Personalized Health Intervention Tracker Test (PHIT-Test) for Benign Prostatic Hyperplasia (BPH)

Progress Report

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Changes

The need statement, design specifications and team responsibilities have not changed since the preliminary report. However, the project scope and design schedule have been updated to account for the changes in the design process. The original plan was to deploy the beta version of the product to the clinic to gather data by December. This was not possible as the group has also been considering alternative designs, and the process of choosing the solution extended beyond the planned time frame. A beta version of the product will still be created by the December deadline, but this will not be delivered to clinical use. The plan has been adjusted to complete the data collection features of the website by the end of January, and the machine learning model will be implemented directly following that. The relevant part in the design scope regarding the project schedule has been updated to account for this change.

Before:

"The prototype of the product that will be used to collect the initial patient data will be completed and deployed to patients and clinicians by December 1st."

After:

"The prototype of the product that will be used to collect the initial patient data will be completed and deployed to patients and clinicians by February 25th."

Statement of Design Alternatives

A total of five design alternatives have been brainstormed and each design is described below in detail with its initial sketches. The five design alternatives will be compared and contrasted in the following sections to select the best design. The drawings included in this section are not the actual shape or design that will be used for the final product. The drawings are rough visualizations of what each product could look like. More specific mock-ups and images for the final chosen design will be included in the Overview of the Chosen Solution section.

Design #1: Full mobile application

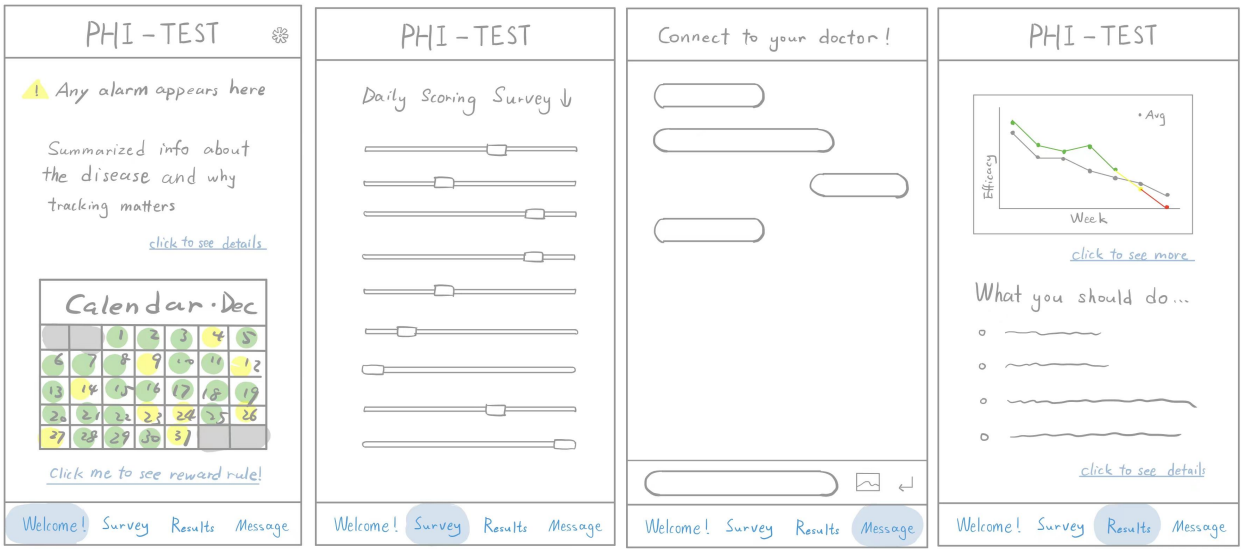


Figure 1. Mock-up design for a mobile application solution.

A mobile application (both or either for iOS or Android) could be developed to collect data. The user of the application will use the application to record data, and the data will be communicated with the central database through the REST API. Both the patient and the physician will be using the same application, but different sets of pages will be shown for each party. Some unique features of creating a solution in the form of a mobile app is that notifications could be delivered if patients do not log data regularly. Also, the process of accessing the data collection system would be easier, since if the website url is not

bookmarked, opening an app that is already installed on a mobile device could be easier than opening a website.

