



Improving Medication Adherence, One Pill at a Time

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Summary

Pillpal is a mobile application that combines positivity and emotional support in order to improve medication adherence. Pillpal's target users include patients who have a chronic disease and must regularly follow a medication regimen. It includes those who need to take their medication for the benefit of their long-term health, but who do not necessarily receive immediate perceived benefits from their treatment.

There is no one-size-fits-all solution to medication nonadherence. However everyone can name a simple trigger that reliably brings him or her joy. It might be a picture of a puppy napping, a forgotten uplifting song, or a short note from a loved one. Pillpal delivers these triggers as rewards to patients who successfully stick to their medication schedules. Typically, when it comes time for patients to take medication they, at worst, feel unhappy or agitated and, at best, feel neutral. Instead of delivering a jarring alarm, indicating that it's time to take medication, Pillpal repurposes the reminder as an opportunity to experience peace and joy.

Introduction

More than 187 million Americans take one or more prescription drugs, and as many as half are not taking medication as prescribed by their doctor.¹ This can have dangerous consequences for patients, and it leads to waste within the healthcare system. There are dozens of reasons a patient might be nonadherent, and there are even more products and services — in the form of apps, pill modifications and behavioral health interventions — that attempt to address these issues.

Our research has revealed that there is no one-size-fits-all solution. As a result, we created a mobile application that can be customized by our users, in particular those who are struggling to remember to take their medication. The application employs positive affect — a state of pleasurable engagement with the environment — in order to help patients stick to their drug regimen.

Everyone can name a simple trigger that reliably brings him or her joy. It might be a picture of a puppy napping, a forgotten uplifting song, or a short note from a loved one. When these things are experienced, they have the potential to briefly move an individual to a place of positivity. Pillpal delivers these triggers as rewards to patients who successfully stick to their medication schedules. Typically, when it comes time for patients to take medication they, at worst, feel unhappy or agitated and, at best, feel neutral. Instead delivering a jarring alarm, indicating that it's time to take medication, Pillpal repurposes the reminder as an opportunity to experience peace and joy.

¹ *Improving Patient Medication Adherence: A \$290 Billion Opportunity*. Report. Accessed May 01, 2017. http://www.nehi.net/bendthecurve/sup/documents/Medication_Adherence_Brief.pdf.

The Nonadherence Problem

Medication nonadherence can be costly for both for patient health and the healthcare system as a whole. The American College of Preventative Medicine (ACPM) defines nonadherence as the intentional or unintentional overuse or underuse of prescription medications. It occurs when patient behavior does not coincide with medical or health advice. A study in the *Journal of the American Medical Association* found that 59 percent of adults in the United States reported that they take prescription drugs, and studies have estimated that approximately 50 percent of patients do not take medications as prescribed.^{2,3}

Nonadherent individuals are at a greater risk for increased morbidity and even death, and 30 to 50 percent of treatments are unsuccessful due to a failure to stick to a medication regimen, according to the ACPM.⁴ Health events related to nonadherence are estimated to be responsible for \$100 billion in medical costs per year.²

Why Patients Miss Their Medication

The reasons for nonadherence are often complex and situational. The World Health Organization concluded in an analysis that successful adherence is the result of an optimal interaction between the social environment, patients and healthcare professionals.⁵ Some of the most common patient-reported reasons for not taking medications include forgetfulness (30%),

² Brown, Marie T., MD, and Jennifer K. Bussell, MD. "Medication Adherence: WHO Cares?" *National Center for Biotechnology Information*, April 2011. Accessed May 1, 2017. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3068890/>.

³ Kantor, Elizabeth D., PhD, Colin D. Rehm, MPH, and Jennifer S. Haas, MD. "Trends in Prescription Drug Use Among Adults in the United States From 1999-2012." *JAMA*, November 3, 2015. <http://jamanetwork.com/journals/jama/fullarticle/2467552>.

⁴ "Medication Adherence - Improving Health Outcomes." American College of Preventative Medicine. Accessed May 1, 2017. <http://www.acpm.org/?MedAdhereTTProviders>.

other priorities (16%), deciding to omit a dose (11%), lack of information (9%), and emotional reasons (7%) (27% of patients gave no reason), Duke University Health Services Researcher Hayden B. Bosworth, PhD, has reported.⁵ In particular, the WHO has emphasized the importance of improving adherence when it comes to taking long-term treatments. Adherence in this situation is often especially low when the disease being treated is asymptomatic, and a patient does not perceive the benefit of taking medication.

Our own research performed through interviews with a dozen patients and healthcare professionals indicated that forgetfulness, irregularity of schedule, aversion to taking medication and a complex regimen are common reasons patients do not take their medications as prescribed. Bosworth writes that the multitude of reasons for nonadherence can fit into one of three categories:

*1. Health literacy barriers related to not knowing what to do and why. 2. Behavioral barriers that address not having the skills necessary to accomplish medication management in the context of everyday life. 3. System or administrative barriers related to access and fragmentation of care.*⁵

Positive Affect Intervention

Another piece of research that informed our approach to this problem included a study on positive affect's impact on medication adherence. The study's authors from New York University School of Medicine defined positive affect as "a state of pleasurable engagement with the environment and reflects feelings of mild everyday happiness, joy, contentment, and

⁵ Bosworth, Hayden. *Enhancing Medication Adherence The Public Health Dilemma*. Dordrecht: Springer, 2013.

enthusiasm.”⁶ Researchers monitored adherence (via electronic pill bottles) in 256 hypertensive African American patients. They found that a positive affect intervention, coupled with education about the disease, was more effective than education alone.

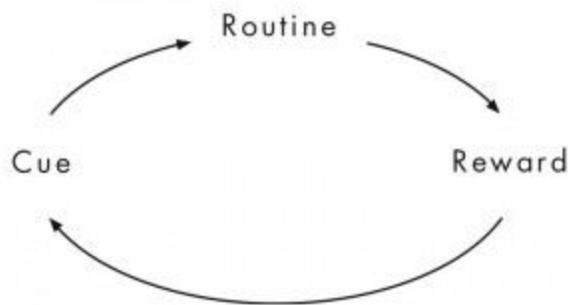
Patients in the positive affect group were regularly prompted to identify small things in their lives that invoked positive feelings. They were then asked to incorporate these thoughts into their daily routines. Individuals in this group were also sent surprise gifts. After 12 months, researchers found that, with 42 percent achieving adherence, medication adherence was higher in the group that received the positive affect intervention than in the control group, in which 36 percent were adherent.

The Habit Loop

Our research also led us to literature on habits and how individuals form them. More specifically, journalist Charles Duhigg thoroughly reviewed the literature on habit formation and presented a thorough summary in his book *The Power of Habit*. We looked here for inspiration, as, ideally, successful medication taking can become as routine as remembering to brush your teeth. Duhigg describes the process of carrying out a habit as follows:

This process within our brains is a three-step loop. First there is cue, a trigger that tells your brain to go into automatic mode and which habit to use. Then there is the routine, which can be physical, mental or emotional. Finally, there is a reward, which helps your brain figure out if this particular loop is worth remembering for the future.

⁶ Ogedegbe, Gbenga, MD. "A randomized controlled trial of positive-affect intervention and medication adherence in hypertensive African Americans." *JAMA Internal Medicine*, February 26, 2012. Accessed May 1, 2017. <https://www.ncbi.nlm.nih.gov/pubmed/22269592>.



Over time, this loop — cue, routine, reward: cue, routine reward — becomes more and more automatic.⁷

With enough repetition, a habit is born. The loop is simple in theory, and while many existing medication reminder systems (discussed below) seem to attempt to establish a habit, they do not build in a third step — the reward. In some cases, a built-in reward for taking medication is unnecessary because the act of taking medication itself provides a reward. For example, when an individual has a headache, she might take ibuprofen, and the reward is relief from the pain. However, there are many other conditions that require medications that do not produce any immediate or perceived benefit. For example, hypertensive patients often do not experience symptoms as a result of their high blood pressure. Regular medication is needed to

⁷ Duhigg, Charles. *Power of habit: why we do what we do in life and business*. New York: Random House Trade Paperbacks, 2014.

prevent damage to blood vessels, though. If too much damage occurs, it can lead to heart attack, stroke or heart failure in the long-term.

All of our research led us to believe that, since our product would target a particular patient population that does not receive an immediate perceived benefit from taking medication, it was important to provide some kind of reward to the user for successfully taking medication. This is in line with the habit loop concept. It is not enough to provide only a cue — an alarm on a smartphone for example. According to the habit loop, this alone will not trigger the routine — specifically, the act of taking medication. In order to propel the action following a cue, a reward must be provided so that the habit loop is completed.

