprived]

Ideas for the gamification elements within the app included adding high scores, and a leaderboard, to add an element of competition.

"I know it may be very effective, like if I was in a competition with someone else? Oh my God! I would- I would be sleeping at 8:00 PM every single day! Yeah, I would do that…making it competitive, more competitive would be nice, because that's how I play… I'm just so competitive and just get so stressed if I don't win. So obviously if I was playing with the Sleep Solved study, I would be sleeping not at 8:00 PM at 6:00 PM!" [013, Asian or Asian British: Any other Asian background, young woman, 18, 40% most deprived]

3. Perceived benefits of Sleep Solved

Participants in the study, most of whom were from low SES groups and underserved populations, described feelings of improved mood and energy, potentially as a result of improving their sleep schedule, while others described feeling more relaxed.

"I didn't [think sleep was important] *until I started sleeping more. And now I do 100%. More happy, more energetic and just more, just more energetic really. Happier…A lot more happier." [034, White British, young man, 16, 40% most deprived]*

"I kind of have like been in a higher mood. Than before I start [Sleep Solved]." *[051, Asian British, young woman, 16, 20% most deprived]*

Some in our sample spoke about how they were now more productive in the mornings. Compared to their poor sleep before using Sleep Solved, they are now able to have a calmer start to their morning, setting them up for the day ahead with less stress, worry and anxiety.

"I'll make myself some breakfast ... for the rest of the day. I feel so much better. That I've had a drink and I've had something to eat. And I've like had time to get ready instead of rushing, which then stresses me out... I just feel a lot calmer" [037, Asian or Asian British: Pakistani, young woman, 17, 20% most deprived]

Sleep Solved was described as a useful "tool", formula or "recipe" to help with sleep, with most of these interviewees, being from the 10-50% most deprived regions of the UK. To remind themselves of the sleep behaviors, users described checking back in with the app occasionally to prompt themselves, or during periods when they have difficulty sleeping. Others relied upon the sleep hacks to guide them during periods where they were not sleeping as well:

"I think I will, if I feel like I've forgotten how to help my sleep. At the moment I do think I've like, I've got it tracked, like I have the recipe for good sleep because I haven't had a bad sleep in a while, … I have the recipe down for a good sleep. Obviously when I go to university … I probably use Sleep Solved again to help me figure out what routine would help." [018, Black, Black British, Caribbean or African: African, Woman, 16, 20% most deprived]

Since trying the Sleep Solved hacks, interview participants from the most deprived areas of the UK described achieving a more regular sleep routine, feeling less tired, waking at the same time every day and described perceptions of deeper sleep. Many had dramatically improved the amount they were sleeping each night, from as little as 3 to 5 hours of sleep per night, to 7 to 9 hours of sleep each night, after using the Sleep Solved app.

"Using the Sleep Solved hacks. That has helped me…when I usually get up to about five hours of sleep I'm normally getting now say about 7 hours… I've been sleeping for a lot longer than

normal…Because if I use [Sleep Solved], *it'll benefit my sleep and like, help me get better sleeping instead of like a couple of hours"[020, White British, young man, 17, 10% most deprived]*

For one participant with chronic back pain and arthritis, the change in his sleep had been particularly remarkable, with prescriptions for sleep medication no longer necessary since using Sleep Solved:

"There was a massive difference. I was sleeping for three hours before. And I slept for 9 hours last night. I would say [I'm sleeping more than 9 hours] *mostly every night now. Now I've gone back to* [my doctor], *and said that there's been a bigger change, and they no longer see* [sleep medication as] *necessary. He said it's a massive increase, which could ultimately help my back* [pain] *with more rest." [035, White British, young man, 16, 30% most deprived]*

When asked, the majority of those interviewed were keen to continue to use Sleep Solved going forward, whereas others had shared the sleep hacks with friends and other members of their family who had difficulty sleeping.

