RUN-O2:
A Self-Management Tool for Runners with Asthma

Asthma in Exercise: Background & Motivation

General Implications:

The majority of the asthmatic population deals with exercise-induced asthma (EIA), creating a barrier for them to engage with consistent and enjoyable forms of physical activity–something all individuals deserve access to.

More than 80% of asthmatic patients develop EIA

Gong (1992)

Poorly controlled asthma can affect airway health, as well as performance and training outcomes

Hostrup et al. (2024)

Mastering EIA is critical in asthma management

Carlsen & Carlsen (2002)

Variability and Unpredictable Nature:

Triggers and medication types depend on each individual. This highlights a need for personalized, well-designed symptom management strategies that move beyond the typical "one-size-fits-all" approach in healthcare for chronic conditions.

Asthma attacked caused by exertion are indistinguishable from those caused by other stimuli.

Kaptchuk et al. (1995)

With irritable airways, exercise, fluctuations in temperature and humidity cause trouble. Temperatures, elevations, etc. impact different people differently

Kaptchuk et al., (1995)

Wide Range of Triggers: dust | exercise | weather changes | grass, weeds | cold air | air conditioning | work environment

Gautier & Charpin (2017)

Self-Management Tools for Asthma:
Background

Based on the current literature:

Gap: asthmatic runners lack a reliable, independent self-management tool that integrates easily into their daily routines without physician input.

Challenges: Many rely on physician guidance to avoid triggers or specific activities, limiting their ability to engage in physical activity (Gong, 2016).

Opportunity: a real-time, personalized asthma control tool to empower users, reduce reliance on physicians, and enable safer and consistent exercise.

- To be clinically viable, the tool must be data-driven, ensuring evidence-based suggestions and safety for users, addressing limitations highlighted by Huckvale et al. (2012) and Alharbi et al. (2023).

Physicians can teach patients to avoid conditions that exacerbate EIA, such as air pollution.

Gong (2016)

There remains much to be done if apps are to find broad use in clinical practice; clinicians cannot recommend tools that are inaccurate, unsafe, or lack evidence

Huckvale et al. (2012)

Establishing a self-management tool for asthma control and prediction is an attractive area for researchers

Alharbi et al. (2023)

Limitations exist in providing smart and accurate predictions tailored to individual asthma patients' needs

Alharbi et al. (2023)

Goal & Approach

Objective

Design an innovative self-management tool for runners with asthma using the **Person-Based Approach**, ensuring it aligns with user needs through a set of guiding design principles (Yardley et al., 2015). This requires qualitative research to understand the potential users, as well as multiple iterations of user evaluation.

Steps Included

1. Identify challenges that asthmatic runners face during exercise
2. Pinpoint gaps in existing asthma management devices & running personal informatics devices
3. Define features for a solution to address these limitations and make focusing on every day life easier
4. Design & evaluate prototypes through iterative testing for usability

By following the Person-Based Approach, the design of Run-O2 will leverage previous research studies and an analysis of successful tools for asthma patients and runners. It will facilitate data-driven decision making, focus on self-management and daily life outside of management, and reduce overall reliance on clinician management.

User Requirements – Gathering

Aims

- Identify user needs that overlap between running communities and asthmatic communities
- Define key features and functionalities to guide the core design
- Decide on an optimal configuration (e.g. mobile application, wearable, web dashboard, etc.)
- Apply the Person-Based Approach to develop user-centered design principles through secondary research

Methods

Literature Analysis:

- **"***Examination of relevant theory and evidence from previous trials"* (Yardley et al, 2015).
- Assess existing self-management tools to determine strengths, weaknesses, and gaps
- Identify which features should be retained, improved, or excluded
- Evaluate current and successful device formats to inform a configuration

User Research:

- **"***Synthesize previous qualitative studies of user experiences of similar interventions"* (Yardley et al, 2015).
- Identify user groups and analyze their needs, motivations, and pain points
- Develop personas and scenarios to guide the user-focused design process.

User Requirements – Key Findings

Challenges with Current Asthma Management Tools:

- **Personalization:** current tools offer no customization, failing to provide comprehensive and tailored programs *(Kotses et al., 1996; Alharbi et al, 2021)*
- **Predictive Modeling:** effective predictive models for asthma attacks require both bio signal data and environmental data, but most studies rely on one or the other *(Huckvale et al, 2012)*
- **Limitations in Tracking:**
  - Symptom diaries lack features like data entry validation and require more effort than automated data collection
  - Calculators are prone to numeric errors, compromising validity

Key User Study & Literature Findings:

- **Primary Challenge for Users:** preventing asthma attacks, which involves tracking risk factors and determining when special precautions are necessary *(Siddiquee et al., 2016)*
- **Tracking Triggers:** monitoring what triggers asthma attacks, as symptoms don't always appear immediately after exposure *(Huckvale et al, 2012)*
- By making suggestions, a system can help users "get proficient in managing it, or [...] delegate care practices to the self-care technology and concentrate on other everyday activities", such as their exercise *(Nunes et al., 2015).*

User Requirements – Outline

Dashboard Features

- Provide personalized pre-run guidance based on data, helping users manage symptoms during their run.
- Visually display post-run metrics to help users identify patterns in flare-ups, causes, and mitigation strategies.
- Offer tailored recommendations and predictive insights (e.g., inhaler use trends) to support long-term asthma management and optimize running performance over time.
- Allow users to manually enter or edit relevant data to ensure accuracy.

Wearable

- Continuously track breathing on runs, detect irregularities, and provide alerts with suggestions to prevent asthma attacks.
- Enable users to log inhaler use with a single button tap, automatically time stamping data for the dashboard.
- Track and record key bio-signals in real-time to enhance asthma monitoring and risk prediction.

Both (Dashboard & Wearable)

- Asthma Risk Prediction: analyze environmental conditions and bio-signals to forecast asthma risks before and during runs.
- Personalized Experience: adapt recommendations and alerts to each user's unique asthma profile, leveraging historical data
  - Similar to the personalization of typical fitness wearables and personal informatics devices, but with additional data regarding their asthma to re-establish their feelings of normality (Genuis & Bronstein, 2016)
- Integration between interfaces: ensure synchronization between the wearable device and the web dashboard for real-time updates, cross-platform compatibility, and a cohesive user experience.

