NapEze - New Parents' Sleep Coach

Justification for Target User Group:

Becoming a new parent is never easy financial stress, noise and disruptions in their work life balance to name a few. But one of the biggest disruptors to any new parent's wellbeing is sleep. About 68% of adults achieve at least 7 hours of sleep a night, this number falls to just 10% after having a child. Failing to achieve 7 hours sleep can increase your likelihood of Arthritis by 40%, depression by 56.85% and stroke by 50%. Furthermore, not being able to have regular prolonged sleep at a time where being sharp, alert and vigilant is so important, can produce a high stress environment for both parents, creating further fatigue.

This is particularly true for first time parents who, not having any reference to go off, don't even have the reassurance that what they are experiencing is normal for the baby. Alternatively, enduring these challenges without realising that what they are experiencing is abnormal and requires intervention can be equally problematic. As a result, improving child's sleep and helping to induce regular sleeping patterns will improve the sleep of their parents and thus improve their wellbeing.

There are many reasons that can contribute to a baby's lack of sleep. Amongst the most influential:

- Circadian rhythms - babies don't develop their circadian rhythms (the internal biological clock that regulates sleep-wake cycles) until they are 6 weeks old and it can take several months to mature
- Small stomach sizes - the smaller the size the more regular a baby will need feeding and the more regular they will wake up through the night.
- Learning to differentiate between night and day - new-borns do not know the difference between night and day. It takes them time to learn and as a result, take time to develop regular sleeping patterns.

You may notice that all these causes have a thing in common. They are all variable factors. therefore, how much the baby is developed will often determine how much impact each factor will have on its sleep. This leads us to the first requirement for the app:

NapEze needs to be able to provide customised sleep schedules for each baby. As they develop, so too must the strategies around giving them the most sleep. The app needs to be able to learn about the baby's development and its sleep cycles including other factors that may impact this (i.e.: mealtimes). Every set of Parents will have different schedules meaning the app will also need to consider when the users would ideally like to fall asleep and wake up when providing advice.

As being able to keep track of the baby and their habits is so important, the app needs have the capability to input and monitor the child's age, size, and weight regularly to track growth and development. It must also have the functionality to allow parents to regularly log detailed sleep data, including sleep duration, frequency, and any disturbances as well as food logs to show the times and frequency of meals. As a result, it must be designed to make the input of information simple and easy to do.

As much as it's important to make inputting information easy, the app is only useful if parents can understand and interpret what the personalised information it is providing. Therefore, NapEze needs to be able to display to parent's the optimal times for the baby to eat, sleep and reduce their stimulus in a simple schedule for their day.

To make all this possible the app will contain a lot of private data about the child as well as the parents. As a result, the app must take strong measures privacy and data security to protect the sensitive information.

Method

Selecting a recommender method, among other factors, largely depends on what data is available to the system. Therefore, when choosing a recommender method, it is important to identify what information needs to be utilised by the app to produce its recommendation.

Content-based systems like that used in Netflix's movie recommender. For our project, it would mean recommending schedules to parents based on their responses to earlier advice and schedules. However, for our use-case, the factors influencing a baby's sleep patterns are dynamic and not exclusively based on past preferences. Babies grow and change rapidly, and what was effective one week might not be the next. This method won't adapt quickly enough to the evolving needs of a baby. Knowledge-based systems can use a broader range of information, including expert knowledge, to make recommendations that evolve more rapidly to a user's preferences and needs.

An alternative solution is shown in:

This is shown through a study focussed on knowledge based Clinical Decision Support Systems (CDSSs). These systems use a combination of electronic health records as well as patient data to give advice for physicians and provide patient specific recommendations. In doing so the physicians can ensures that recommendations are based on comprehensive, up-to-date information, making them more relevant and responsive to changing needs of their patients.

In this study we can see why choosing a knowledge-based recommender is the most suitable for our app. A Knowledge-Based recommender would allow the app to leverage detailed knowledge about infant sleep patterns at different stages in their development as well as what influence external factors can have. This will allow the app to provide an optimal eating and sleep schedule for the parents to meet based on these attributes and their own preferences. Changing the profile and preferences will over time allow the system to adapt to the changing sleep patterns of both the baby as it develops and the parent's if their lifestyle changes.

Input and Background data

For the recommender to work the user will be required to inform it of both information about the child as well as their own preferences. To be able to apply tailored advice for the user the app will record the Baby's height, weight, gender and age - done through a form on the app upon initial register. Along with this form the user will be able to input their own preferences regarding their preferred sleeping length (in hours) as well as what time they would like to wake up. This will ensure the advice provided by the app is calibrated to align with the current stage of the infant's development but doesn't compromise the user's routine or wellbeing.

This app will utilise three sets of background data. Our first data set will contain sleep patterns for children of a variety of sizes and ages. This will provide the baseline that the app uses to judge the sleep quality of the user's child. It will provide the main context for the recommender to apply with other knowledge of user logs, preferences and further background knowledge to produce its optimal schedule.

Another of the sources of background information will come from the system's knowledge of Circadian Rhythm Development. Studies like *The Development of Circadian Rhythms in a Human Infant* outline the development of circadian rhythms in a human infant from birth to 6 months. This, when compared with the baseline sleep habits and the user's sleep logs, will show if the baby's sleep-wake cycle is aligning with typical circadian rhythm development, suggesting adjustments like more daylight exposure during mornings. Similarly, should the user's sleep logs not respond to the recommenders advise around Circadian rhythms, the system will consider whether the baby is able to differentiate night and day sleep patterns, suggesting interventions like structured daytime activities and night-time quietness to try and develop this differentiation.