"I've told my mum more, kind of about it than anyone else, but she thought [Sleep Solved] *was like quite interesting and cool because I was showing her all of it. And then I kind of talk to her about it, like in the morning when I have to, like, pick what you want… she thinks it's like, really good and kind of interesting because, I mean, she sometimes struggles sleep as well. So I was gonna, like, recommend us some of the hacks to her." [006, White British, young woman, 17, 40% least deprived]*

"So I've mentioned it to four friends, five? and from that I think, two, three of my friends have decided to join the study now…. Yeah, it's cause I've seen good effects from [Sleep Solved]. *So I was like, why not? Whenever I see good effects from something or I really enjoy it, I usually recommend it to my friends. And because I'm like, pretty nice and trustworthy person, they listen to me… if they can't get the app, or they just don't want to for some reason, I'm able to advise from my perspective for what I've seen, it works, or I think might work for them nicely." [056, White: Any other White background, young man, 17, 10% most deprived]*

Discussion

This paper aimed to explore adolescents' views, expectations and experiences of Sleep Solved, with a particular focus on members of the underserved populations that it was intended to benefit. The positive experiences of and engagement with Sleep Solved described by this sample of adolescent participants were encouraging, and many reported substantial benefits for their mood and sleep The methods recommended in the sleep hacks, including regular sleep and wake times [55], getting up after 20 minutes if unable to sleep (thereby reducing the amount of time spent in bed) [56], progressive muscle relaxation [57, 58] and mindfulness meditation [59] are all evidence-based sleep behavior change techniques that have been successfully used in adult populations. From these results, it is clear that Sleep Solved has the potential to be effective in adolescent, underserved and low SES populations.

Low SES has been linked to significantly poorer user engagement with mHealth apps, including those that target health behaviours [18-20]. The majority of those interviewed from low SES or underserved groups joined as they experienced poor or irregular sleep. As some had not heard of Sleep Solved, or its potential benefits, they were motivated to take part by recommendations from close friends or college staff. The need for trusted authority figures to refer those who may need it to the Sleep Solved app is an important finding, as adolescents experiencing poor sleep or mental health may not always be aware of supportive interventions, or seek them out themselves [60, 61]. People are substantially more likely to engage in a digital health intervention when it is recommended to them by a recognized authority figure, such as a trusted friend, health professional or the government [62-64]. Considering this, and the need for underserved and low SES adolescents to be well supported into the intervention, future referral pathways for Sleep Solved would benefit from being promoted by an authority figure or trusted peer. Research has shown that participants who hold positive expectations about an m-health intervention are more likely to find the intervention effective and engage more in using the app [65]. Therefore, the need for the potential benefits of Sleep Solved to be framed positively will be crucial for any future roll out.

Overall, the challenges faced by participants from low SES and underserved populations, such as the potential for low literacy levels, lower English language skills, a poor reading comprehension or low health literacy, were well met by the Sleep Solved app. Participants appreciated the accessible, science-based information provided by Sleep Solved, with praise for its readability and ease of understanding. Great care was taken to make Sleep Solved as accessible as possible to users from underserved groups, particularly those with lower literacy levels, and lower health literacy [28, 29]. Similar research with underserved groups has found that users with low literacy skills can struggle to understand some of the language used in online interventions, even text perceived as ‘simple’ by the research team [66] highlighting the need for effective co-production at all stages of the research project [28, 29]. These efforts to make the app more inclusive, understandable, and easy to use have the added benefit of improving the usability of the app for all participants, not just those who may have difficulties with reading or understanding [66].

The ‘sleep hacks’ provided by Sleep Solved were seen as being more legitimate and trustworthy than sleep advice they had seen on social media platforms. How adolescents trust health information on social media can be complex [67, 68], with many placing more belief in health-related information from legitimate websites, compared to social media or networking sites [68]. Participants in this study also spoke of learning about sleep and sleep-related advice on social media platforms. The quality of health-related information on social media apps used by adolescents in this study has been found to be low [69, 70]. As promotional materials for the study made clear that it was being conducted as university research, this may have influenced participants’ positive perceptions of the Sleep Solved app. The advice in Sleep Solved might have therefore been seen as more trustworthy [60], removing the need for users to continuously appraise and monitor the accuracy, relevance and credibility of the information presented to them.