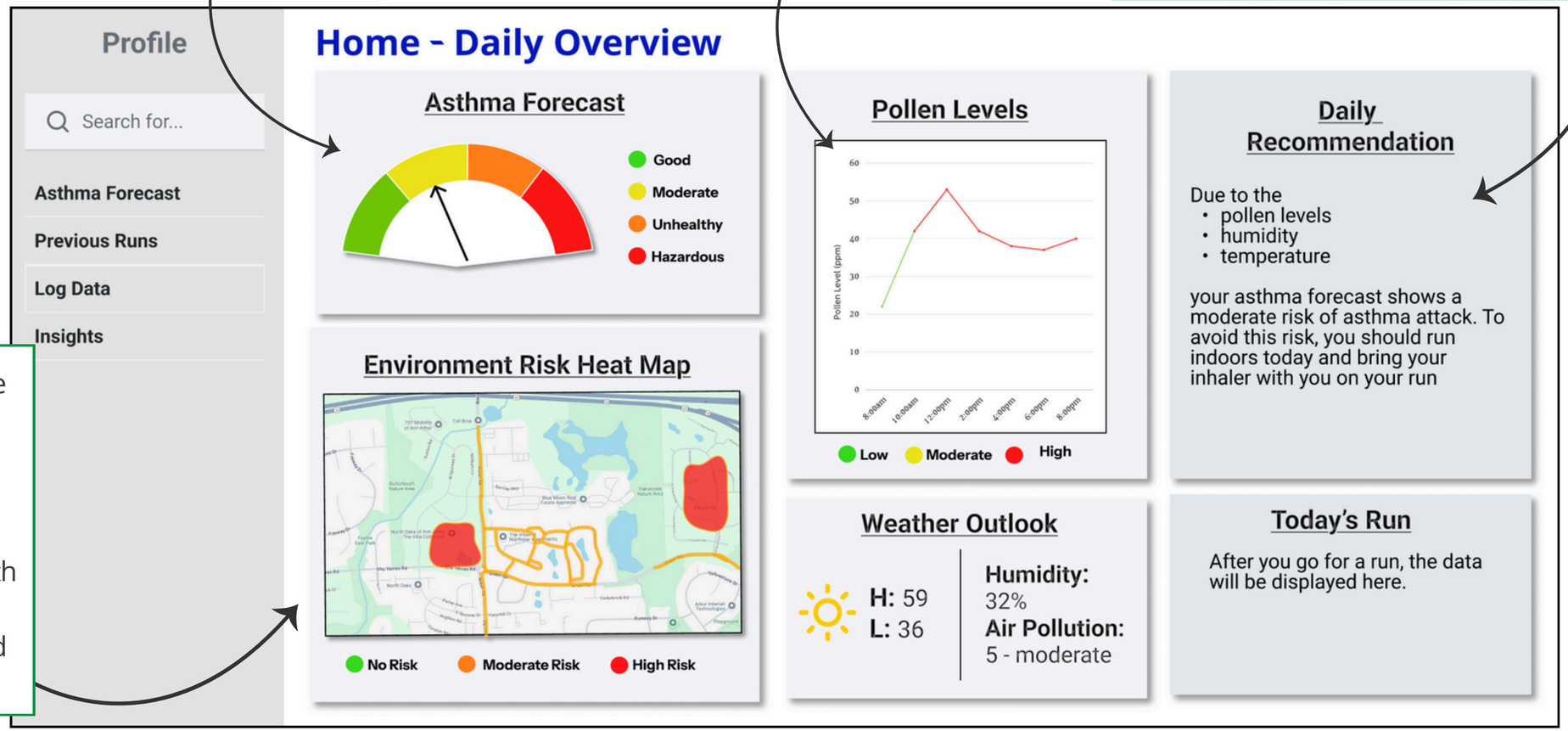
Prototype Design: 1st Iteration

Web Dashboard – ‘Home’ Page

The **‘Home’ page** is highly personalized to each individual, with visualizations charting information about their particular triggers and geographic location. For example, this user (due to historical responses to pollen levels, humidity, and air quality) has an asthma forecast of ‘Moderate’, whereas another user may have ‘Good’ if pollen is not a common trigger for them.

This chart will show the top trigger for this individual (in this case, pollen) and how that trigger will change throughout the day, giving them idea of what time of day is best to run outdoors. For another user, this may show an allergen such as dust mites or smoke levels.

The daily recommendation section will provide a written summary based on key points from the visualizations and will inform the user of how they should plan to run this day given their data.



The ‘Environment Risk Heat Map’ will be visible on all user’s profiles, but will change based on their typical running routes. It maintains consistency in the color coding and legend for previous visualizations and provides the user with an idea of where to run, so they can adjust their route to avoid flare-ups and triggers.

Web Dashboard – ‘Analytics’ Page

This page provides historical and predictive analytics to help the user understand their progress and any changes in their self-management. The first chart shows the users’ breathing rates on previous runs, along with timestamped inhaler use. They can navigate to different runs on different dates using the button below the chart to see how using the inhaler helped relieve their symptoms.

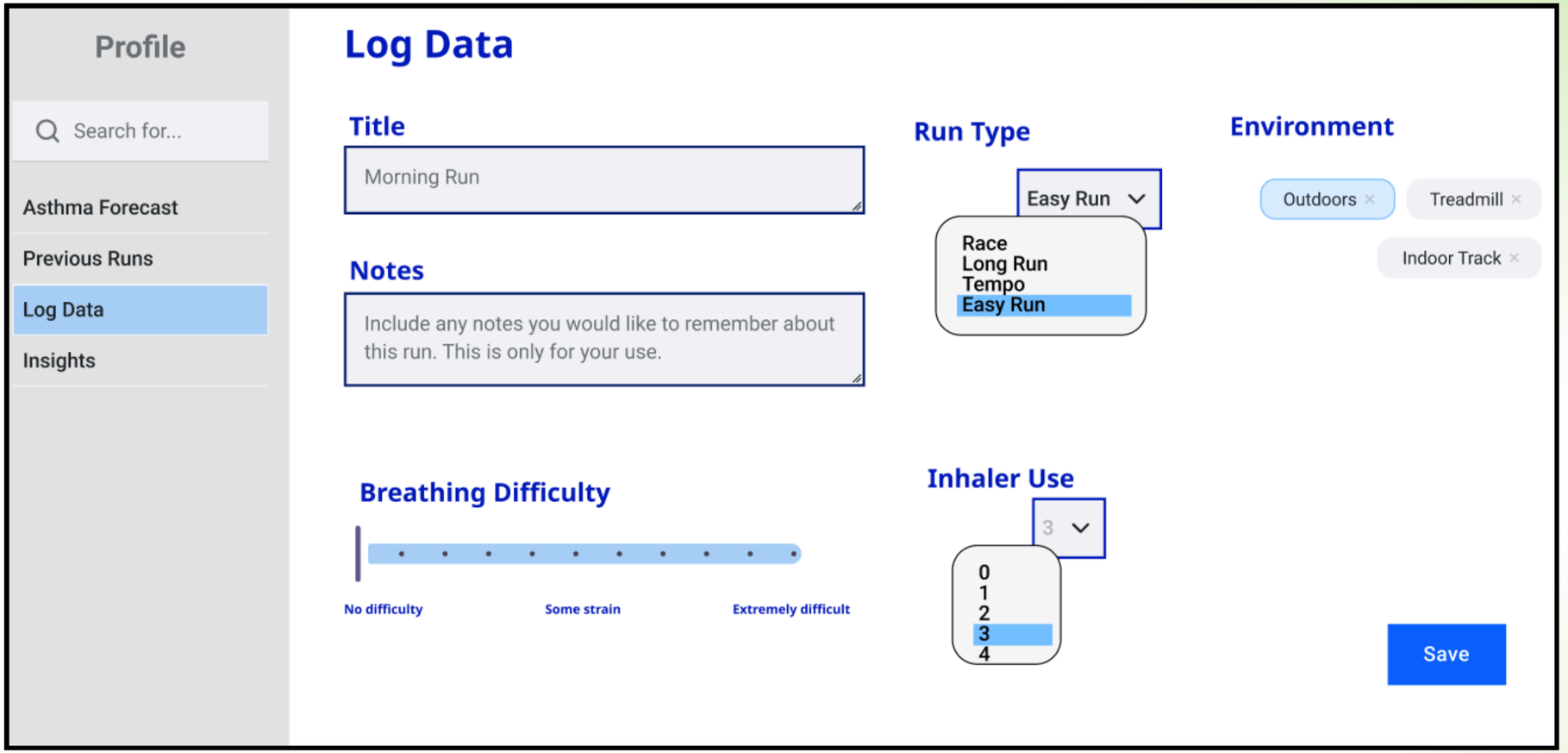
This chart shows the predicted average inhaler use per month, based on historical trends. It will look different for each user, based on their reaction to seasonal changes and geographic location. The chart can be toggled by ‘Existing’ to show data from the months of the year that have already passed and ‘Predicted’ to show the upcoming months, giving the user the ability to plan ahead for more problematic months and also understand why their asthma fluctuates throughout the year.