Existing Solutions

Medication Reminders

There are more than 100 smartphone medication adherence apps. The vast majority of these are designed to act alarm systems, which remind users to take their medication at set times.

⁸ Among these is an application called Medisafe, which is widely regarded as one of the best solutions in this category. More than 4,500 users have reviewed the app on iTunes, and it has a rating of 4.5 stars out of 5. Yahoo Tech Journalist David Pogue declared it the clear winner among medication reminder apps after he conducted a review of 47 mobile applications in the

⁸ Aungst, Timothy Dy. "Smartphone medication adherence apps: Potential benefits to patients and providers: Response to Dayer et al." *Journal of the American Pharmacists Association* 53, no. 4 (2013): 344-45. doi:10.1331/japha.2013.13102.

space.⁹ In addition to providing reminders, Medisafe provides several other main features: a way to manually enter the medication name, illustrations of the medications, a to-do list that displays which medications are coming up, and the option to monitor other users' adherence in order to hold them accountable. The main cause of nonadherence that the app aims to address is forgetfulness.

Pill-Focused Systems

Other organizations have looked beyond the mobile app in order to tackle this problem. Proteus Digital Health has developed an ingestible sensor the size of a grain of sand. When embedded in a tablet, it can indicate that a patient has taken his or her medication upon consumption. This information is then tracked in Proteus' system so that patients — and doctors — can monitor their progress.

Another solution developed by a company called PillPack takes a patient's medication list and creates personalized packages based on which medications should be taken on certain days and at certain times. PillPack then ships its customers these pre-sorted packages so that they don't have to manage the sorting of the pills themselves. Both Proteus and PillPack aim to address the problem of a complex regimen.

Punitive and Positive Approaches

Lastly, there are solutions that employ behavioral economics concepts to help users achieve their goals. The use of punitive measures are popular approaches among many of these

⁹ David Pogue. "David Pogue tested 47 pill-reminder apps to find the best." Yahoo Finance. March 21, 2017. Accessed May 1, 2017. <https://finance.yahoo.com/news/david-pogue-tested-47-pill-reminder-apps-to-find-the-best-154017023.html>.

systems. For example, Wellth created a solution that aims to increase adherence among heart failure patients who have recently been discharged from the hospital. Upon enrollment into the program, patients receive \$100. Then, for every time they are nonadherent, they lose \$2 of that money.

One system called Mango Health, which provides a mobile application that is, at its core, a medication organization and reminder tool, does provide a form of rewards to patients who successfully stick to their medication regimen. These rewards come in the form of a gift card to stores like Target or Starbucks as well as money that the user can give to charity. However, these rewards are not guaranteed. If users successfully stick to their medication taking goals, they are entered into a weekly raffle for a chance to win these items. Our solution is different in that it is more closely aligned with the habit loop discussed above; after a cue, Pillpal incentivizes the action of taking medication, as it reliably closes with a reward each time. We elaborate on this in a detailed description of Pillpal below.

Our Solution

Through all of this research, we found the current market for medication reminder systems is missing a method that goes beyond a basic alarm, and that shifts the perception of the medicine taking experience away from the traditional view of being a negative nuisance to a positive and enjoyable one. This inspired Pillpal, a medication reminder system that associates the medication taking experience with a positive trigger.

The system takes in information about a patient's medication, which can either be entered manually or pulled from the patient's electronic health record available on the Epic system. When a user receives a pill reminder, he or she will also receive a positive trigger. These triggers are used as an opportunity to cultivate a peaceful and positive experience to create an association between taking medication and feelings of tranquility and happiness. Lastly, Pillpal captures self-reported adherence information which is summarized in a report and integrated with a patient's Epic electronic health record.

Because all patients are different and no one intervention will work best for everyone, we provide a menu of options for positive triggers. The mobile application includes the following content:

- Messages from loved ones
- Positive music
- Visuals — i.e. cute animal pictures, travel pictures
- Comic strips

Messages from loved ones are used to help inspire sentiments of love and reinforcement from support groups. A user can select friends and families as part of his or her support group, and use their support to motivate the user to continue with his or her medication regimen. This is applied either through a text message from a support group member, or by notifying chosen support group members about when the user misses a pill.

All of these triggers are intended for the mobile application to provide a positive experience while taking medication in order to encourage users to improve compliance of prescribed medications and help make the entire experience more enjoyable.

Process

User Research Methods

We employed four research methods: surveys, interviews, competitive review usability tests and usability tests. A survey was conducted to understand patients and medication taking trends at a high-level, as well as to validate our research questions. Interviews focused on gaining deeper insights about user behaviors, needs, and pain points. These conversations informed our decisions throughout the entire application design and development process. We performed two different types of usability tests — a competitive review of another application and a test on version one of our own application — with different goals in mind. The competitive review was conducted with MediSafe, a popular medication reminder app. We aimed to observe how users interacted with this existing application so that we could learn the strengths and pitfalls of an application with similar functionality. We later conducted usability tests on the Pillpal app so that we could understand user expectations and experiences with version one of our own product. We plan to incorporate findings from these tests into future versions of the app.

Questions and Goals

The high-level goal of our user research was to understand medication adherence behavior (i.e. why people miss medication) as well as users' interactions with medication

adherence apps. To this end, the team researched target users who take medication — including both those who successfully take medication and those who find it difficult to do so. The two questions we tried to answer were: 1) What are the challenges for patients when it comes to successfully taking medications and adhering to their regimen? and 2) How can we make the process of entering medications and setting up reminders more manageable, efficient, and enjoyable?

1. Survey

The first method that we used for user research was a survey. The use of the survey was twofold. First we wanted to get a lay of the land and understand if the problem that we aimed to address — forgetfulness — was actually a problem among our intended users. Before we even began the user research phase, we did an extensive literature review on the problem of medication nonadherence. We also saw statistics and numbers that supported our hypothesis that medication nonadherence is a big challenge for the medication taking population. Most of these studies focused on chronically ill patients who were categorized as older adults. We wanted to test how this problem plays out in a somewhat younger population, which would be the target user for the product; they would be more likely to use a smartphone-based tool, as they tend to be more tech-savvy than older adults.

Second, another hypothesis we had formed based on the literature and interviews with doctors was that the problem of medication nonadherence involves factors other than forgetfulness. We categorized all of the factors that we had heard or read about as either a memory problem or motivation problem. Our hypothesis was that motivation would be a major problem with medication nonadherence. More specifically, patients might not take medication

because of bad side effects, or not having enough knowledge about the medication. In other cases, they experience no immediate or perceived benefit from taking their medication.

As a result of our research, the two basic questions we were trying to get answers to were: “Would people really say that they have problem with sticking to their medication regimen?” and, if so, “Is it is more of a memory problem or motivation problem?” The second use of the survey was to recruit people for the next round of user research, i.e., in-depth interviews.

A. Survey Design

The recruitment for the survey was done via convenience sampling. The criterion was that only those actively on medication should take the survey. We posted the survey on the UC Berkeley School of Information Noise Slack channel and Noise listserv. The channel and listserv have almost all current and past Information School students, staff and faculty. We did not ask for any demographic or identifying information because of the sensitive nature of our enquiry. There were two branches the survey could take, depending on whether the respondent reported as having a medication adherence problem or not. There were a total of four to five questions depending on the branch.

The survey started with general broad questions aimed at making sure that the respondents actually do take medication. The first question asked: How many medications do you take? We also included different types of possible medications like pills, inhalers, eye drops, etc. We included this because medication can be of different types. However, many do not

necessarily think of all these types as medication, and we were concerned with learning about all of them. It was a closed category question with 1, 2, 3, 4 and 5 or more as options.

The next question was concerned with how many times respondents take medication in a day (with similar options as above). Apart from making sure that respondents actually take medication, we also wanted to see if people with a more complex regimen (more medication, more times per day) would have a harder time sticking to their regimen. So we asked if they face a problem sticking to the regimen. If they answered yes, they moved to branch two, where we gave them a closed category of options about the type of problem. The last category was “other,” and it allowed them to write in detail how they would describe their problem. Our categories included more specific problems that could either be classified as a memory or motivation problem. At the end of the survey, we gave respondents an open response question in order to allow them to elaborate more about their experience and to leave their email if they were willing to discuss more.

B. Survey Results

We received a total of 22 replies on the survey. Fifteen out of 22 people said they took just one to two medications. Similarly, a large majority (14 out of 22) reported that they took medication once or twice a day. Although a majority of people indicated that they had a simple regimen, we did see some extremes where people took more than five medications. Some took medication more than four times a day. Seventy-three percent of people indicated that they do have problem sticking with their regimen. This supports our first hypothesis that the problem actually exist — even in a younger population.