Gamification, the chance to collect Sleep Stars when using Sleep Solved was also a popular motivating feature of the app, encouraging friendly competition between users. This is similar to prior sleep app research. For example, adolescents using the Sleep Ninja app can work towards a black belt in sleep at the end of a six-week programme [61], whereas users who meet their sleep

and wake up time goals in the Sleep Town app could collect a variety of buildings and coins [62]. Engaging in gamification can enhance feelings of reward and accomplishment when achieving a target behavior, such as keeping to a regular sleep schedule [62, 63]. Social relatedness is also an important factor in popular sleep hygiene game designs, such as the use of friending, social prodding and group quests [71]. While social relatedness was not employed directly as a game design feature in Sleep Solved, interviewed participants spoke of a degree of social competitiveness, and requested for leaderboard, and the ability to form friendship groups in future iterations of the app. In addition, adolescents have previously expressed a preference for gamified elements; self-tracking behaviors that reward progress towards their goals, increasing their motivation to engage with the app and regularly track their progress [64].

Changes to behavior and health, like those promoted by our Sleep Solved co-created sleep intervention, can potentially lead to 'ripple effects': outcomes relating to the intervention that were not an explicit goal of the intervention, but that can have a positive impact [72, 73]. These positive ripple effects can extend beyond participants themselves, to their familial and social domains [72-75]. In addition to their own use of Sleep Solved, participants spoke of sharing the app, and the sleep advice contained, with others who had difficulties sleeping, such as family members or friends. This included social connections who would not have met the initial age range (14-18 years) or inclusion criteria for the study. As numerous participants had observed helpful effects from Sleep Solved, they described sharing the app with others who they felt could benefit from getting better sleep, and from following the sleep hacks recommended in the programme. These findings mirror participants' recommendations to widen the availability of Sleep Solved, from being available to 14–18-year-olds, to older and younger participants. Other apps that address maladaptive sleep behaviors, such as Sleep Healthy Using the Internet (SHUTi), have been successfully co-created and culturally tailored to be inclusive and relevant to a range of demographic groups, including American adults [38], Black women [76] and those with caring responsibilities [77], to older adults [77] and adolescents in the UK [28].

Limitations

Although this study took great care to purposively sample adolescents from a variety of ages, genders, ethnicities and levels of socioeconomic deprivation, our findings will not be reflective of all UK adolescents' experiences. Although we purposively sampled interviewees who had not engaged with the app, people who had more positive experiences and views of the app will have been more likely to agree to be interviewed. For this reason, while the encouraging views expressed by many of our interviewees provide an indication of the benefits it can provide, particularly for adolescents from underserved and low SES populations, these findings cannot be used to estimate the likely benefits at a population level.

Future work

Many participants expressed a desire to continue using Sleep Solved in the future, even beyond the end of this research study. User enthusiasm for the Sleep Solved app, and participants reporting positive promotion of Sleep Solved to friends and family members, was an unexpected but encouraging finding. Future iterations of Sleep Solved could potentially be tailored to different age ranges, such as versions for children, young adults, or older adults.

Conclusions

This study of Sleep Solved and wider Sleep Well intervention has shown promising results in varied range of underserved and ethnically diverse adolescents with sleep difficulties from across the UK. Sleep Solved was perceived as easy to use with interesting and appealing content that was easy to read and understand for users with lower literacy or health literacy.

Co-created features of the app, including the science-based sleep hacks and Sleep Stars gamified rewards system were well liked by participants, enabling them to better understand the science behind the recommendations and track their progress towards their goals. Participants may require the encouragement of authority figures to take part in Sleep Well, as they may not be aware of or seek out support for their sleep or mental health difficulties. The potential benefits and helpfulness of the app will need to be highlighted for any future roll out, in order for participants to form positive expectations about Sleep Solved. Future work, adapting the Sleep Solved app to different age ranges or cultures might extend the usefulness of the app.

Acknowledgements

The authors would like to thankfully acknowledge the support of our partner schools and colleges across the UK in the recruitment of participants to the Sleep Well Study. The authors also gratefully acknowledge the support of our partners in the recruitment of PPI contributors, namely; The Association of Colleges, E-Act Multi-academy Trust, the McPin Foundation, Bristol Young People's Advisory Group and Off the Record, Bristol. The authors wish to appreciatively acknowledge the work of PIP Creative in the graphic design development of the Sleep Solved intervention. Finally, the authors are very grateful to the funders of this research, The Prudence Trust.