Design #2: Full web application

Figure 2. Mock-up design for a full web application solution.

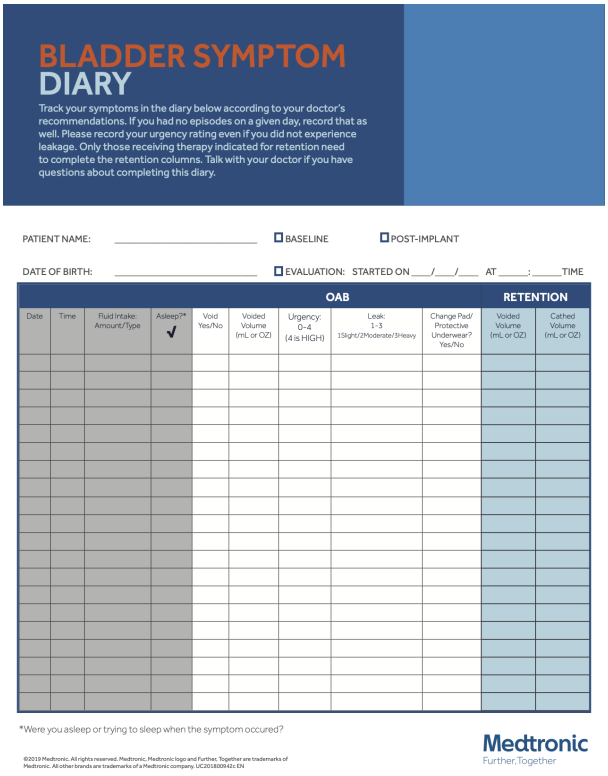
A web application (website) could be developed to collect data. The website will have automatic width adjustments so that when accessed from a mobile device, the page will adjust the placement of its contents into a layout similar to the ones for a mobile application. This feature will be extremely useful because the website can be accessed from different devices. The website will be compatible with almost all common web browsers, thus accessible from any mobile and desktop devices. Also, patients would typically feel more comfortable logging data

on their mobile phones, while physicians would be monitoring the measurements from an office. The same website domain will be used for creating the pages for both patients and physicians, but the sets of pages that each party would be able to access will be different. The website will have the same functionality as the mobile app.

Design #3: Mobile application that redirects to a webpage

This is more of a creative solution to our project, which combines both the concept of a mobile app and the versatility of a web app. The idea would be to create a mobile app that upon opening of an app would automatically open a default web browser installed on the mobile device and redirect the page to the homepage of the website.

Design #4: Pen and paper recording



BLADDER SYMPTOM DIARY

Track your symptoms in the diary below according to your doctor's recommendations. If you had no episodes on a given day, record that as well. Please record your urgency rating even if you did not experience leakage. Only those receiving therapy indicated for retention need to complete the retention columns. Talk with your doctor if you have questions about completing this diary.

PATIENT NAME: _____ ☐ BASELINE ☐ POST-IMPLANT

DATE OF BIRTH: _____ ☐ EVALUATION: STARTED ON ___/___/___ AT _____:_____TIME

				OAB					RETENTION	
Date	Time	Fluid Intake: Amount/Type	Asleep?* ✓	Void Yes/No	Voided Volume (mL or OZ)	Urgency: 0–4 (4 is HIGH)	Leak: 1–3 1Slight/2Moderate/3Heavy	Change Pad/ Protective Underwear? Yes/No	Voided Volume (mL or OZ)	Cathed Volume (mL or OZ)

*Were you asleep or trying to sleep when the symptom occured?

Medtronic
Further, Together

Figure 3. Sample paper recording sheet.

This solution would involve improving the already existing pen and paper survey format of the tracking sheet. The tracking sheet could take many forms, such as a form of a notebook,

or a sheet of paper that can stick to the wall. However, the overall idea of using printed sheets of paper and a pen to record data would remain the same.