Surprisingly though, the biggest problem that came out of the survey data was “forgetfulness” which falls into the realm of a memory problem. This meant that going forward, we could not ignore the learning that people sometimes miss medication just because they forget. This is why we focused on scheduling as the central feature of the app.

The other option, which allowed patients to write about their problem in their own words, also led to some interesting observations. For example, individuals shared that they forget to take their medication if they go out (change in normal schedule), or if they get drunk, or because they have just gotten used to suboptimal health. People also shared interesting insights in the last open response question. Some people highlighted the role of habit. As expected, we did see that people with a more complex regimen have a problem sticking to medication. We contacted those who took the survey, including both those who had a problem of medication nonadherence, as well as those who did not — that way we could learn about what they were doing right. We followed up with those who agreed to speak with us in an interview.

2. Interview

We felt that this research method would be key in our quest to gather rich, qualitative insights about a person’s attitudes toward medication and his or her medication taking behavior. A person’s medication habits and preferences can often be a very private matter — one that is hard to get access to through something like a survey. In order to learn about these intimate nuances, we needed to build a rapport with our participants. Since it is hard to broach a topic like a person’s medication habits, most people that we recruited were friends who we knew had been on medication, or friends of friends who we were able to reach out to. While our sample was

partially convenience, we tried to keep it representative and random by also recruiting people from our initial survey who agreed to being contacted for a follow-up. All in all, we conducted more than a dozen interviews with both patients and physicians.

When beginning our interviews with patients, we told the participants that if there was a question that they felt uncomfortable with, they did not need to answer a question if they felt uncomfortable. Some of the questions included were:

- Can you tell me a bit about your medication taking history or condition?
- How long have you been taking this medication?
- What are the biggest challenges that you face in keeping up with your regimen?
- Do you use any methods to remind yourself of your medication time?

In structuring these questions, we also wanted to ensure that the protocol flowed, so that the participant was always primed for the question that followed next. This report discusses many of the findings we obtained through interviews in a separate section called “Insights” below.

3. Competitive Review Usability Testing

We conducted four usability tests on the Medisafe pill reminder app and found useful insights about the user comfort level and pain points. We tested the app on Android for two users and iPhone for two users. There were a total of six tasks, some of which hit the core feature of a reminder app like adding a pill, editing and deleting. Other tasks were more advanced and sought to explore very specific features in the app. Below are the key takeaways from the test.

Areas/features That Users Liked or Found Helpful:

- Entering the medication itself is straightforward, as the app guides user to enter the medication when they first install the app.
- Autocompleting the medication name is also helpful when the name of the medication is unfamiliar or hard to spell.
- Menu for sending the report was very straightforward and easily visible.

Problems Users Experienced:

- There is an overwhelming amount of information when finding the right medication, mainly caused by the number of variants of the same medicine.
- Entering the time for medications was cumbersome as it relied on scrolling the hours and minutes for each timing.
- There is lack of explanation for some fields that users found to be too technical and/or confusing (e.g. Rx Number).
- The menu for editing or deleting the medication is hard to find, and it is unclear whether the medication has been modified for all repeating alerts or for just the single instances (lack of confirmation).
- It is unclear where to change the alert settings. The alert menu in settings only allows the user to change the ringtone.
- It is unclear what a Medifriend is and how a Medifriend is different from other friends or doctors.

Recommendations:

- A tutorial or a help menu can assist first-time users to understand the technical aspects and navigate through detailed menus with less frustration, and increase learnability of the app.
- Improve information architecture by making menu options more consistent and streamlined.
- Streamline user flow for adding items to the pillbox. For example, enable entering the hour and minutes directly as opposed to scrolling. Also, display the list of searched medication in the order of most frequent usages or consider consolidating all similar medications into a single option to alleviate confusion in navigating through the myriad option of medications.
- Clarification of repeats when modifying medications (e.g. “Just for this instance” or “all following series”) will alleviate user confusion and anxiety.

4. Pillpal Usability Testing

We conducted five usability tests with Pillpal. At this stage, the mobile app represented version one of the product. Our goals included gaining an understanding of users’ expectations for the app, discovering the common issues they faced when using it, and obtaining general feedback about what users liked and disliked about the application. We collected this information with the intention of applying it toward improving Pillpal in future versions.

Users were recruited from our own personal contacts. There was one criterion for recruitment: users had to be taking medication at that point in time. Users performed the test on whichever smartphone they felt most comfortable using. Two used Android devices, and three used iPhones. The one-on-one sessions were held in quiet settings and lasted between 15 and 30

minutes. Users were asked to complete a list of eight tasks. Interactions were recorded using the laptop hugging method, and the videos were later analyzed. This resulted in the following insights:

Areas/features That Users Liked or Found Helpful:

- Users correctly understood that the “Today” page displayed a list of the medications they would take that day and the times at which they would take them.
- Users liked the look of the “Reward” page. They noted that setting up their preferences was easy.
- Adding a new medication was simple.
- Adding a contact and making them a “favorite” was easy for users.
- After users saw the reward for the first time, they reacted by saying “Oh Cool!” or “Awwwww!” One user said she liked the randomness of it because it was a surprise.

Problems Users Experienced:

- Spelling the medication name (i.e. ibuprofen) correctly was difficult for users, as the app does not have autocomplete or a drop-down menu for choosing medications.
- The concept of the app’s reward feature required an explanation in order for users to understand how they would take advantage of it and how they would set it up.
- For a given medication, users were confused between which details could be edited in “Settings” and which should be edited in the “Edit” page.
- Though adding a “favorite” contact was easy, it was not obvious to users what designating someone as a “favorite” contact meant.

- One user said that she wished that, after she added a selection from a category into her favorites, it should be deleted from that category so that she could confirm that it was successfully added to her favorites.
- On the “Reward” page, users were not sure what some of the icons represented. For example, it was unclear that an icon of a moon rising out of a horizon line represented ambient music.
- The “Reward” page screen is very click sensitive due to the display of many selectable icons. As a result, users sometimes click items by mistake.
- Only one out of five users figured out that she could swipe a medication on “Today” to retroactively record taking her medication.

Recommendations:

- As users begin to type a medication name, the application should give them a list of suggestions in order to help spell the medication name correctly.
- Some kind of tutorial for setting up the application should be provided. It could come in the form of a video that explains the concept behind the app or in a step-by-step written guide.
- The application should more clearly indicate what the purpose of the “Edit” and “Settings” pages are and what the difference is between them. Or the two pages can be combined into one.
- Icons on the “Reward” page should be clearly labeled so that a user understands what each one represents.

- “Reward” icons could have a clickable “+” sign. This way the entire icon isn’t clickable, which right now causes users to make mistakes.
- The “Today” medication list should have an indication that a user can take action here when appropriate. Perhaps a red dot could appear on the medication that has not been taken. This way, users feel prompted to address the notification.

Data Analysis

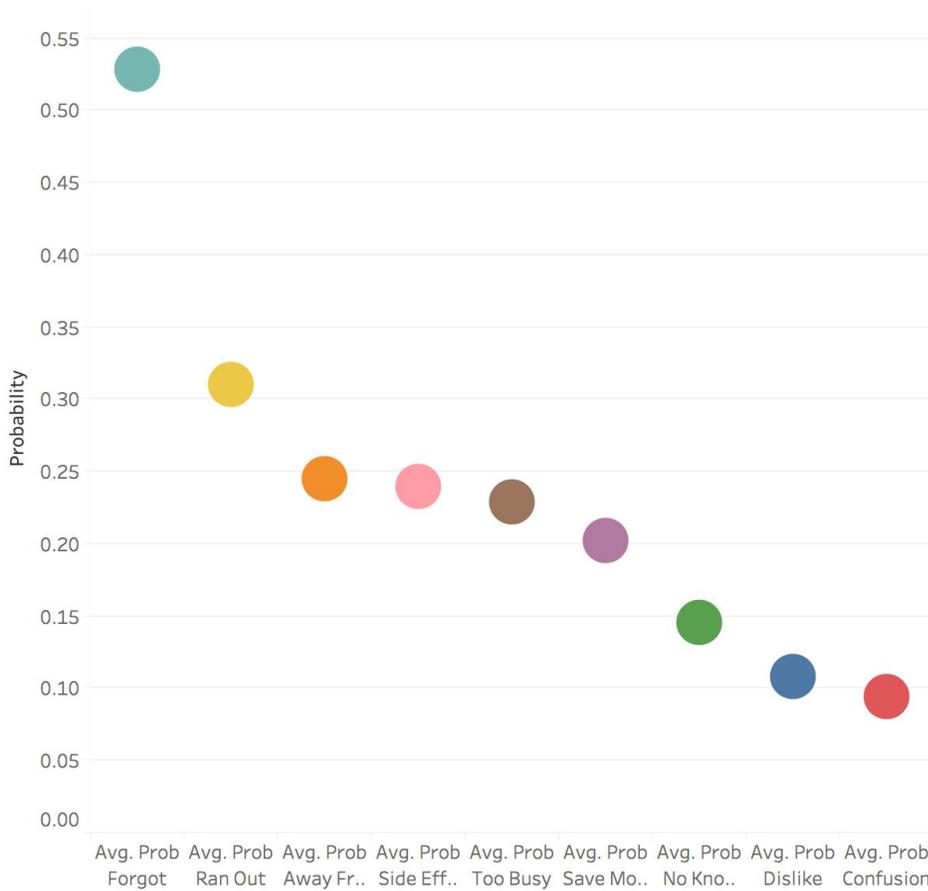
Additionally, we used neural networks to train a model to determine reasons for medical non-adherence. Using a dataset from a survey administered by the National Community Pharmacists Association and Langer Research Associates, of around 1020 adults with chronic conditions that require medication, we used demographics to predict reasons for lack of adherence.¹⁰ Given the privacy constraints in collecting health information, we focused on demographics such as sex, age, education, and income because this information is more readily available. When applying this model to our application, this data can be collected and used to provide customized solutions to users. We discuss this more in the Future Work section below. Finally, the reasons for non-adherence we used in the model were:

- Side effects
- The patient didn’t believe the treatment was necessary
- The patient was too busy or didn’t have time
- The patient didn’t understand what the medication was for
- Confusion about what to do
- The patient was trying to save money
- The patient forgot
- The patient didn’t like taking the medication

¹⁰ National Community Pharmacists Association (NCPA). NCPA Poll: Medication Adherence in America: A National Report Card, Feb, 2013 [dataset]. USMISC2013-NCPA, Version 2. Langer Research Associates [producer]. Cornell University, Ithaca, NY: Roper Center for Public Opinion Research, RoperExpress [distributor].

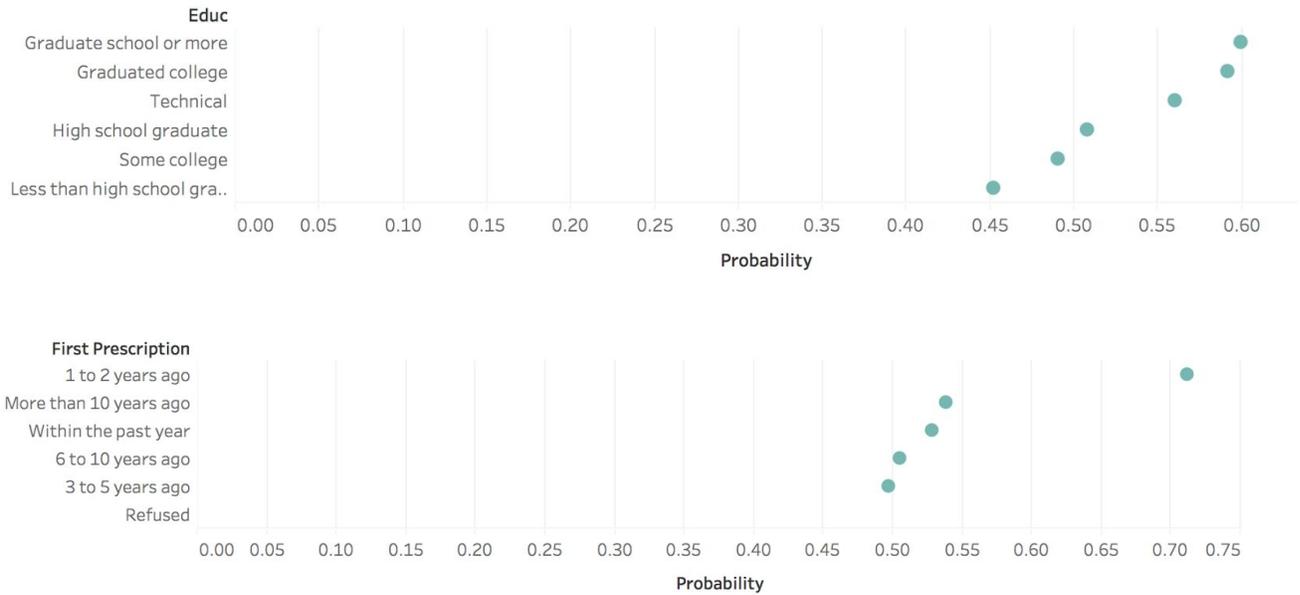
- The patient ran out of medication
 - The patient was away from home and didn't have medication available
- From our model, we found that the top predicted reasons for non-adherence were

forgetting to take medication and running out of it. The figure below visualizes all of the potential reasons for non-adherence included in the survey and the average predicted probabilities.

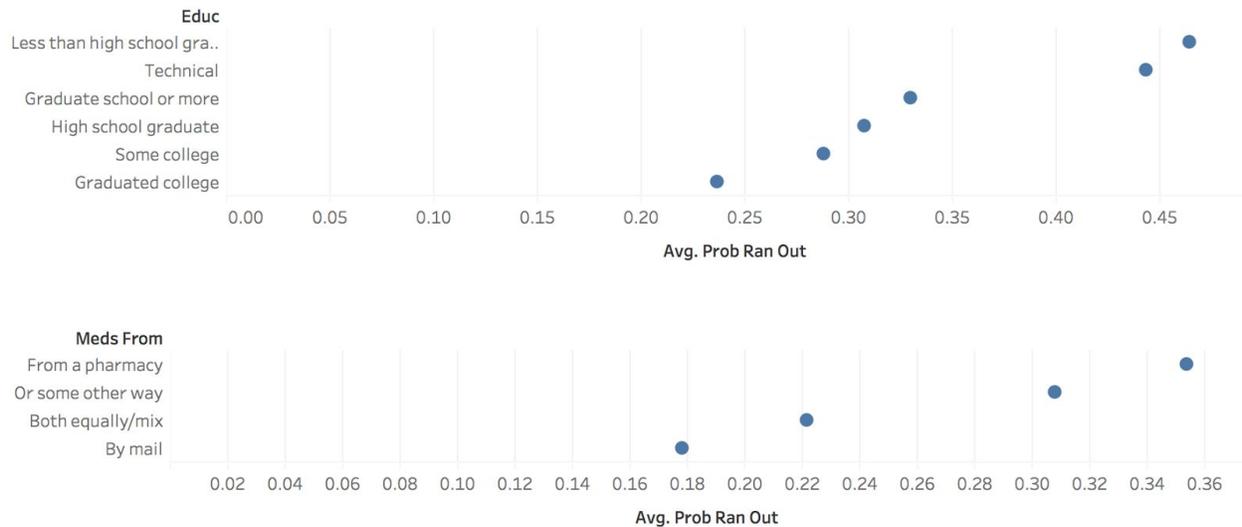


This conclusion provides support for the necessity of a useful reminder solution. We dug further into this area to answer the question: what types of people are forgetting to take their medication most frequently?

The figures below show that adults with more education are more likely to forget to take medication. Additionally, patients who have most recently started a new medication are also more likely to forget, making them a great user group to target when distributing this application.



Other interesting results included the types of people who are predicted to run out of medication. We also found that less educated patients and those who receive medication by mail are more likely to run out of medication.

