BEWELL: Can AI and self-tracking improve your health and lifestyle?
Research Design

Megan Nguyen, Kelly Short, Mahmoud Ghanem, and Ayoade Israel

Overview

With today's wellness applications, their purpose is to promote a healthy lifestyle, and they vary from specialized activity tracking, sleep analysis, nutrition management, mindfulness and general wellness monitoring solutions. Most of them require manual tracking boards and provide only summary statistics. BeWell, our wellness application, tracks all these key wellness topics, but rather than having to manually input and type information, we leverage wearable technology and voice recordings. The voice recordings are transformed into text files by openAI's Whisper. By leveraging both active and passive data, we believe we can enhance the traditional analysis that many applications are capable of. Many users may want to know more than just a summary, they want to know what lies hidden behind the data. Our ongoing goal is for the user to hopefully learn more about their lifestyle than they would expect and gain healthier habits in the process.

The key focus of our research will be around the topic of sleep. Insomnia, a prevalent and significant sleep disorder, is seen in approximately 33-50% of adults. It's associated with reduced quality of life, increased healthcare costs, and increased risks for serious psychiatric and medical conditions. Historically, insomnia research studies have been supported by sleep diaries where people self record their sleep patterns. The sleep diary has been considered the standard for subjective sleep assessments and is used broadly still in the field. [1] [2]

The introduction of wearable technology has changed the landscape recently and studies at home have been conducted to look at the effectiveness of this data on predicting quality and characteristics of sleep. Due to this evolution in wearable technology and the use of Whisper AI to gather contextual data, we would like to take a slightly different approach to how we collect the data. However, the same fundamental goals and observational techniques to sleep research studies will still be leveraged and built upon. The fundamental objective is to determine how we can help customers achieve a higher quality sleep index?

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[1] https://my.clevelandclinic.org/health/diseases/12119-insomnia#:~:text=How%20common%20is%20insomnia%3F,at%2010%25%20to%2015%25

[2] https://academic.oup.com/sleep/article/35/2/287/2558899

The user group who opts in to the study are the main intended audience. We want to show them the results at the end and incentivise healthier behaviors based on our findings. Our secondary audience is internal employees at BeWell for informational gathering on improving their application.

The rest of the document outlines the proposed design.

Research Question

Does mixed use of user voice input and wearable technology data improve the prediction of the quality of sleep based on indicators such as physical activities, caffeine/alcohol intake, and screen time leveraging OpenAI's Whisper and the BeWell Application?

Sub Questions:
- Does increase in screen time before bed drive worse sleep quality?
- Are highly active people prone to better sleep quality?
- How does alcohol and caffeine affect someone's sleep quality?
- Do age or gender have an affect on someone's sleep quality?

Study Design

The main design of this research will be a quantitative study. It will be observational and will collect data over time, also known as a time series analysis.

In regards to which type of observational study we will require, this project is more analytical than descriptive. We aim to pursue a case control study.[3] This is when the researcher identifies people with an existing health problem, in our case, insomnia, and a similar group without the problem, i.e., our control: those without insomnia. We will compare the two groups with respect to exposures. It often starts with the outcome of interest (good quality sleep) and looks back in time for exposures that likely caused the outcome of interest (activeness during the day, low screen time, etc.).

When picking our control vs our group of interest, we use self diagnosed insomnia as our differentiator. The controls should be selected from the same localization or setting

[3] https://www.cureus.com/articles/25270-observational-study-designs-synopsis-for-selecting-an-appropriate-study-design

of the cases. The way we plan to do this is by looking at our application users. Since the application will have already been rolled out, we are assuming we have a wide range of users who have input their personal demographic and profile data into our application. This, essentially, is our sample frame: BeWell's Application users within the United States. We will be able to apply sampling techniques to this dataset.

Data
We will collect the data from Our AI App BeWell using users' voice-recording data processed by openAI's Whisper.
- The data is available on the user's application database and stored on their devices as designed by the application and will be collected once we receive each user's consent.
- BeWell data has users' profile information such as age and gender.
- BeWell data has users' daily activities such as (steps, miles, standing, screen time, activity category, active time) through passive collection with wearable technology.
- BeWell data has user sleep-related nutrition such as the amount of caffeine drinks and alcohol.
- BeWell will collect via voice recordings information on quality of sleep which will essentially replace the need for a sleep diary survey.
- BeWell will assess sleep quality using app sensors, wearable technology, and AI technology following the American Academy of Sleep Medicine (AASM)[4] guidelines.
  - The guidelines are:
    - (1) awake;
    - (2) rapid eye movement sleep (REM);
    - (3) non-rapid eye movement (Non-REM);
    - (4) sleep stage 1 (N1);
    - (5) sleep stage 2 (N2) and
    - (6) sleep stage 3 (N3).