This chart represents the average breathing rate experienced by the user in each season–this is helpful for those who experience allergic asthma flare-ups, so they can see what months they have their symptoms under control (within target range on the chart), and what months they require more effort.

The “Smart Training Suggestions” are similar to the ‘Daily Recommendations” from the home page, but are tailored to long-term management. It tracks patterns over time and ensures that Run-O2 will have longevity and help the user long-term, past immediate use.

The ‘Top Triggers’ chart will be updated based on which variables affect the user’s breathing the most on runs. It can provide important information on what to avoid and look out for to mitigate and avoid future flare-ups.

Web Dashboard – ‘Log Data’ Page



Design and motivation inspired by Strava (Strava., n.d.)

Users can manually log or edit exercise data collected by the wearable device in the dashboard ‘Log Data’ page.

This accommodates the product requirement of mitigating incomplete or inaccurate data collection from the wearable device (Huckvale et al., 2012).

Prototype – watch interface

The Run-O2 watch is similar to the 'personal coach' aspect of the dashboard. It will monitor the user's symptoms and bio-signals while they run and provide real-time recommendations to assist them. The interface will account for their previous running data to differentiate between elevated breathing due to asthma or due to typical cardiovascular energy expenditure, and provide recommendations on pace or medication based on this.

The watch will monitor the user's heart rate and respiration, keeping track of any potential triggers or symptoms. If it detects abnormalities, it will vibrate with an alert and recommendation to mitigate the symptoms and continue running, rather than ending their run pre-maturely.

The "Log Inhaler" button on the top left will allow users to track real-time medication use during their run. This data will be synced with the dashboard and can be used to understand how inhaler use during runs helps alleviate symptoms. It will also be used for historical insights to track notable changes over time.

During a run the interface will display typical metrics and color coded respiration rates - healthy (green), mild (yellow), and risky (red). This will allow the user to continuously monitor their breathing and have a frame of reference for if they want to slow down or use their inhaler.

User Testing: Evaluation Goals & Methods

Aims

- Determine if the visualizations are effective at communicating desired insights and information
- Discover strengths, pain points, and unintended effects of interacting with the watch while exercising
  - Is any of the information unnecessary or unclear?
  - Is there any information missing?
- Ensure that the manual data logging process is intuitive and none of the selection methods are confusing

Methods

Following the Person Based Approach, the evaluation method will rely on further qualitative research–particularly, think-aloud interviews, as recommended by Yardley et al. (2015), to “gain immediate reactions to every element” and to directly observe its use. To achieve this, the following user tasks were outlined and user interactions with the interface to achieve these tasks were observed.

User Tasks:

1. Explain the main function of each page in the dashboard - how are they different? How do they work together?
2. Explain each visualization and how you might use this information
3. Describe each watch face and how you might use this information

User Testing: Findings

General Feedback

- In the “Seasonal breathing rate changes” graph: unclear as to whether this visualizes the average values or not
- In the watch interface, receiving a notification mid-run about having an unproblematic breathing rate may be distracting and too much information; to mimic a typical wearable for running reduce alerts where not needed
- In the “Breathing Rates on past runs” graph, make sure the star icon that indicates inhaler use is more prominent and that the meaning of it is explicit through a legend

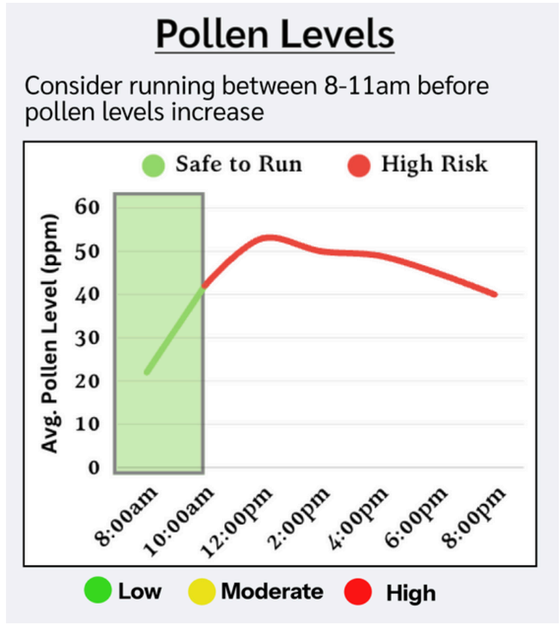
Understanding & Information Availability

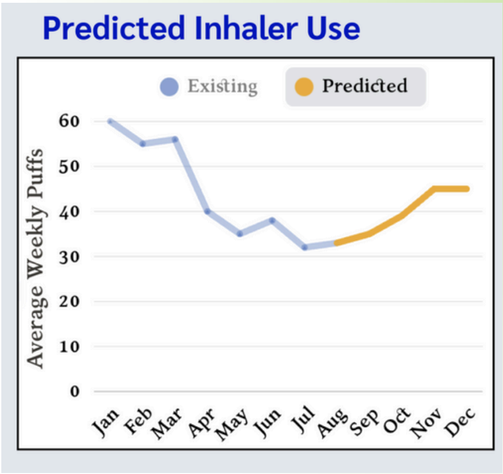
- Provide more context and description for visualizations to reduce misinterpretation and increase the benefit
  - Currently, it relies on some level of technical expertise or ability to read charts quickly and efficiently, where some users may learn, or comprehend, better through text
- The asthma forecast visualization is initially confusing until the rest of the visualizations have been digested; providing additional context or description for this can reduce initial confusion

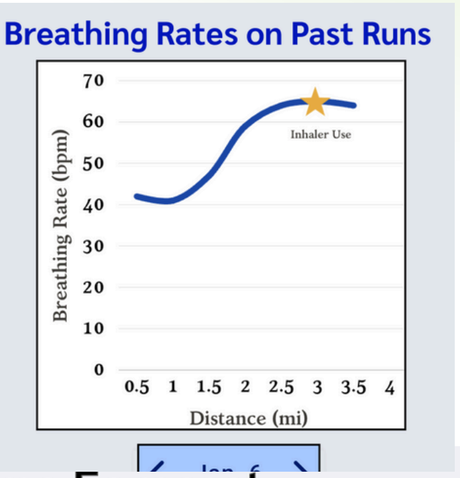
Iterations and Design Changes

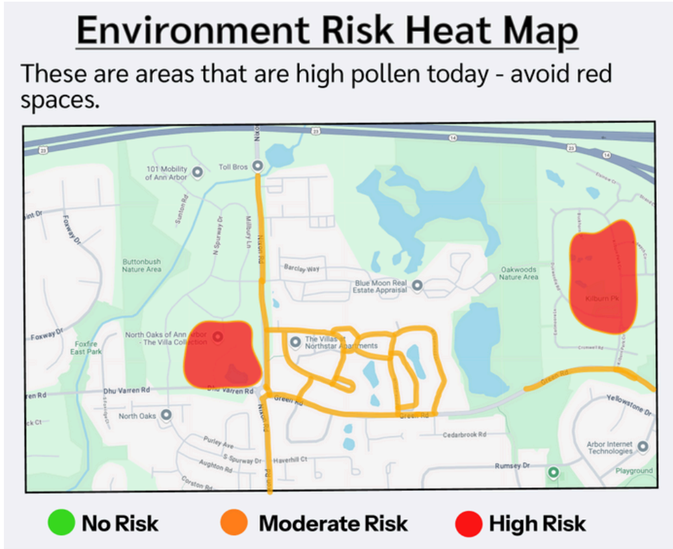
- **First:** remove the notification of a ‘good’ breathing rate from the watch to alleviate unnecessary distraction
  - This highlights a tradeoff between reassurance of good breathing and less distraction to mirror a typical running experience