Conflicts of Interest

LR reports having equity ownership in BeHealth Solutions, LLC, who originally licensed the Sleep Healthy Using the Internet (SHUTi) program from the University of Virginia. Somryst, a commercial prescription digital therapeutic for insomnia, was developed based on the SHUTi program by Pear Therapeutics, who subsequently sold their license to Nox Health. Nox Health has a royalty agreement with BeHealth Solutions, LLC and the UVA Licensing and Venture Group. LR is a consultant of Nox Health. The terms of this arrangement have been reviewed and approved by the University of Virginia in accordance with its conflict of interest policy.

Abbreviations

CBT: cognitive behavioural therapy
COREQ: Consolidated Criteria for Reporting Qualitative Research
iCBT: internet-based cognitive-behavioural therapy
LSOA: Lower-layer Super Output Area
PBA: Person-based approach
PPI: patient and public involvement
SES: Socioeconomic Status

SHUTi: Sleep Healthy Using the Internet
SMILE: Smile for Life
SSI: single session intervention
YES: Youth Empowerment and Support

References

1. Dewald, J.F., et al., *Adolescents' sleep in low-stress and high-stress (exam) times: a prospective quasi-experiment.* Behav Sleep Med, 2014. **12**(6): p. 493-506.
2. Tonetti, L., et al., *Effects of sleep timing, sleep quality and sleep duration on school achievement in adolescents.* Sleep Medicine, 2015. **16**(8): p. 936-940.
3. Leijse, M.M.L., I.M. Koning, and R.J.J.M. van den Eijnden, *The influence of parents and peers on adolescents' problematic social media use revealed.* Computers in Human Behavior, 2023. **143**: p. 107705.
4. Montag, C., et al., *Problematic social media use in childhood and adolescence.* Addictive Behaviors, 2024. **153**: p. 107980.
5. Yin, L., et al., *Social networking sites addiction and FoMO: The mediating role of envy and the moderating role of need to belong.* Current Psychology : A Journal for Diverse Perspectives on Diverse Psychological Issues, 2019. **40**(8): p. 3879-3887.
6. Latif, K., et al., *Social comparison as a double-edged sword on social media: The role of envy type and online social identity.* Telematics and Informatics, 2021. **56**: p. 101470.
7. Felden, É.P.G., et al., *Sono em adolescentes de diferentes níveis socioeconômicos: revisão sistemática.* Revista Paulista de Pediatria, 2015. **33**(4): p. 467-473.
8. Zeringue, M.M., et al., *Neighborhood environment and adolescent sleep: The role of family socioeconomic status.* Sleep Medicine, 2023. **109**: p. 40-49.
9. Mayne, S.L., et al., *Neighborhood environments and sleep among children and adolescents: A systematic review.* Sleep Med Rev, 2021. **57**: p. 101465.
10. Bagley, E.J., et al., *Community violence concerns and adolescent sleep.* Sleep Health, 2016. **2**(1): p. 57-62.
11. Neally, S.J., et al., *Understanding the Association Between Neighborhoods and Adolescent Sleep: Evidence from Add Health.* Sleep Epidemiol, 2024. **4**.
12. Troxel, W.M., et al., *Examination of neighborhood disadvantage and sleep in a multi-ethnic cohort of adolescents.* Health & Place, 2017. **45**: p. 39-45.
13. Philbrook, L.E., J.A. Buckhalt, and M. El-Sheikh, *Community violence concerns and adolescent sleep: Physiological regulation and race as moderators.* Journal of Sleep Research, 2020. **29**(3).
14. Feng, X., et al., *Impact of Residential Green Space on Sleep Quality and Sufficiency in Children and Adolescents Residing in Australia and Germany.* Int J Environ Res Public Health, 2020. **17**(13).
15. Guglielmo, D., et al., *Racial/ethnic sleep disparities in US school-aged children and adolescents: a review of the literature.* Sleep Health, 2018. **4**(1): p. 68-80.
16. Ruiter, M.E., et al., *Normal sleep in African-Americans and Caucasian-Americans: A meta-analysis.* Sleep Med, 2011. **12**(3): p. 209-14.
17. Grandner, M.A., et al., *Sleep disparity, race/ethnicity, and socioeconomic position.* Sleep Med, 2016. **18**: p. 7-18.
18. Berry, V., et al., *Does Social and Economic Disadvantage Predict Lower Engagement with Parenting Interventions? An Integrative Analysis Using Individual Participant Data.* Prevention Science, 2023. **24**(8): p. 1447-1458.
19. Nuijten, R., et al., *Pilot Evaluation of the Impact of Lottery-Based Incentives on Engagement Levels of Male Low SES Vocational Students With an mHealth App.* Front Digit Health, 2021. **3**: p. 748588.