We will ask users for consent from both treatment & control groups to collect their data for the study. We will generate questions for enrolled users to determine their eligibility for the study.

Users can opt-out of the study anytime before the study analysis starts. Their collected data will be deleted.

All Personal Identified Information data collected for the study will be anonymous.

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[4] https://www.nature.com/articles/s41746-020-0244-4

Sample

- **Population:**
    - An equal representation of users in the United States. We want to look at all demographics.
- **Sample Frame:**
    - All users who use the BeWell Application and record sleep information. This will help target those who are health conscious and care about their sleep.
- **Sample:**
    - We will use quota sampling to choose random users that fit either a treatment (users with self-diagnosed insomnia) or a control condition (users with no sleep issue). Any difference in outcome between the treatment and the control group is due to the intervention of the observational variables (ex: alcohol, activity time,..). We chose this method because it is most appropriate for predicting the casualty of sleep insomnia.
    - We will randomly choose 5000 users as a subset of a statistical population in which each member of the subset has an equal probability of being chosen to represent the chosen characteristics in the entire population (like age, gender) from our BeWell 10M users to generalize to the US population.

Variables and/or Intervention

- An observational study will occur, so there's no experiment or intervention. The outcomes, however, will be measured and used to help the user make changes to their lifestyle if seen as harmful.
- Our algorithm will take in quantitative data taken throughout the user's day and use artificial intelligence to send alerts, reminders, and predictive insights at the end of the study in hopes of acting as a lifestyle or health coach. This is to hopefully include this new feature to the application after the study is finished.
- Some predictor variables we plan to look at are screen time, physical activity/exercise, liquid intake, nutrition, age, and gender which will come from the voice recordings and wearable technology.
- A derived variable we will look at is unusual sleep behavior. That would be someone who gets less than seven hours of sleep or more than eight hours, and they will show signs that they didn't sleep well.

Statistical Methods

- We will use the case-control statistical method where there's a gold standard that represents the controls, while the diagnostic procedure is the "case". For example, if we compare someone who watches television for a long period of time before sleeping and someone who doesn't, we can see how that may affect their sleep schedules and the effect it has on the following day.
- To answer our research question, we will specifically track screen time, liquid intake, and physical activity. We will account for demographic factors, such as age and gender.
- We will compare the users' sleep pattern over a quantity of time to see what their sleep looks like.
- We will analyze all users' collected data and create a general model to compare opt-in users' behavior individually and provide instructions to improve their sleep quality. Users who choose to opt-in will be provided with the deep analysis done by the study for their case.
- We want to eventually evaluate how the application affects the user's behavior. This will be addressed in a follow-up study.

Potential Risks

Privacy. Selected candidates using the app might be scared of having their information/activity tracked. We will have a note in our privacy policy to help them understand that this will not be happening. They are in control of their own data. There will be legal implications put in place. We will also make sure to prevent any form of information leak to third parties unless requested by the patient.

Response Bias. Some of the candidates might decide not to fill in some data or forget to record this data. Users may believe that their sleep is already sufficient and won't need to get reminders or insights to improve their sleep, or users may forget to record their daily information and extraneous factors. Another scenario that might occur would be users will lie about their data in order to preserve/save their reputation.

Selection Bias. There can be bias if only certain types of people opt in. We won't be able to account for the users that are not using the application, wearable technology, or voice recording technologies (outside users of the sampling frame).
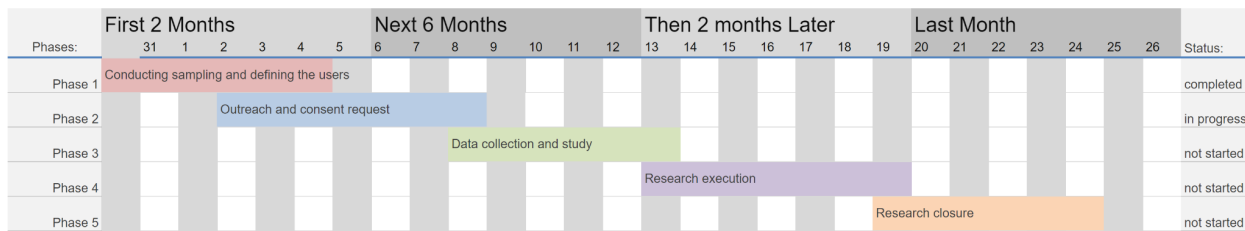
Wearable Technology Bias. The wearable technology used could be biased. To work around this, our application uses voice recordings which will help compare the voice