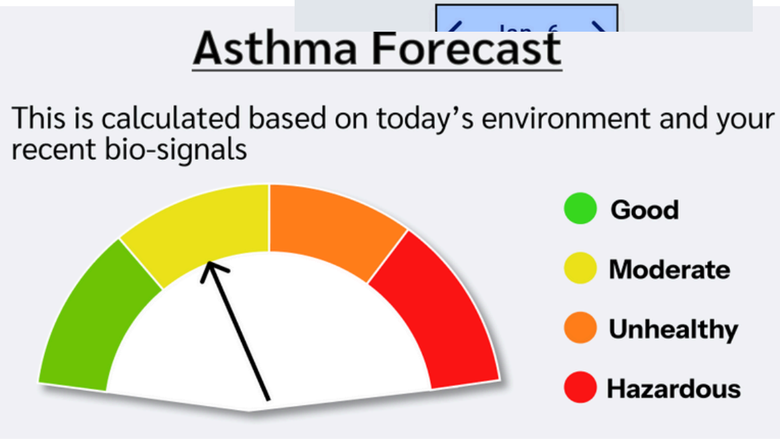
- **Second**: ensure clarity in the visualizations (seen among the figures on the right). This will involve:
  - Revising axes names
  - Revising graph titles
  - Incorporating descriptive captions
  - Incorporating legends where missing and necessary







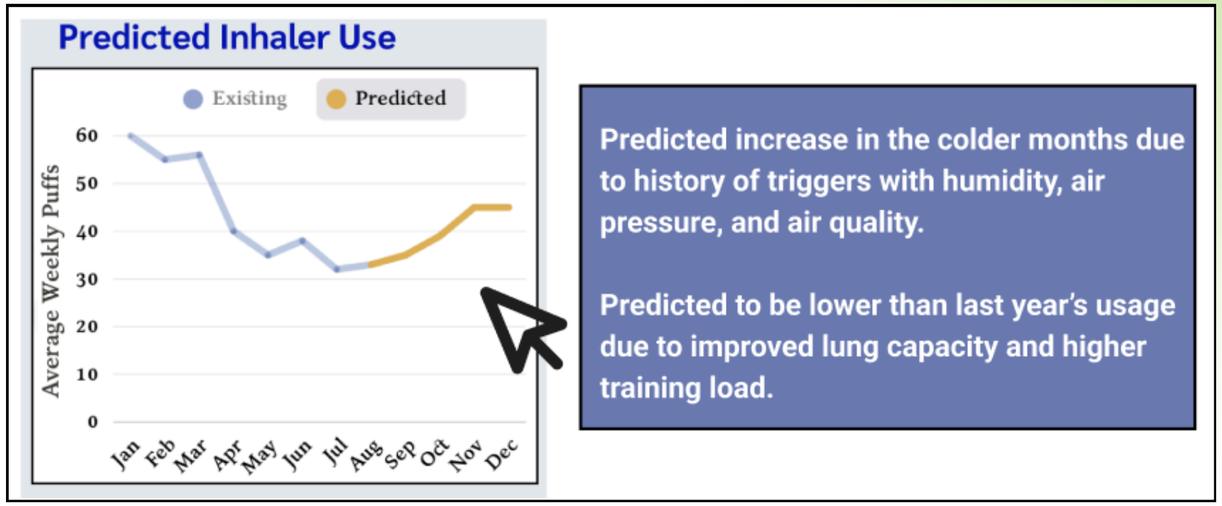


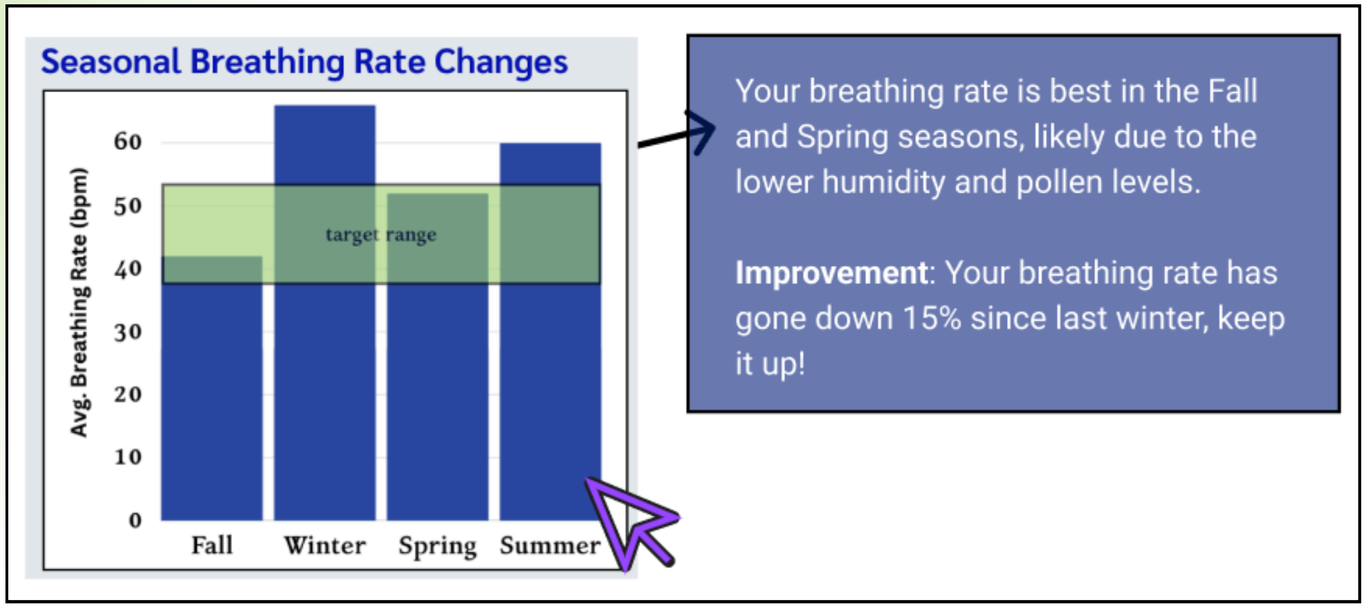


Iterations and Design Changes

Third: implement informational pop-ups for each visualization to make the visualizations more comprehensive and actionable and reduce risk of misinterpretation

- When the user hovers over a graph, a short summary with action items and insights will communicate key takeaways.