Design #5: Physical device + mobile application

A physical device could be created to record some of the quantitative data such as frequency of urination. This device would be placed near the toilet or attached to the toilet and would record each time a patient urinates either automatically or upon a press of a button. The device will communicate with the patient's mobile device through bluetooth. There isn't an already available device in the market that, thus a new physical device must be developed if this design were to be chosen. The mobile app would also include surveys for collecting qualitative data that cannot be measured by the external device.

Analysis For Design Choice

The five design alternatives have been compared to determine which solution would best meet the design specifications. A Pugh chart has been constructed to compare multiple design criteria (Table 1). The design specifications that hold the greatest weight are accessibility, messaging capability, and patient compliance. These are the hallmark features of the product that is being designed because existing solutions do not have such properties. The next important design specifications are data analyzability, ease of use by both doctors and patients, and engagement time. These design specifications in the Pugh chart account for more specific criteria outlined in the original design specifications regarding the usability of the solution. The final chosen design should be convenient to use and take less time to complete data recording. Additional design specifications that bear less weight are accuracy of input, development time, cost, and easy to learn. Below is the Pugh chart and explanations for the score given to each solution.

Pugh Chart

Design specification	**Weight**	**1. Mobile app**	**2. Web app**	**3. Mobile app that redirects to website**	**4. Pen and paper**	**5. Physical device + mobile app**
1) Accessibility	10	6	9	6	10	2
2) Messaging capability	10	10	10	10	0	10
3) Patient compliance	10	10	9	10	2	6
4) Data analyzability	8	7	10	10	2	7
5) Ease of use by doctors	8	2	10	2	7	2
6) Ease of use by patients	8	8	10	10	3	2
7) Engagement time	8	10	8	9	4	6
8) Accuracy of input	6	5	8	8	8	10
9)Development time	6	5	7	6	10	3
10) Cost	4	5	10	5	6	1
11) Easy to learn	2	6	6	6	8	3
Final score		**664**	**806**	**704**	**460**	**478**

Table 1: Pugh Chart

1) Accessibility: This refers to how easily the users of the product can access the recording system. Accessibility can be affected by the type of device a user owns, and the ease of distributing the final product. Higher scores represent more accessible and compatible solutions. The mobile app has a lower score (6) for this criterion than the web app (9)

because multiple versions of the app must be developed to account for the operating system of different devices. The web app can be accessed by almost all kinds of web browsers, as long as the user has internet access. Pen and paper has the highest score (10) because it is not limited by the type of the device a user owns, and it could be easily distributed. The physical device has the lowest score (2) because the device would be installed on the toilet and the user cannot use the device while he or she is away from home.

2) Messaging capability: Users should be able to send messages to doctors. All solutions that include web apps and mobile apps can let users send messages. But pen and paper solutions can not have this function.
3) Patient compliance: This refers to the capability of motivating the users to regularly interact with the app. The pen and paper recording method (2) is difficult to have features that motivate users. On the other hand, the mobile app (10) and web app (9) could have gamification design, so patient compliance could be maximized. The score for the mobile app is slightly higher than that of the web app because in a mobile app, notifications could be sent to the device to remind the user.
4) Data analyzability: This refers to the product being able to analyze and display analyzed data. All solutions including mobile apps (7) and web apps (10) can conclude and analyze data. The web app can utilize more advanced web frameworks to process and visualize the collected data, hence receives a higher score than the mobile app. However, data collected in the traditional pen and paper recording is difficult to be processed and gets the lowest score (2).
5) Ease of use by doctors: This refers to how easy it is for the doctors to use the product to monitor patient progress and be able to update the survey questions as needed according to the treatment procedure. As doctors typically use computers in their office, it would be easier for them to use web apps (10) than mobile apps (2). Using pen and

paper (7) wouldn't be too difficult as well as it has been the conventional method of patient symptoms tracking.