recordings to the application recorded data. For example, if the watch recorded six hours and the user slept five hours, the voice would serve as a way of enhancing the data recorded for more accuracy. Depending on the variable being recorded, we will decide which data source we will want to utilize. For example, if the person is sleeping, the watch records it via the pulse reading, while for things like food intake, the user recorded data is more valid.

Sample Size. There is a possibility that we might have an insufficient amount of volunteers for the study. We will provide sleep analysis to the people who volunteer to take part in the study, as a way to better improve their sleep. We will also make sure to have enough people from different races, demographic factors and regions in the U.S. take part in the project. In addition, it might take some time for some selected candidates to get used to the app.

Deliverables

11 Months Project Timeline

Phases:	First 2 Months						Next 6 Months							Then 2 months Later							Last Month							Status:
	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
Phase 1	Conducting sampling and defining the users																											completed
Phase 2			Outreach and consent request																									in progress
Phase 3								Data collection and study																				not started
Phase 4														Research execution														not started
Phase 5																					Research closure							not started

This project will take about 11 months to complete. This project will be done in 5 phases which includes:
1. Conducting sampling and defining the users (1 month)
2. Reaching out to the user to get consent for data collection and study (1 month)
3. Data collection and study (6 months)
4. Research execution (2 months)
5. Research result and presentation (1 month)

Phase 1 - Conducting sampling and defining the users: 1 month.
- Outline how data is going to be collected e.g., wearable technology and voice recordings.
- Seek information from healthcare professionals to see what variables affect sleep.

Phase 2 - Reaching out to the user to get consent for data collection and study: 1 month.

- Define major goals and discuss budget.
- Plan out our communication strategy.
- Reach out to multiple candidates that are selected randomly, these can be done via email, mail, text messages, etc.
- Get consent from randomly selected candidates.
- Create work break-down structure, Gantt chart, and go through potential risks.

Phase 3 - Data collection and study: 6 months.
- Apply the case control study.
- Data will be collected.
- Selected candidates will record data daily during this 6 months time frame.
- Work on app quality and tracking.

Phase 4 - Research Execution: 2 months.
- Data analysis.
- Insights will be created.
- Check for quality deliverables.
- Confirm data collected and insights provided are useful.

Phase 5 - Research result and presentation: 1 month.
- Present feedback and data collected, including data analysis to the selected candidates and app management.
- Summary of the whole process, information gathered, and report will be documented.
- Determine if the new predictive insights should be embedded into the application.
- Survey individuals on the application process and usefulness.

Statement of contribution

- Megan Nguyen: I edited the entire research design, and refined my variables and statistical methods sections. It was great that the team was able to get together to go over the research design report before submission. The research design could be further improved by including information about how we could resolve the potential risks. That would require more thought, however.
- Ayoade Israel: I focus on writing the potential risk section and deliverables section. Including creating the chart for the project timeline. I also created the slides for these 2 sections. On the other hand, there isn't much that needed to be changed to improve the design on my end aside from the fact that we could have

added more information like the sampling size formula and how it relates to our project in the sampling section. Thank you.
- Kelly Short: I contributed by refining the overview , questions, and research design sections. I also helped with the editing of other sections and reviewed the document final draft with the team. In addition I put together a few of the slides and recorded my portion. I think as a group we could have spent more time on focusing on the presentation and the format there but we choose to focus the majority of our work on the research paper itself!
- Mahmoud Ghanem: I reviewed the research design report and provided notes for other sections to make sure that we all have a well understanding of the research question and research processes. Review the data section and choose a specific random sampling method(quota) for the research, Make sure that all sections answer the research question. Sent out meeting invites.

References

(1) https://my.clevelandclinic.org/health/diseases/12119-insomnia#:~:text=How%20common%20is%20insomnia%3F,at%2010%25%20to%2015%25.
(2) https://academic.oup.com/sleep/article/35/2/287/2558899
(3) https://www.cureus.com/articles/25270-observational-study-designs-synopsis-for-selecting-an-appropriate-study-design
(4) https://www.nature.com/articles/s41746-020-0244-4