20. Scott, H.C., C. Craddock, and L. Craig, *What features of a nutrition resource are important to adolescents of a low socioeconomic status?* Public Health Nutr, 2020. **23**(10): p. 1716-1725.
21. Gautam, N., et al., *Socioeconomic status and health behavior in children and adolescents: a systematic literature review.* Frontiers in Public Health, 2023. **Volume 11 - 2023**.
22. Egan, L., et al., *Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers.* Health Promot Int, 2024. **39**(6).
23. Duncan, L.G. and P.H. Seymour, *Socio-economic differences in foundation-level literacy.* Br J Psychol, 2000. **91 (Pt 2)**: p. 145-66.
24. Bonifacci, P., et al., *Literacy Acquisition Trajectories in Bilingual Language Minority Children and Monolingual Peers with Similar or Different SES: A Three-Year Longitudinal Study.* Brain Sci, 2022. **12**(5).
25. Hoff, E., *Interpreting the early language trajectories of children from low-SES and language minority homes: implications for closing achievement gaps.* Dev Psychol, 2013. **49**(1): p. 4-14.
26. Svendsen, M.T., et al., *Associations of health literacy with socioeconomic position, health risk behavior, and health status: a large national population-based survey among Danish adults.* BMC Public Health, 2020. **20**(1): p. 565.
27. Scott, B. *Readability Scoring System v2.0*. 2023 [cited 2023 15th November]; The Readability Scoring System v2.0, which lets users score their text online using 9 popular readability formulas.]. Available from: https://readabilityformulas.com/readability-scoring-system.php.
28. Bennett, S.E., et al., *Using the Person-Based Approach to Co-Create and Optimize an App-Based Intervention to Support Better Sleep for Adolescents in the United Kingdom: Mixed Methods Study.* JMIR Hum Factors, 2024. **11**: p. e63341.
29. Duffy, A., et al., *Crowdsourcing Remote Co-design Towards Improving the Validity and Reliability of mHealth Application Development – A Case Study on Sleep Solved: A mHealth App Designed Virtually with Teens.* EAI Endorsed Transactions of Pervasive Health and Technology, 2025. **11**.
30. Sørensen, C.L.B., et al., *Developmental trajectories in mental health through adolescence and adulthood: does socio-economic status matter?* Epidemiol Psychiatr Sci, 2025. **34**: p. e33.
31. Mar, J., et al., *Socioeconomic and gender inequalities in mental disorders among adolescents and young adults.* Span J Psychiatry Ment Health, 2024. **17**(2): p. 95-102.
32. Denford, S., et al., *Engagement in rapid public health research among young people from underserved communities: maximising opportunities and overcoming barriers.* BMC Public Health, 2024. **24**(1): p. 2217.
33. Khan, N., et al., *Diversity, community engagement and co-design in research: a rapid review.* BMJ Leader, 2024: p. leader-2024-001046.
34. Bonevski, B., et al., *Reaching the hard-to-reach: a systematic review of strategies for improving health and medical research with socially disadvantaged groups.* BMC Med Res Methodol, 2014. **14**: p. 42.
35. Cormier, M., et al., *Sleep well, worry less: A co-design study for the development of the SMILE app.* DIGITAL HEALTH, 2024. **10**: p. 20552076241283242.
36. Werner-Seidler, A., et al., *A Smartphone App for Adolescents With Sleep Disturbance: Development of the Sleep Ninja.* JMIR Ment Health, 2017. **4**(3): p. e28.
37. Yardley, L., et al. *The person-based approach to enhancing the acceptability and feasibility of interventions*. Pilot and Feasibility Studies, 2015. **1**, 1-7 DOI: 10.1186/s40814-015-0033-z.
38. Ritterband, L.M., et al., *Efficacy of an Internet-Based Behavioral Intervention for Adults with Insomnia*. Archives of general psychiatry, 2009. **66**(7): p. 692-698.