Reflections & Learnings

Goals & Design Reflection

- Designed for all asthma patients, regardless of severity, ensuring **inclusivity** through personalized data-driven insights
- **Empowers** users with self-management, **reducing reliance on clinicians** while accommodating diverse triggers, medication needs, and running abilities
- Predictive modeling analyzes historical data to provide **actionable insights rather than passive** and general suggestions

Privacy, Security, and Safety

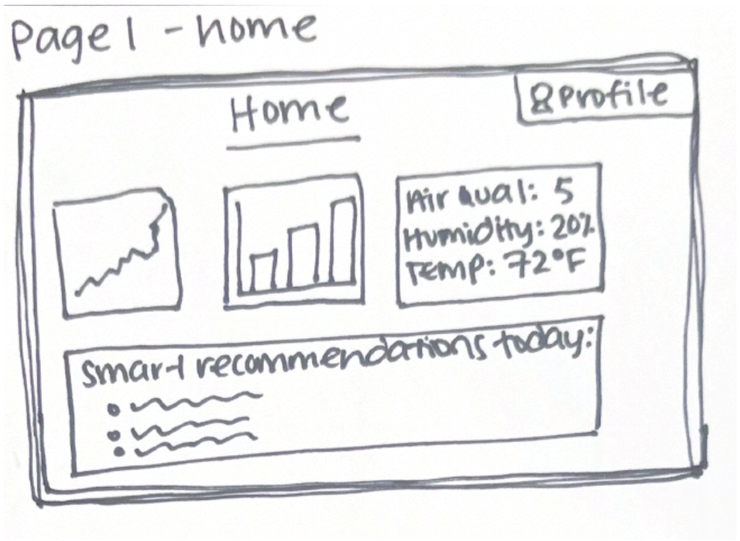
- User-controlled data with password protection and the ability to edit or delete records
- Anonymization/pseudonymization protocols in place if data is ever used externally
- Disclaimer to communicate that Run-O2 is designed to supplement (not replace) medical advice
- Manual data entry to prevent misinformation and erroneous data

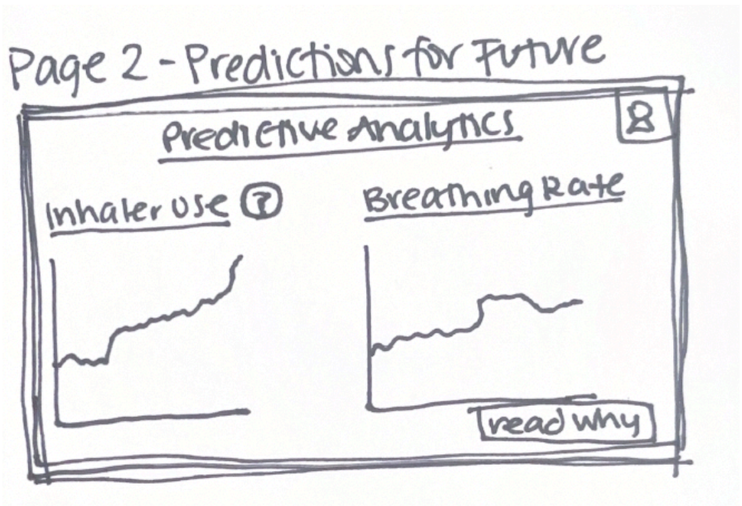
Clinician Integration

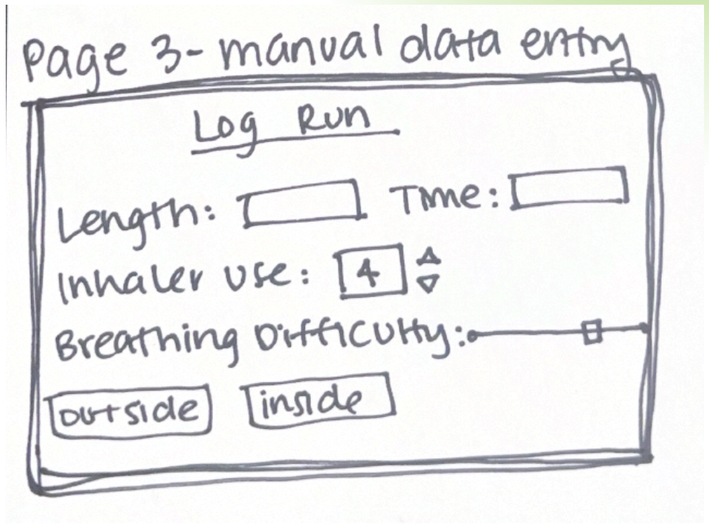
- Data will be downloadable for doctors, aiding in communication (e.g. medication adjustments or emergency care)
- The data can be integrated with, or input into EHRs, to update symptom and treatment plans based on recent inhaler use and changes in each patient's condition

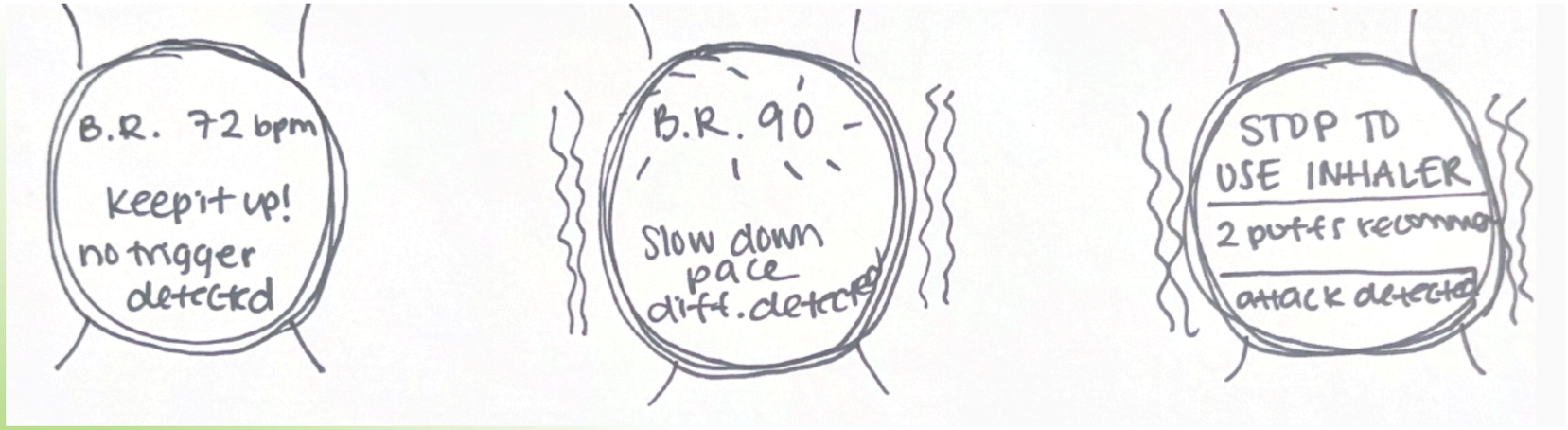
Appendix

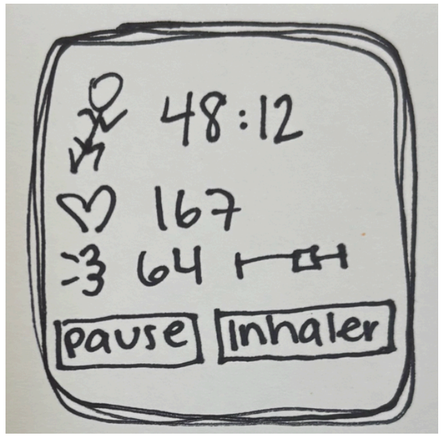
Crazy 8 Design Sprint Sketches











Persona Development

Persona and Scenario #1

Maya

Age: 21
Location: Utah
Occupation: Student
Activity Level: Recreational

DESCRIPTION

Maya is a 21-year-old female and recreational runner with exercise-induced asthma. She resides in Utah, where there are frequent seasonal and weather changes. Her asthma is triggered when she does any form of cardio.With running as a hobby, she wants to find a way to manage her symptoms to enjoy her runs.