6) Ease of use by patients: The process of logging data must be easy for the patients. Both the web app (10) and the mobile app (10) will be easy to use. Pen and paper (9) should also be easy, but there could be some inconvenience caused by losing the sheet. The solution involved in a physical device (2) may be challenging to use since the patient must become familiar with operating the physical device. Also, physical devices are prone to arbitrary malfunction.
7) Engagement time: The amount of time required to take the survey every day. A shorter engagement time is highly preferred, as patients may get bored on taking long, repetitive surveys and may quit because of this reason. Having everything integrated in a mobile app will make it faster for users to find the survey than finding the webpage from a stack of tabs. Also, mobile apps use slide bars for setting the score while web apps use radio buttons, and the former option takes less time than the latter. Though, the difference in time commitment for both is not significant, so the mobile app solution got (10) and web app got (8). The third solution is as easy to locate as the mobile app, but has one more step of opening the browser link, so its score is (9). Using a mobile app with physical design inherits the convenience of a mobile app, but extra time is needed for taking care of the physical device, so it got a (6). Using pen and paper wastes time in preparation for writing, and it also takes extra time to archive the results. Thus, it only scores (3).
8) Accuracy of input: Mobile apps usually use slide bars to do rating, while web apps use radio buttons. Research has shown that the slide's starting position on a bar will affect the score[2]. Moreover, using slide bars to do questionnaires has been proved to have a higher discrepancy in measurement than using radio buttons[3].
9) Development time: This refers to the time required to develop the solution. Higher scores indicate faster development time. Pen and paper solution has the highest score (10)

because it is easy to develop. The physical device takes the longest time so that the score is the lowest (3). The web app (7) will take less time than the mobile app (5) because for the mobile app, at least two versions of the app should be made, one for iOS and one for Android. The app that redirects to the website (6) will be in between the web app and mobile app because it involves creating both solutions.

10) Cost: A higher score is given to the solution that has a lower cost. The cost for the physical device (1) is the highest because it requires the cost for the material. The web app (10) is cheaper than the mobile app (5). Maintaining a website on the AWS EC2 t2.micro instance is free. In order to publish mobile apps to the app store, a one-time developer fee of 25 dollars must be paid. However, mobile apps could be still cheaper than pen and printing papers (6).
11) Easy to learn: This refers to how easy it is to initially learn how to use the product. A higher score represents a solution that is easy to learn. Learning the use of mobile apps and web apps is a similar process so that the score is similar. Using pen and paper is easiest for people of all ages to learn so that the score is highest. Physical devices combined with apps may take the longest time to learn so that the score is lowest.

According to the final scores in the Pugh chart, the best solution is the web application. Web application will be the most versatile platform because it is well-suited to be used by both the patient and the physician. The website layout could be adjusted to be viewed on both a handheld mobile device and a desktop computer. Since one product will be created for both the patient and physician, each user can choose his or her preferred method to access the recording system. Creating a website reduces the development time significantly compared to creating a mobile app. In order to make the recording system available to as many patients and doctors as possible, the product should be developed in both iOS and Android. However, this would be a separate procedure, and not efficient. Also, with the web application, more features

could be implemented to increase user compliance as there are more various web frameworks that could be used. Furthermore, a web application has lower cost. Because of these reasons, a web application has been chosen as the final form of the solution.

Overview of the Chosen Solution

Based on the analysis in the previous section, the web application has been chosen as the final solution. The website will include three main pages: dashboard, survey page, and result page. A navigation bar will allow the users to switch between pages. A big title of PHI-TEST and a logout button should be present above the navigation bar.

The dashboard

The dashboard will be the first page that users see after logging in, so it must give an overview of what this web app is about and it should grab users' attention as quickly as possible. As shown in Figure 5, different features are modulated into blocks of different colors. The yellow box displays a user alert, which is triggered if the survey data is abnormal or if the doctor has sent a message to the user. The blue box shows background information of the website with an emphasis on why taking routine surveys is critical for the prognosis. The pink box contains a tracking progress calendar and a button named "View Leaderboard" by clicking which will take the users to a separate page where users will be compared with (and hopefully, motivated by) other users. The calendar will be deployed with the Django calendar package.