Our final source of background data will come from study based around the correlation between eating and sleep in children. One of the main influences on sleep for any human is eating schedule. This is even more the case for babies. This information informs the recommender of optimal eating times for children. Helping the system to understand if a baby's bad waking pattern is due to sleeping habits or in-fact adjustments in feeding schedules might improve sleep, allowing it to prioritise these recommendations instead.

Critical Review
Strength 1 & 2:

Knowledge based recommenders don't require user feedback to operate NapEze. Because the system already has understanding through expert research, the app will be usable and useful to its users as soon as they register and enter in their baby's profile and preferences.

Another strength is the adaptability of the system. Changing the baby's profile will instantly change the advice and schedules it is providing. This means the user is always receiving the most relevant and suitable advice for their child and lifestyle.

Transparency checklist:

See Table 1 in the Appendix

Usability threat 1 & 2

Breadth of Experience:

The app's reliance solely on data points like sleep times and mealtimes may overlook other crucial factors influencing the baby's sleep such as environmental or even medical factors. As the app's recommendations therefore don't may not consider the full scope of factors it could cause parents to neglect other more impactful influences on their child's sleep.

Controllability:

The system does not utilise user feedback as a way of rating recommendations, instead comparing the user logs to the recommended schedule as a way of validating its recommendations. This could lead to the system continuously recommends a certain action that could be of no benefit at all and could in-fact be hindering the schedule of the family.

References

- Analytics Vidhya, (2015). Beginners Guide to Learn About Content-Based Recommender Systems. Available at: https://www.analyticsvidhya.com/blog/2015/08/beginners-guide-learn-content-based-recommender-systems/ (Accessed: 19 November 2023).
- Gholamzadeh, M., Abtahi, H. and Safdari, R., (2023). The Application of Knowledge-Based Clinical Decision Support Systems to Enhance Adherence to Evidence-Based Medicine in Chronic Disease. Journal of Healthcare Engineering, [Online] Available at: https://doi.org/10.1155/2023/8550905 (Accessed: 20 November 2023).
- Lee, H., Li, B., DeForte, S. et al., (2022). A large collection of real-world pediatric sleep studies. Scientific Data, 9, 421. Available at: https://doi.org/10.1038/s41597-022-01545-6 (Accessed: 21 November 2023).
- McGraw, K., Hoffmann, R., Harker, C. and Herman, J.H., (1999). The Development of Circadian Rhythms in a Human Infant. Sleep, 22(3), pp.303-310. Available at: https://doi.org/10.1093/sleep/22.3.303 (Accessed: 20 November 2023).
- Rosen, L.A., (2008). Infant sleep and feeding. Journal of Obstetric, Gynecologic, & Neonatal Nursing, 37(6), pp.706-714. Available at: https://doi.org/10.1111/j.1552-6909.2008.00299.x (Accessed: 19 November 2023).

Appendix

General:	
Does the system inform the user about the purpose of personalization?	Yes
Does the system inform the user who developed the technology and is liable in cases of wrongdoing?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about their rights under data protection law?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about possible risks of engaging with the system?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Input:	
Have users given informed consent about the collection, processing, and storage of their data?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about the fact that data is collected for personalization?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about which data is collected to produce personalized content for them?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about pre-processing done with the data collected for personalization purposes?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user if their data is used and shared beyond the goals of personalization?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Processing:	
Does the system inform the user about the kind of data that is processed to create a certain personalized item?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system explain to the user why they are receiving a certain personalization?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about the behavioural models underlying the personalization system?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Does the system inform the user about possible constraints of the model such that may result from pre-processing or biases in the dataset?	Yes, in the terms and condition & privacy policy that the user is required to agree to before registering on the app
Output:	

Does the system present information to the user in a location where they can notice it and access it easily?	Yes, once the user submits the eating and sleep logs for the day, they are transported to the advice page displaying the information. The home page also updates to show the new recommendation
Does the system provide information to the user in a comprehensible way, and can they act upon this information?	The advice page is structured with two clear graphs comparing their current sleep statistics to historical logs and baseline sleep statistics for children their age/size/gender. Below that is a text box divided into congratulating positives at what they are doing well and advice for where they can improve. The home screen Then displays the recommended schedule for Eating, stimulation and bed-time, along with two buttons to adjust the Baby's profile and the parent's preferences
Does the system provide the user with information in a clear and simple language that avoids technical terms?	The language will be written with the aim to be understandable by every parent. Although some technical language may be used where applicable in the aim of _specificity_, the app could always be adapted to include a dictionary of terms should the user become confused.
Does the system make it clear to the user that they interact with a machine?	The app being located on a phone would imply that a machine is being used to produce the recommendations. However, a loading screen could be added between input and output describing this more clearly.
Control:	
Does the system provide the user with the opportunity to specify their goals which are then used for personalization?	Yes. Once the user registers on the app the first pages they are taken too are baby profile configuration page and the Parent preferences page. It is on the later that the user will select their target sleep length and "wake-up time" for the recommender to base its schedule recommendations around.
Does the system provide the user with different options as to the personalized content they receive?	The system provides the user with different advice they can utilise to achieve the target schedule. But no there are not multiple schedule recommendations that the user can choose from as the system is set up so that its recommendation is the optimal schedule. A separate option would therefore not be as useful to the user.
Does the system provide the user with opt-in and opt-out options (e.g. for data collection)?	No. The data policy is currently set up as binary (yes or no).
If applicable, can the user adjust frequency and timing of personalized content?	Not applicable.
Does the user have a say in which data or models are used for personalization?	No.
Does the system encourage the user to give feedback and express their opinion about the personalization mechanisms used (type, frequency, duration, etc.)	No.

Table 1: Transparency checklist for NapEze