39. Manicavasagar, V., et al., *Feasibility and Effectiveness of a Web-Based Positive Psychology Program for Youth Mental Health: Randomized Controlled Trial.* J Med Internet Res, 2014. **16**(6): p. e140.
40. Schleider, J.L., et al., *Acceptability and Utility of an Open-Access, Online Single-Session Intervention Platform for Adolescent Mental Health.* JMIR Ment Health, 2020. **7**(6): p. e20513.
41. Maity, A., et al., *How do adolescents experience a newly developed Online Single Session Sleep Intervention? A Think-Aloud Study.* Clin Child Psychol Psychiatry, 2024. **29**(3): p. 1137-1158.
42. Quesenbery, W. and D. Szuc, *3 - Culture and UX*, in *Global UX*, W. Quesenbery and D. Szuc, Editors. 2012, Morgan Kaufmann: Boston. p. 33-53.
43. Moura, F.T., N. Singh, and W. Chun, *The influence of culture in website design and users' perceptions: Three systematic reviews.* Journal of Electronic Commerce Research, 2016. **17**(4): p. 312-339.
44. Cowdell, F., et al., *How and how well have older people been engaged in healthcare intervention design, development or delivery using co-methodologies: A scoping review with narrative summary.* Health & Social Care in the Community, 2022. **30**(2): p. 776-798.
45. Grindell, C., et al., *The use of co-production, co-design and co-creation to mobilise knowledge in the management of health conditions: a systematic review.* BMC Health Services Research, 2022. **22**(1): p. 877.
46. Yardley, L., et al., *The Person-Based Approach to Intervention Development: Application to Digital Health-Related Behavior Change Interventions.* J Med Internet Res, 2015. **17**(1): p. e30.
47. Hennink, M.M., B.N. Kaiser, and V.C. Marconi, *Code Saturation Versus Meaning Saturation: How Many Interviews Are Enough?* Qualitative health research, 2017. **27**(4): p. 591-608.
48. Braun, V. and V. Clarke, *Using thematic analysis in psychology.* Qualitative Research in Psychology, 2006. **3**(2): p. 77-101.
49. Lumivero. *NVivo (Version 14)*. 2023; Available from: www.lumivero.com.
50. Tong, A., P. Sainsbury, and J. Craig, *Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups.* International Journal for Quality in Health Care, 2007. **19**(6): p. 349-357.
51. Office for National Statistics (ONS). *Ethnic group, England and Wales: Census 2021*. 2022; Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/ethnicity/bulletins/ethnicgroupenglandandwales/census2021.
52. Ministry of Housing Communities & Local Government. *National Statistics: English indices of deprivation 2019* 2019; Available from: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019.
53. McLennan, D., et al., *The English Indices of Deprivation 2019 : Technical Report.* , in *Guidance*. 2019, Ministry of Housing, Communities and Local Government: London.
54. *The English Indices of Deprivation 2019 : Frequently Asked Questions*, in *Guidance*, C.a.L.G. Ministry of Housing, Editor. 2019, Ministry of Housing, Communities and Local Government: London.
55. Chaput, J.P., et al., *Sleep timing, sleep consistency, and health in adults: a systematic review.* Appl Physiol Nutr Metab, 2020. **45**(10 (Suppl. 2)): p. S232-s247.
56. Spielman, A.J., P. Saskin, and M.J. Thorpy, *Treatment of chronic insomnia by restriction of time in bed.* Sleep, 1987. **10**(1): p. 45-56.
57. Jacobson, E., *Progressive Relaxation*. 1938, Chicago, IL: University of Chicago Press.
58. Toussaint, L., et al., *Effectiveness of Progressive Muscle Relaxation, Deep Breathing, and Guided Imagery in Promoting Psychological and Physiological States of Relaxation.* Evid