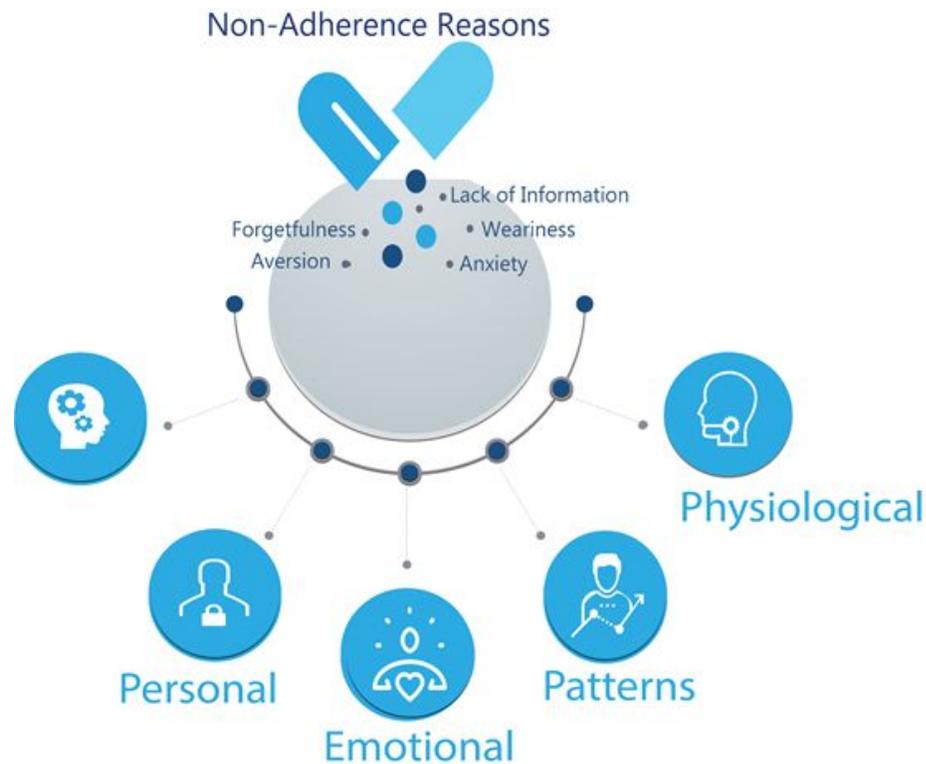


Insights

Our research and literature review helped us to gain some key insights into the experience of taking medication. We learned that the experience is much more than just remembering to take the pill and the physical process of actually popping it. We learnt that the pill is also a reminder of the underlying condition and how the person taking the pill feels about it. The experience is filled with emotions, and each person's emotions are very unique. Furthermore, how different people work their way through these emotions is also very unique. As we learned more about the process, we found some resonance with factors causing medication non-adherence as discussed in medical journals¹¹, which included reasons like lack of information, anxiety, financial issues etc. In addition, we found that there were a few factors that hadn't been understood and/or documented that well, including aversion and weariness of taking medication. We delved deeper into these less explored reasons, and gleaned very valuable

¹¹ "Medication Adherence - Improving Health Outcomes." American College of Preventative Medicine. Accessed May 1, 2017. <http://www.acpm.org/?MedAdhereTTProviders>.

insights while working with people taking medication. Our key insights are discussed in detail below.



1. Cognitive

We learned that there is a cognitive component in the process of remembering to take the pill, and it gets more involved as the number of pills increases. At times, the complicated names and dosage instructions of the medication add further to the problem and make it harder for people to remember and keep track of their regimen. Some conditions cause people to become feeble and reduce their cognitive abilities. In such cases, the problem gets even worse. Moreover, age also contributes to feebleness and decline in cognitive abilities and these issues get magnified for the older population. Last but not the least, the process of remembering if one has

already taken the pill is just as important and cognitively involved as the process of remembering to take pill in the first place.

The following quote by David Pogue¹² highlights some of the issues discussed above:

“When I was recovering from a kidney stone last year, my doctor told me to take ibuprofen, two pills, four times a day; phenazopyridine, one pill, three times a day; ciprofloxacin, two pills twice a day; docusate sodium, one capsule, three times a day; and solifenacin succinate, one pill, once a day.

Seriously? You’d need a spreadsheet!

Now imagine that you’re on 10 prescriptions. Or 20. And you don’t have to be old and feeble to have trouble.”

As discussed before and summarized by the quote above, there is a high cognitive cost to the process. We also were alerted to the fact that older people often have multiple chronic conditions and have to be on a lot of different medications. While this adds to the cognitive load of remembering, it also involves being aware of potentially harmful drug interactions, which patients need to be mindful of while taking their medication. On the other hand, we saw that the same problem manifested itself in younger people when they had irregular schedules as a result of weekend/weekday routines, travel etc.

¹² David Pogue. "David Pogue tested 47 pill-reminder apps to find the best." Yahoo Finance. March 21, 2017. Accessed May 1, 2017. <https://finance.yahoo.com/news/david-pogue-tested-47-pill-reminder-apps-to-find-the-best-154017023.html>.

2. Emotional

As discussed at the beginning of the section, popping a pill is more than a just a memory problem, involving remembering to take medication at the right time. The pill is also a reminder of the underlying condition, and that could be associated with several emotions. These emotions could have a huge spectrum depending on the condition, the person's stage in the treatment, the person's stage in life and individual personality. We discovered a huge range of emotions in our research — they spanned from annoyance from a short-term antibiotic course, to resignation over a change in life plans due to a condition related to an immune system disorder, from anxiety about trying out a new drug and not knowing if it would work or if it would cause more side effects than relief, to disappointment about the fact that the patient would need to be on the particular medication for the rest of her life.

As discussed above, since the range of emotions relied heavily on the person's condition, personality, life stage and treatment stage, the emotions one went through on a day to day basis varied a lot. There is very low predictability and pattern in such emotions. Emotions inherently are convoluted and adding all these hugely varying dimensions just made it more complicated. Fortunately, we also learned that people close to the person taking medication often understood what the person is going through. We learned that close friends and family had a good understanding of what emotions are running through the person's heart. We heard heartwarming stories of how partners and close friends had said just the right things at the right times to lift up the patient's spirits. The following quotes from our users summarize some of these emotional journeys.

“Six months into my married life, I learnt about this condition. My own immune system, which was supposed to protect me, was attacking my body. I was heartbroken at first and could not have gotten through it without support from my wife.”

“I was having this painful cystic acne and I could not even eat because of the pain. When I had my meds and complained about the horrible after taste, my friend would often joke and say, atleast now you can eat! I would laugh and forget about it.”

We encountered other stories of people who had been through conditions like cancer and had to work on their financial plans to be prepared for the worst, which involved additional intense and unique emotions.

3. Personal

After learning that the pill taking experience is filled with various emotions, we further learned that just as the emotions one goes through are unique, individuals have unique ways of dealing with them. In fact, we learned that even when different people had the same emotion, they dealt with it in different ways. At this point, personal and emotional may sound very similar and interrelated, but the amount of variation we saw along the personal dimension caused us to treat this as a separate factor so that we could account for it separately in our solution.

Just like we needed to create a space for emotions, we needed to think about enabling users with ways to deal with them in their own way. The following stories might help

disambiguate the difference a bit more. Sally (name changed), had a condition that her mother had also dealt with. She understood that she would need to deal with the condition on a long-term basis and try out different medication until she found something that might work well for her. Additionally, she would be in pain and suffering all this while. She was also good with taking her medicines, except for a few slips here and there. However, she saw the idea of sharing her journey and pain with friends and family as burden. She wanted to deal with her situation in her own way. She shared that she would turn on her favorite TV show when she was in pain because she knew she had to ride it out. This way of dealing with the situation is very different from the user who said that he could not have dealt with his situation without his wife's support.

We further found evidence for this insight in Xavier Amador's piece titled "Why Won't You Take Your Medication?"¹³ where he delves deeper into the personal and emotional aspects of taking medication. Here is a question he poses to his son whom he is trying to get to take anti-psychotic medication:

"Why won't you just take your medication? I take pills for my cholesterol every night and it's no big deal."

After making various efforts to get his son to take medication and understand his struggle, he concludes by saying:

¹³ "Why Won't You Take Your Medication?" Pete Earley. October 12, 2010. Accessed May 04, 2017. <http://www.petearley.com/2010/03/12/why-wont-you-take-your-medication/>.

“I learn a lot from my son. One lesson he has taught me is that taking anti-psychotic medication is much more complicated than being told by your doctor that you have high cholesterol.”

4. Patterns

We were already aware of the importance of quantification through our literature review, and our user research further bolstered its significance. We learned that there were two dimensions to this issue: micro patterns and macro patterns, where micro patterns include personal patterns and macro patterns include condition-related patterns. Both are discussed in detail below.

A. Micro Patterns

We observed that people had a hard time recalling their own adherence patterns and even those who could recall them sometimes recalled them inaccurately. One user told us that she was young and had no issues in remembering to take her supplements. Additionally, she was well motivated to take them, as she knew they made her feel better. She recounted the following after she first saw her own adherence pattern:

“I knew that I sometimes missed taking my pills in the morning especially on one of the crazy mornings, the kind we all have sometimes. After I saw my report, I realized that I had missed on more days than I had taken it on, and that was very disappointing.”

We further heard from physicians that people had a hard time recalling how many times they had taken their medication when they were asked to do so at the doctor's office. This interferes with planning and suggesting a better treatment plan that might work for the patient, as it is hard to estimate how much the medication might have worked.