SYMPTOM MANAGEMENT

- Daily inhaler
- Rescue inhaler
- Has tried using an iPhone diary app to track medication and symptoms as well as a custom self-made Excel spreadsheet

GOALS

- Enjoy running as a hobby with fewer asthma flare-ups
- Gather insight into asthma symptom and trigger patterns

PAIN POINTS

- Has attempted using an iPhone diary app to track her symptoms but was unable to draw useful insights, and felt restricted to the limited data logging options
- Carries her rescue inhaler on every run and often stops runs short due to flare-ups

NEEDS

- Predictions of 'good' vs 'bad' running days based on daily symptoms
- Adaptive workout suggestions based on symptoms or recommendations on when to carry an inhaler

Maya wants to run a faster 5k time this year and decides to do an interval workout at the park. She starts a dynamic warm-up, but **after a few minutes of jogging, she feels tightness in her chest**.

She checks her smartwatch, which alerts her that **her breathing rate/pace has increased significantly faster than usual,** which is an early **sign of an impending asthma attack**. Her watch suggests that she slows down on her warm-up and increases her intensity more gradually. She follows the suggestion and continues her intervals at a modified pace. Halfway through, **Maya's watch detected another spike in breathing strain and sends a short vibration to prompt her to take a longer recovery break** before the next interval.

She realized that without these real-time insights, she would've assumed that her breathing was only attributed to the intervals pace, not her asthma. **Had she not listened and modified her workout, she would've had an asthma attack, forcing her to stop entirely**. After her workout is complete, Maya reviews her post-run analytics on the dashboard, noting that adjusting her warm-up and pacing helped her complete the session without any major issues.

Reviewing her training trends, her dashboard points out that short warm-ups in colder air trigger her symptoms much faster, which she will remember for her next workout.

Persona and Scenario #2

Carson

Age: 27
Location: Massachusetts
Occupation: Athlete
Activity Level: Professional

DESCRIPTION

Carson is a 27-year-old professional post-collegiate track and cross country athlete. He has allergic and seasonal asthma, leading to symptoms all-year-round and severe flare-ups in the Winter and due to allergens (pollen and mold). He regularly trains in high-intensity environments, racing both indoors and outdoors.

SYMPTOM MANAGEMENT

- Daily inhaler
- Rescue inhaler
- Works with a physician during training and races to navigate flare-ups in real-time

GOALS

- Perform competitively without negative impacts from asthma symptoms and flare-ups
- Predict asthma attacks before starting a workout or race to mitigate the situation before it occurs

PAIN POINTS

- Flare-ups negatively impact his performance despite working with a coach and physician
- Races both indoors and outdoors, and cannot predict allergens such as mold indoors or pollen levels outdoors

NEEDS

- Real-time breathing feedback during training to navigate worsening symptoms
- Personalized predictions of asthma attacks based on real-time training symptoms
- Better understanding of what triggers cause the worst reactions

Carson is in training season for his upcoming race, but his **seasonal asthma has been unpredictable**. He checks his wearable's daily asthma risk forecast, which **warns him of high pollen counts and dry air,** both of which are triggers for him. Carson debates whether to train indoors or outdoors and checks the personalized workout suggestion on the dashboard.

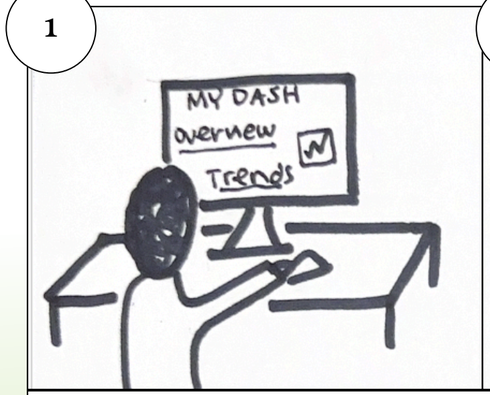
Based on his past symptom history, Run-O2 recommends: (1) an indoor treadmill session to minimize pollen exposure and (2) if running outdoors, a pre-run inhaler dose. Wanting to simulate race conditions but stay safe, he runs outside but takes a puff from his inhaler. Carson also plans his route to avoid pollen exposure by checking the heat map on his dashboard to determine where pollen levels are high in his neighborhood.

Midway through his run, **his smartwatch detects an increase in his respiratory rate and abnormal wheezing**. His watch vibrates and **prompts him to slow down** for two minutes to recover. By following the guidance, **he avoids a full asthma attack and finishes his workout strong.**

Later, reviewing his post-run analytics, Carson sees how his allergens negatively impacted his breathing efficiency. He notes that his wearable helped him adjust in real-time to make a better decision about when and where to train.

Storyboards

1

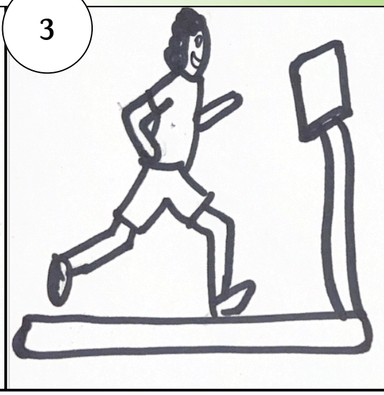


Carson's coach scheduled a long tempo workout today. Carson checks his dashboard to know what to expect from his asthma during the day. He sees that the pollen levels are high and that the last time the pollen levels were high, it led to him stopping his outdoor run and finishing it in the indoor track.

2

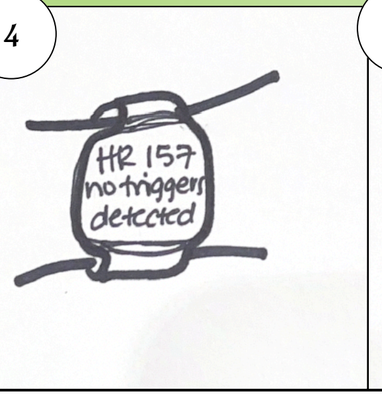
The dashboard gives him a recommendation to run on the treadmill today and to bring his inhaler just in case.

3



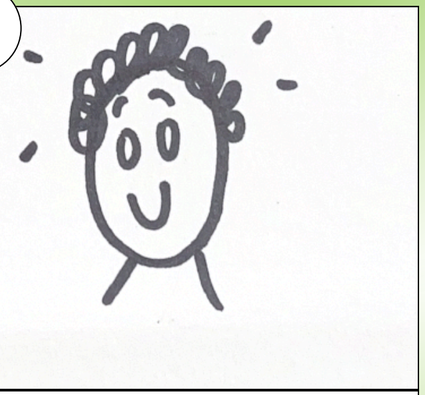
Carson decides to run on the treadmill and feels great. He finishes the tempo workout without any breaks or flare-ups.

4



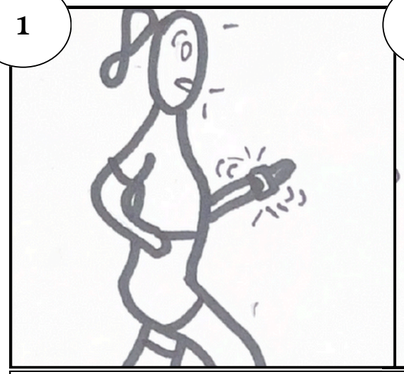
His watch gives him feedback about his breathing and heart rate during the run, which are positive, so he continues without using his inhaler.