Figure 5. Picture of a prototype dashboard page.

Survey Page

As the target audience would be patients of benign prostatic hyperplasia (BPH), survey questions will mainly focus on its symptoms. Considering the symptoms of this disease, some sample survey questions have been developed. Users can choose simple surveys or professional surveys by themselves. Simple surveys will be true or false questions only. For example, whether the user has abnormal urine or not. The professional survey questions will be more specific including each abnormal condition and more descriptions. The sample questions for surveys will include three parts: questions related to pain, questions related to urine and other questions.

Pain			
Pressure or cramping in the groin or lower abdomen		stomach ache	
Frequent pain or stiffness in lower back, hips, pelvic or rectal area, or upper thighs		Painful ejaculation	
Urine			
Blood urine	Urination frequency	Urine smells	Urine emptying
Urine intermittency	Urine urgency	Weak stream	Urine straining
Nocturia	Dribbling of urine		
Others			
nausea or vomiting		fever or chills	

Table 2. Items that will be included in the survey.

Result Page

Tracking records will be summarized and visualized in the result page. Users will be able see the trend for their own data points, and how good or bad their medication effect is compared with the average data points. Some tips generated based on the survey result will be present below the visualization graphs. The message window with the doctor will be placed right next to the graphs, encouraging users to reach out to their doctors whenever some abnormal result trend shows up. Data visualization will be achieved by using Chart.js or Plotly, as both have been demonstrated to work well with Django. The message system will be powered by Django's own messages framework. However, the choice of packages is not finalized and is still subject to changes.

User Engagement Considerations:

To promote user engagement and enhance user experience, a strategy called gamification, which means the use of game design elements in non-game context, will be implemented in the website to enhance autonomy, competence and connection[4]. Some game

design elements that can be included are score systems, progress levels and leaderboards. The score system lets users gain scores for finishing tasks such as continuously answering the survey for a certain number of days. Progress bars and levels can be used to show the user's progress based on scores. Leaderboards will display the user's username, score and ranking among all patients, and virtual badges will be rewarded to those who keep an outstanding record[5]. However, considering the fact that the target users (urological patients) consist mainly of more elderly people [6], additional reward rules should be considered. One choice is to provide “real” benefits, for example letting users redeem their scores for a discount when they visit the doctor next time. Another idea is to send attractive advertisements like “keep tracking and get the chance to win a $200 gift”.

Another possible feature to add for this purpose is using a chatbot to encourage and remind the users, as experimental research has shown that adding this kind of supportive chatbots can indeed increase user engagement, and lower the probability that a user quits [7].

Website’s improvement considerations:

To help improve the website design and to perform analysis on the effectiveness through the assessment of gamification, feedback from users is needed. However, since this portion is needed only before the launch of the final website, the portion will not be directly implemented in the three pages. There will be a link to a specific feedback page for users. One section of the feedback page can be about the gamification design with the following questions:

- The rewards system, progress levels and leaderboards are interesting (strongly agree to strongly disagree)
- Difficult to understand the reward systems(strongly agree to strongly disagree)
- Do not want to see the scores or leaderboards(strongly agree to strongly disagree)
- Other suggestions

Proposed Budget

Since this project does not have a physical prototype and will entirely be created with programming, renting the server will be the only cost for making the prototype. Currently the top choice is AWS EC2 t2.micro instance, as it allows up to 750 hours of use free of charge each month. In the case that the program exceeds the allocated memory, it may incur a small amount of fee, usually under $10. This can be covered by the students as the memory limit will not be exceeded in most cases.

Moreover, determined by how the reward system will eventually be like, an additional budget of about $200 may be needed to cover the benefit provided to the users. However, this is not required, and this could also be supplied by the students if needed.

References

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