B. Macro Patterns

Through our discussion of the topic with experts in the medical field, we learned that some patterns were dependent on the particular medication in question and the condition for which it was being taken. The example that we heard the most was that of antibiotics. We learned that people usually stopped taking antibiotics on the third or fourth day or as soon, which was usually as they got relief. Particularly, in the case of antibiotics it is very important to attain 100 percent adherence, as failing to do so doesn't only harm the patient, but it also leads to the risk of not fully killing the harmful bacteria. Other patterns included missing after three days, intermittent skipping and not refilling after the first refill is due. In addition to expert interviews, as mentioned above in the Data Analysis section, we looked at datasets related to medication adherence and found that people who report lung problems (e.g. asthma, bronchitis or emphysema) are significantly less adherent than those without such problems.

Moreover, physicians shared that they could do a better analysis of the non-adherence behaviors if they had better quality of information about micro and macro patterns. For instance, not refilling after the first refill could be due to financial issues and the physician could suggest ways to address that specific problem.

5. Physiological

We learned that there was a significant physiological component to the process of swallowing pills. We heard that people found it hard to swallow pills, especially the big ones. They also reported uneasiness, nausea and feelings of the pill being lodged in the throat. These findings were further triangulated based on expert interviews wherein we heard from doctors that almost all pills can have the side effect of nausea and uneasiness. One of the classic examples of this came from a woman who was recounting her experience of taking pre-natal vitamins:

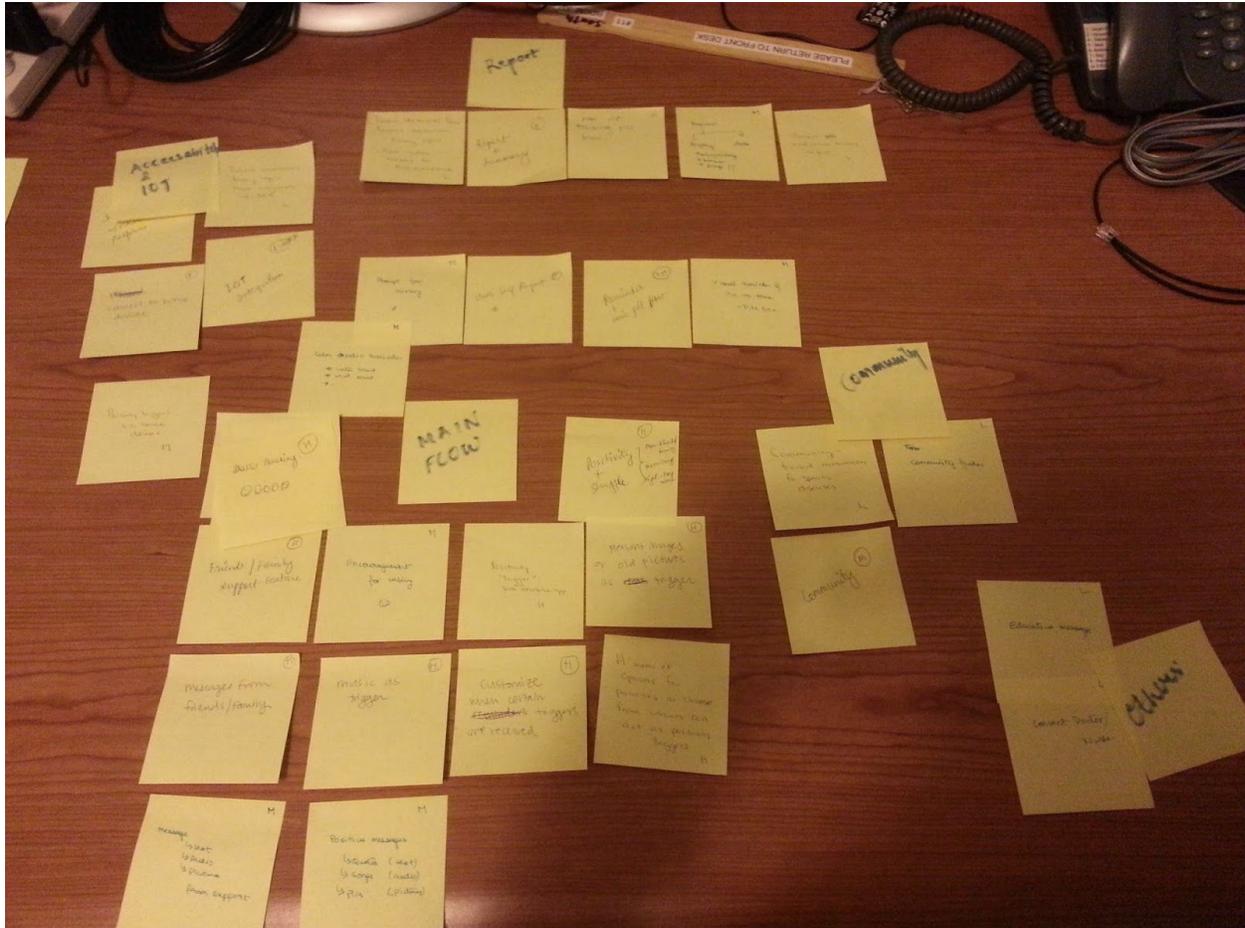
“These pills make me nauseous, especially the big ones.”

We further learned that people used aids like drinking a lot of water, smelling something pleasant or eating something e.g. candy after taking the pill to get rid of the discomfort.

Technology and Design

The literature review and user research conducted throughout the initial phases guided the final phase of product development. We also iterated through several different implementations of the idea before settling on the final solution. We pivoted from our initial idea of a home-based system to a phone app. This was because our target user group, of medicine takers that range in age from 20s to 40s, is usually very mobile and may not be at home at all times. It is important that the user gets a reminder for medication irrespective of their location. Also, based on our user

research, we learned that some users prefer the notification to be discrete and it can be more efficiently delivered via phone rather than a home based Internet of Things (IoT) device.



Feature Ideation Affinity Diagram

Main Features

Based on our survey and interviews, we determined that the biggest deterrent to following a medication regimen is forgetfulness. This, we learned, can play out in two different ways. Most of the medication takers occasionally forget to take medication if their normal day to day schedule changes. For example a student that we interviewed said he often forgets to pack his medication if he goes to spend the night at his friend's house. Since the medicine taking habit

is often built around daily routine like, dinner time or when someone gets back home from work, a change in routine or normal schedule can result in a broken habit. We also saw cases on the exact opposite end of the spectrum, where a person has become so used to taking medicine that they forget if they had taken a dose or not.

Since forgetfulness is one of the main problems, the product was designed with this problem right at the center of the solution. The central part of the application is medication scheduling and organization. In its simplest form, the app allows medicines to be added and scheduled for as many times as needed in a day. Users get a notification at a scheduled time with all the medication they have to take. They are then asked to indicate if they did in fact take it or not for recording purposes. This helps users who forget to take medication because of a change in schedule or any such reason by acting like an alarm notification.

The screen that lists all the medication for the day also color codes each item as either white (neutral state), red (missed state) or green (taken state). If a medication is scheduled and the notification has not gone off, the medication is listed in the neutral state, or white color. If it is missed by either dismissing the notification or indication “I did not take it,” the medication goes in missed state or red color. Lastly if a user indicates either on notification or just on the list later that “Yes, I did take it.” the medication goes in taken or green state.

This organization gives a visual reminder of missed and taken medicine and also helps users who have become so accustomed to taking medication that they take it twice. This organization scheme was devised based on usability testing on a competitor app, Medisafe. We learned that people got confused by the digital pill box organization scheme of that app. Division of medications into “Morning”, “Afternoon”, “Evening” and “Night” might not make sense to

everyone. Moreover, people associate different time ranges with these slots. Users in the usability test indicated they would rather see the name of medication listed as a list with times than understanding the arcane organization. We also made adding medication simple with fewer information fields to be filled in. This design decision was also made based on the feedback from the competitive usability tests. Users often got confused about all the different pieces of information to be filled in to add a single medication. We reduced the information entry to bare minimum possible while still allowing basic functionality of the app.

What sets apart our product from products already present in the market is empathy and positivity. We introduced these factors by building in a support group feature as well as a reward system. We aim to bring positive reinforcement to a patient's medication regimen. We do this by giving users a reward every time they indicate that they took their medication. We wanted to add a component of joy to the over all neutral to negative experience of medicine taking. We learned from user interviews and other user research we performed that different things bring joy to different people. While some people said they would love to read inspirational quotes to keep them on track, others were appalled at the idea of an app trying to give quotes; however, they might like humour as a reward. To be able to actually make the reward system work, it was important to present a wide array of reward categories to select from. Users can select from all categories that interest them and add certain topics to their favourites list. The app then selects one of the categories randomly as reward that is displayed when a user indicates that he or she has taken medication. For example, if the user's favourites include Jazz music and XKCD comics, on indicating that a pill was taken, the app would pick up a comic strip to display. The idea is to use the reward system to keep users incentivized to stay on track with their medication.