5



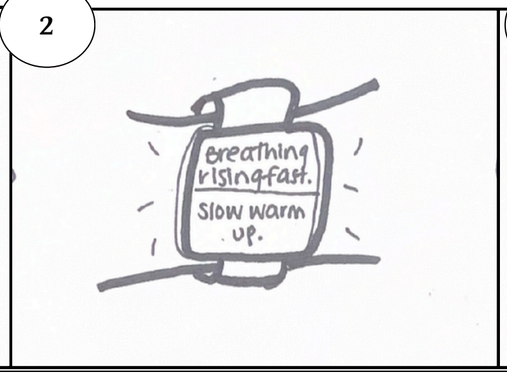
Once his workout is complete, Carson is ecstatic. If he had done this workout outside like he planned, he likely would've had to stop or take breaks, making it a less efficient speed workout. He knows how useful his dashboard was and makes sure to listen to its recommendations more.

1



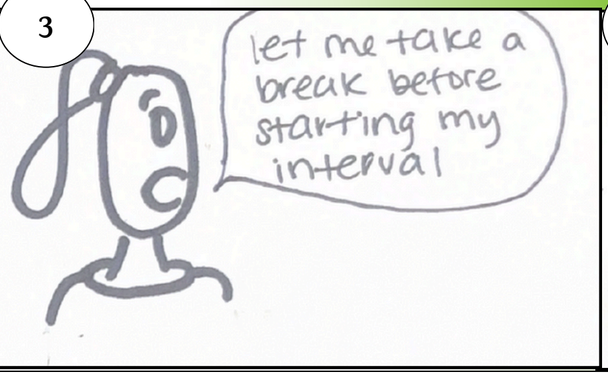
Maya starts a slow warm-up to prepare for her interval workout. These faster sprints usually trigger her asthma, so she proceeds carefully and brought her inhaler like her dashboard recommended.

2



Her watch vibrates and alerts her that her breathing rate is already faster than usual, indicating her asthma may be flaring up.

3

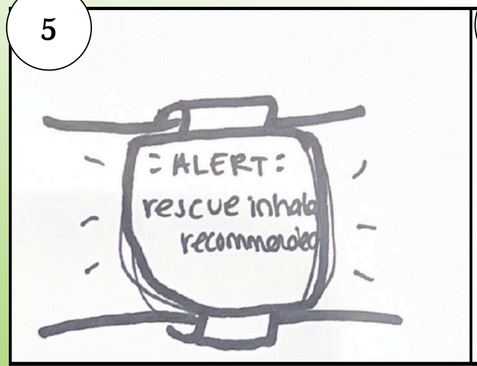


Maya follows her device's recommendation to slow down to prepare before starting her sprints.

4

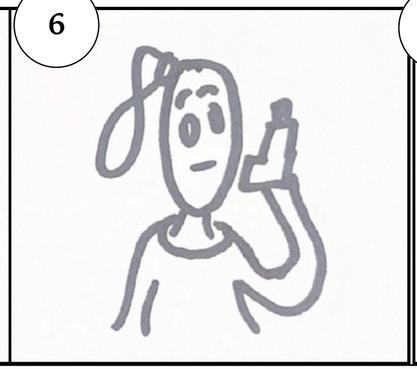
She starts her first interval and struggles to regulate her short breaths.

5



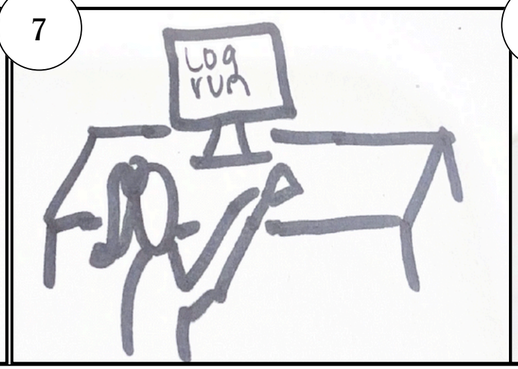
Her watch vibrates to alert her of a potential asthma attack and recommends taking a dose from her rescue inhaler.

6



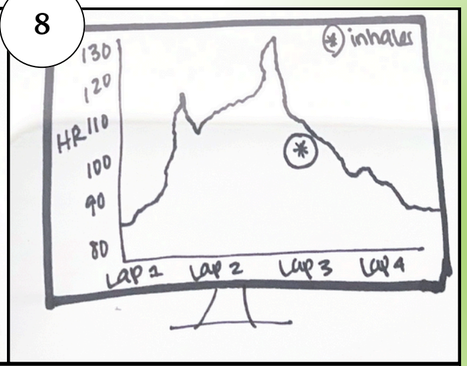
She listens to the recommendation and begins to feel better.

7



After she completes the rest of her intervals at a modified pace, she logs the asthma symptoms she experienced into her dashboard so her watch can continue to give her helpful suggestions during her runs.

8



Later, she can check her dashboard to see how using her inhaler helped her recover and continue her workout. She can use this information for future similar workouts.

Revised Prototype - Watch Interface & Notifications

Revised Prototype - Dashboard Home Page

Profile

Search for...

Asthma Forecast

Previous Runs

Log Data

Insights

Home - Daily Overview

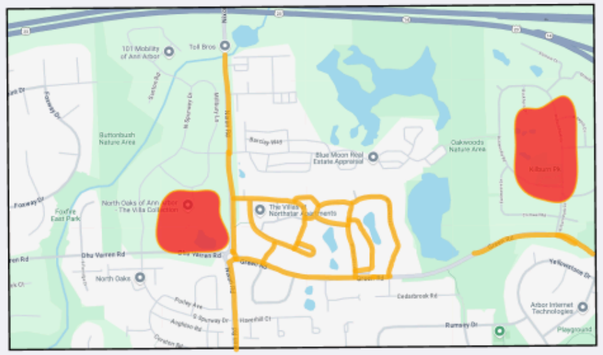
Asthma Forecast

This is calculated based on today's environment and your recent bio-signals

Good
Moderate
Unhealthy
Hazardous

Environment Risk Heat Map

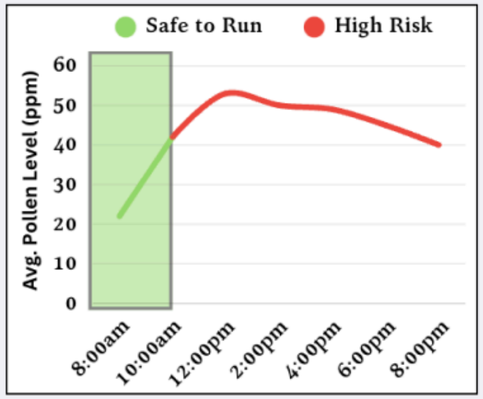
These are areas that are high pollen today - avoid red spaces.