Based Complement Alternat Med, 2021. **2021**: p. 5924040.
59. Ong, J. and D. Sholtes, *A mindfulness-based approach to the treatment of insomnia.* J Clin Psychol, 2010. **66**(11): p. 1175-84.
60. Law, S.F. and A.T. and Le, *A systematic review of empirical studies on trust between universities and society.* Journal of Higher Education Policy and Management, 2023. **45**(4): p. 393-408.
61. Werner-Seidler, A., et al., *Pilot evaluation of the Sleep Ninja: a smartphone application for adolescent insomnia symptoms.* BMJ open, 2019. **9**(5): p. e026502.
62. You, Y., *The gamification of sleep : a case study on user engagement with SleepTown in everyday(night) life*, in *Media and Communication Studies; Department of Communication and Media*. 2020, Lund University.
63. Nour, M.M., A.S. Rouf, and M. Allman-Farinelli, *Exploring young adult perspectives on the use of gamification and social media in a smartphone platform for improving vegetable intake.* Appetite, 2018. **120**: p. 547-556.
64. Beltzer, M.L., et al., *Mental Health Self-Tracking Preferences of Young Adults With Depression and Anxiety Not Engaged in Treatment: Qualitative Analysis.* JMIR Form Res, 2023. **7**: p. e48152.
65. Skvortsova, A., et al., *Increasing the Effectiveness of a Physical Activity Smartphone Intervention With Positive Suggestions: Randomized Controlled Trial.* J Med Internet Res, 2022. **24**(3): p. e32130.
66. Lee, E.W., R.F. McCloud, and K. Viswanath, *Designing Effective eHealth Interventions for Underserved Groups: Five Lessons From a Decade of eHealth Intervention Design and Deployment.* J Med Internet Res, 2022. **24**(1): p. e25419.
67. Freeman, J.L., P.H.Y. Caldwell, and K.M. Scott, *How Adolescents Trust Health Information on Social Media: A Systematic Review.* Academic Pediatrics, 2023. **23**(4): p. 703-719.
68. Freeman, J.L., P.H.Y. Caldwell, and K.M. Scott, *The Role of Trust When Adolescents Search for and Appraise Online Health Information.* The Journal of Pediatrics, 2020. **221**: p. 215-223.e5.
69. Jang, C.W., et al., *Reliability, Quality, and Educational Suitability of TikTok Videos as a Source of Information about Scoliosis Exercises: A Cross-Sectional Study.* Healthcare (Basel), 2022. **10**(9).
70. Hill, G., A. Manuell, and A. Willemsen, *A rapid review of quality of health information on TikTok.* The Journal of Health Design; Vol 8, No 2 (2023): Toward Better Health Care, 2023.
71. Liang, Z., et al., *Sleep Hygiene Games and Gamification: Where Are We and Where Are We Heading?* 2024.
72. Pullmann, M.D., et al., *Expect the Unexpected: A Qualitative Study of the Ripple Effects of Children's Mental Health Services Implementation Efforts.* Implement Res Pract, 2022. **3**.
73. Lipsitz, L.A., *Understanding Health Care as a Complex System: The Foundation for Unintended Consequences.* JAMA, 2012. **308**(3): p. 243-244.
74. Jagosh, J., et al., *A realist evaluation of community-based participatory research: partnership synergy, trust building and related ripple effects.* BMC Public Health, 2015. **15**(1): p. 725.
75. Bush, P.L., et al., *Organizational participatory research: a systematic mixed studies review exposing its extra benefits and the key factors associated with them.* Implementation Science, 2017. **12**(1): p. 119.
76. Zhou, E.S., et al., *Developing a culturally tailored digital health intervention for insomnia in Black women.* Translational Behavioral Medicine, 2024. **14**(2): p. 117-126.
77. Shaffer, K.M., et al., *Effects of an internet-delivered insomnia intervention for older adults: A secondary analysis on symptoms of depression and anxiety.* J Behav Med, 2022. **45**(5): p. 728-738.

Supplementary Files

CONSORT (or other) checklists

Multimedia Appendix: The consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist.
URL: http://asset.jmir.pub/assets/76a870a198b0136b60cad09aa106b445.pdf