To introduce empathy into the process, we added a support group feature. We heard from users and doctors that having a medical condition can be alienating and can lead to loneliness. This gave birth to the idea of a support group. A support group on the app can be a any contact, friend or family, the user can add in a list. After a user adds a contact, that person gets a message that then prompts them to send supporting messages to the user. These messages are stored in a database. When the user takes the medication, either a message from a loved one or a reward is given to the user. We also learned from user interviews that a support group would also be helpful in holding users accountable. Therefore, we added a feature of assigning a designated contact in support group. This contact can not only send encouraging messages but they also receive a notification that the user missed a medication. For sake of privacy, the message would not disclose which medicine exactly was missed but it would nonetheless point out that something was missed.

In addition to a scheduler, organizer, reward and support system, the app also has other secondary features. We learned from user research that, since medication taking is a very personal topic, the way users deal with this process is also very different. The level of interference that a user would tolerate when it comes to medication reminders also differs. Therefore we built in ways to customize, switch on and off almost all the features (apart from basic scheduling) in the app. The support group only provides encouragement from known people. Sometimes it helps patients to know that there are others in the world in similar position. To help with this we added a stats feature in the app. This feature tells you and plots on the map everyone else in the world currently taking the same medication. This feature is just in prototype phase right now. The functional map will become active once people around the world start

using this app. We also have a feature that reports medication taking history. The reporting feature shows in a visual way how many times a medication was taken over a given period of time and when. We also plan to incorporate pattern recognition in the app. Based on the data regarding medication noncompliance (see the Data Analysis section above), we came up with certain demographic and time patterns in medicine taking that can indicate when a person might become non compliant. We can incorporate this pattern matching algorithm in future versions of the app in order to pay special attention — and deliver customized interventions — to those who have been identified as more at risk of skipping medication.

Front End Framework

For the development of the application, we chose a hybrid app development framework. This allows us to develop the app for many different platforms rather than restricting us to specific platforms as in the case of native apps, all with just one code base. For hybrid app development we chose the Ionic 2 framework for the front end. Ionic 2 allowed us to write code once, using HTML5, Typescript, AngularJS 2 and SCSS, and easily and quickly deploy that code into apps with native functionalities on multiple operating systems. It saved us time in the short-term and would be more flexible in the long-term.

The application works like a single page application with just one html page rendering at all times. The transition from one screen to another is done via templates and views. Each screen is made into a template, and upon transitioning to the screen, the template is plugged into the main html page and the dependences are “injected” into the page thanks to Angular’s

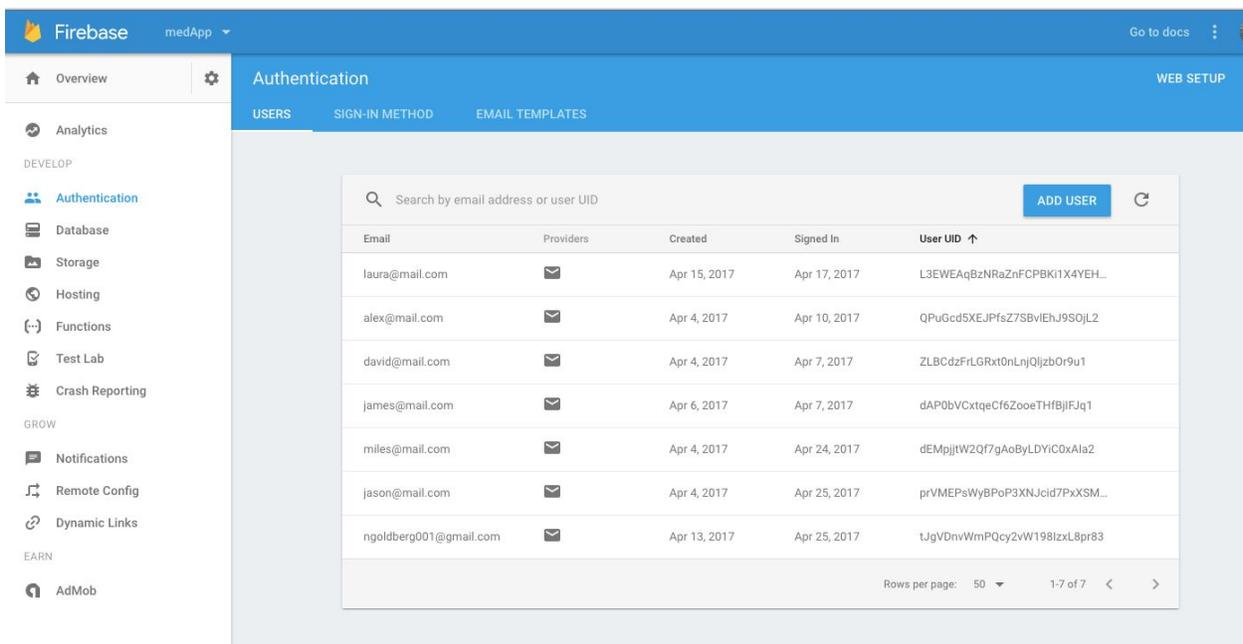
architecture. Since Angular 2 was introduced, the page structures has become more modular and component based. Each page has its components. These components and all the pages are loaded in an application file which is used to initialize the whole application at the start. This page also sets the root view. The components of each page have access to the navigation controller which can be used to navigate to other pages and also send object on navigation.

Angular follows MVC architecture, which means there is separation of views, controller and modules. The whole application is divided into separate pages, each of which has a view and controller. It also has providers, which are basically some general functionality or resources which can be used in multiple pages. We can build custom components by defining them in the components section of the app.

The main plus point of using a hybrid development framework is that from a single code base, we can build code in as many platforms or operating system that we want. The resultant code produced is in native language and runs efficiently on devices. The drawback of having a single code base is not being able to customize the design for different platforms. In some cases, this can lead to poor usability, as each platform has a set of design conventions, and a decision has to be made to give priority to one of the platforms its conventions. Another major drawback of using a wrapper framework like Ionic is not having direct access to native functionality of the operating system. We only have access to those native operations that already have a plugin in Ionic. If we want to make use of some native operation, and a plugin is not available, there is no way to write and integrate code for it in a hybrid app.

Backend Framework

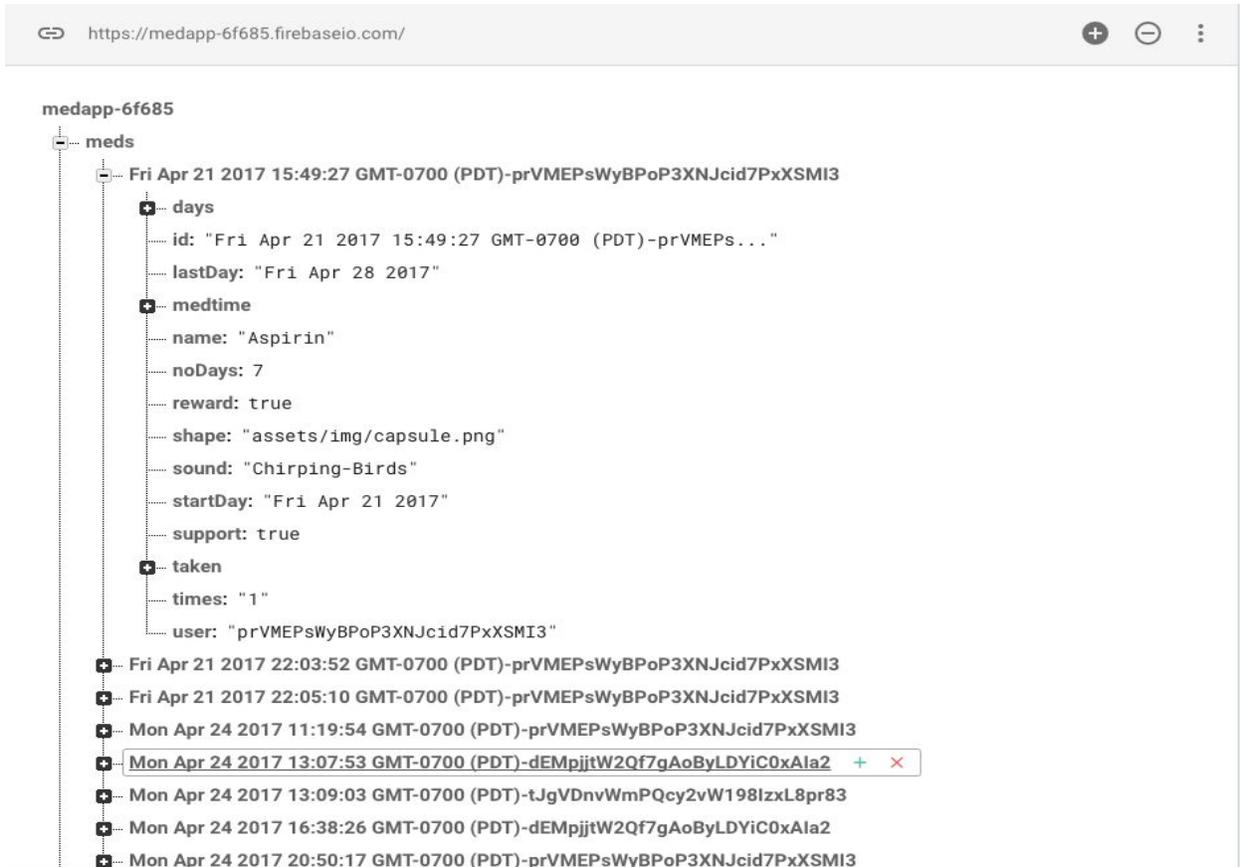
The backend of the app was stored and managed by Firebase. Firebase is a platform that offers wide variety of services over the cloud. For the purpose of our app, we used the Firebase Database and Firebase Authentication service. Firebase Authentication service securely authenticates users without worrying about establishing a backend infrastructure for authentication. We decided to go with this service, as it automatically takes care of security and can be integrated with front end apps easily. It also allows authentication via social login providers like Facebook, Gmail, etc. However we did not want to link our app or restrict its usage by use of these platforms, so we opted for standalone authentication. On authenticating, Firebase stores the email and other metadata related of the user. It also creates a unique UID for each user that can be used to identify each user individually.