No Risk Moderate Risk High Risk

Pollen Levels

Consider running between 8-11am before pollen levels increase



Low Moderate High

Weather Outlook

H: 59
L: 36

Humidity: 32%
Air Pollution: 5 - moderate

Daily Recommendation

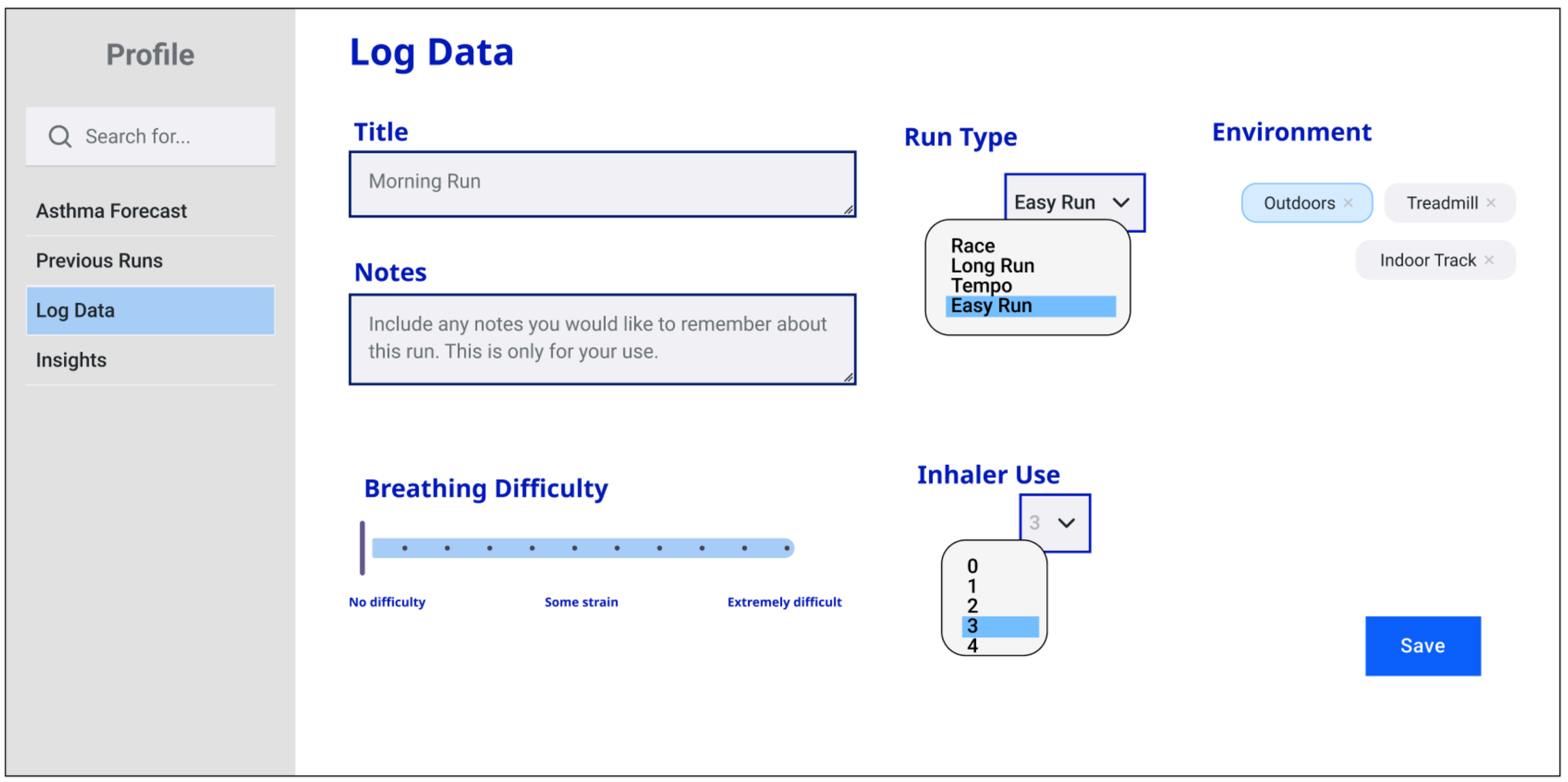
Due to the
- pollen levels
- humidity
- temperature

your asthma forecast shows a moderate risk of asthma attack. To avoid this risk, you should run indoors today and bring your inhaler with you on your run

Today's Run

After you go for a run, the data will be displayed here.

Revised Prototype - Dashboard Data Log Page



Revised Prototype - Dashboard Insights Page

Profile

Search for...

Asthma Forecast

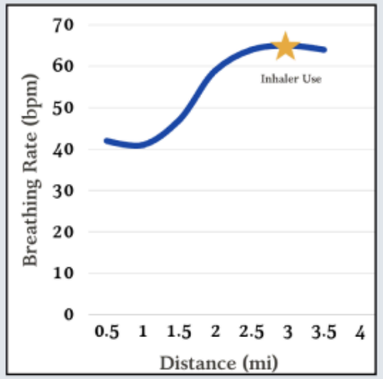
Previous Runs

Log Data

Insights & Personal Coaching

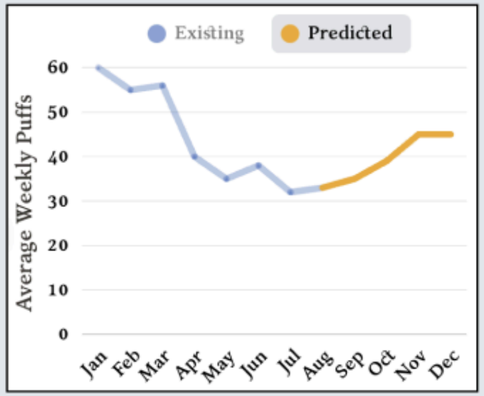
Personal Coaching & Historical Insights

Breathing Rates on Past Runs

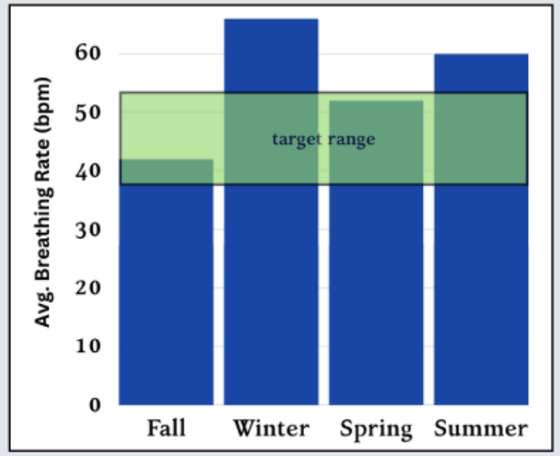


Jan. 6

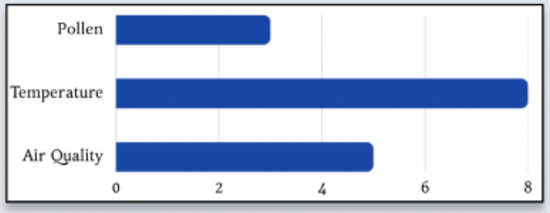
Predicted Inhaler Use



Seasonal Breathing Rate Changes



Top Triggers - Last 6 months



Smart Training Suggestions

- You tend to have fewer symptoms when you warm up for at least 10 minutes before running.
- Hills exacerbate your symptoms - avoid heavy inclines when asthma forecast is moderate or severe.
- You've used your inhaler more than usual this month. It may be time to check in with your doctor.

Downloadable PDF

Final Evaluation Plan

Heuristic Evaluation

- Assess usability using Nielsen's 10 Usability Heuristics for UX (Nielsen, 1994)
- Additional focus on accessibility (colors, contrast, text readability) and interaction efficiency (reducing cognitive load, providing clear navigation between pages, non-disruptive but informative alerts)

User Testing

New participants (recruited via convenience sampling) to ensure unbiased feedback on visualization and interface intuitiveness. The Person-Based Approach used in the first iteration will be replicated here to assess the following:

- **Graph comprehension:** participants will view and describe the data visualizations, including what they communicate and what insights the user might extract
- **Caption efficacy:** participants will provide feedback on the captions and information pop-ups to ensure that they are beneficial
- **Efficacy of features and alerts:** do alerts/vibrations guide actions without overwhelming the user?
    - Users will be provided with scenarios and the supplementary interface screen to observe reactions

Impact

- Validate design iterations
- Ensure user requirements are met
- Support long-term use and sustainable benefits

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