The screenshot shows the Firebase Authentication console for an application named 'medApp'. The 'USERS' tab is selected, displaying a table of registered users. The table has columns for Email, Providers, Created, Signed In, and User UID. There are 8 users listed. A search bar at the top of the table allows searching by email address or user UID. An 'ADD USER' button is visible in the top right corner of the table area. The left sidebar shows various Firebase services, and the top right corner has a 'Go to docs' link and a 'WEB SETUP' button.

Email	Providers	Created	Signed In	User UID ↑
laura@mail.com	📧	Apr 15, 2017	Apr 17, 2017	L3EWEAqBzNRaZnFCPBK1X4YEHL
alex@mail.com	📧	Apr 4, 2017	Apr 10, 2017	QPuGcd5XEJPFsZ7SBVIEhJ9SOjL2
david@mail.com	📧	Apr 4, 2017	Apr 7, 2017	ZLBCdzFRLGRxt0nLnJQjzbrOr9u1
james@mail.com	📧	Apr 6, 2017	Apr 7, 2017	dAP0bVCxtqeCf6ZoeTHfBjFJq1
miles@mail.com	📧	Apr 4, 2017	Apr 24, 2017	dEMpjtW2Q77gAoByLDYiC0xAla2
jason@mail.com	📧	Apr 4, 2017	Apr 25, 2017	prVMEPsWyBPoP3XNJcid7PxXSM...
ngoldberg001@gmail.com	📧	Apr 13, 2017	Apr 25, 2017	tJgVDnvWmPQcy2vW198Izxl8pr83

Firebase Authentication



Firestore real-time database

Another service used on firebase was its real-time database. Firestore implements a document-based database and stores all of the data in JSON format. Data can be manipulated directly in firestore GUI console. However, for the purpose of use in an app, it provides an API that can be used to call various functions that Firestore exposes. To use the database, we used Firestore and AngularFire API. A call to database returns an observable. The observable can then be subscribed in backend or can be used directly by Angular frontend with `async` keyword. Whenever anything in the database changes, the frontend automatically updates. If the observable has been subscribed in the backend, then the code inside the subscribe is executed once on subscription and then every time the database changes.

Firebase is a great service for quick prototyping. It exposes a wide array of services without the worry of setting up a backend logic and server. It also provides inbuilt security. The drawbacks of using Firebase is that it limits the operations that you can perform on the database. The queries are limited by the APIs and the values they can take. It has very tight use cases and does not render itself much to customization.

API integration

To make the app easy to setup and use, we wanted to give users an option to import medication from already existing records. We explored various APIs to do this. Most of the pharmacy-based APIs that we came across like Walgreens and CVS do not offer access to a patient's record. After some search, we came across EPIC. EPIC is patient management software company. Its software is used in various hospitals to hold and manage patient medical records. Its software holds 54 percent of all patient records in the US and 2.5 percent of patient records worldwide.¹⁴ EPIC exposes the records via a public API. Any third party app that needs to use the API can sign up with them and comply to their privacy policy conditions. They also offer a small sandbox with sample patient records for testing purposes.

We integrated Pillpal with the EPIC API to get access to the medication record automatically. For the purpose of the proof of concept we are accessing the sandbox which has sample patient records only. When first-time users sign in, they can choose to populate the app with medication, either manually by adding it one by one, or by importing the information from

¹⁴http://host.madison.com/news/local/govt-and-politics/epic-systems-draws-on-literature-greats-for-its-next-expansion/article_4d1cf67c-2abf-5cfd-8ce1-2da60ed84194.html

the EPIC API. To get access to the API information, users have to provide some personal information like first name, last name and gender. The app then calls the API with this information. This information is only used to call the API and is not stored anywhere in our app or database. There are two API calls involved in the process. The app first calls a patient record with name and gender as a query string. This gives access to a patient ID. This ID can be used to retrieve patient medication information. The response is returned in JSON format which is parsed by the app. All the medication in the response is added to the user's medication cabinet. The format of information returned and the request made follows FHIR HL7 data model. This is a standard data model followed by all health care resources on the web in order to ensure seamless interoperability of electronic healthcare information.

```
$ curl "https://open-ic.epic.com/FHIR/api/FHIR/DSTU2/MedicationOrder?patient=Tbt3KuCY0B5PSrJvC"
{"resourceType": "MedicationOrder",
  "type": "searchset",
  "total": 9,
  "link": [
    {
      "relation": "self",
      "url": "https://open-ic.epic.com/FHIR/api/FHIR/DSTU2/MedicationOrder?patient=Tbt3KuCY0B5PSrJvCu2j-
      P1K.aiHsu2xUjUM8bWpetXoB"
    }
  ],
  "nextLink": f
```

Sandbox text call for Medication order using patient ID

MedicationOrder Search Interaction

Relative URL	FHIR Interaction	HTTP Method	Action
/MedicationOrder?[parameter=value]	Search	Get	Retrieves MedicationOrder resources that meet the specified search criteria.

The search interaction enables the client to query for all medications associated with a given patient's medication list. The client, having established the patient in question, now wishes to retrieve the list of that patient's medications. Currently, Epic's sandbox supports the following search parameters:

Note: To ensure clinical safety for a patient, searches filtered with a dateWritten search parameter will return all active medications in addition to other data returned in the search.

Parameter Name	Parameter Type	Description
_id	Reference	Search for MedicationOrder resources using one or more server ids (equivalent to one or more Get /MedicationOrder/{ID} requests)
patient	Reference	Search for MedicationOrder resources for a specified patient ID.
status	Token	Further refine a search for MedicationOrder resources for a given patient by specifying additional status flags. By default, active medications are returned. Statuses of completed and stopped may also be specified, but the active status must be specified in addition to any other non-active statuses for a valid search.
dateWritten	Date	Further refine a search for MedicationOrder resources for a given patient by specifying a date or a range of dates for when the medication was ordered. Note: all active medications will be returned regardless of date range provided on the search.

Examples

Query	Result
/MedicationOrder?patient=Tbt3KuCY0B5PSrJvCu2j-P1K.aiHsu2xUjUM8bWpetXoB	Returns all active MedicationOrder resources for Jason Argonaut.
/MedicationOrder?patient=Tbt3KuCY0B5PSrJvCu2j-P1K.aiHsu2xUjUM8bWpetXoB&status=active,completed	Returns active and completed MedicationOrder resources for Jason Argonaut.

Apart from using EPIC for importing medications, we plan to use the Twilio API for getting messages from loved ones. Using Twilio we can receive messages asynchronously and save it in our database. Once the user takes a medication, these messages can be unlocked. We can also incorporate multimedia messages from loved ones in the reward system. Apart from messages from a support group, we also rely on APIs exposed by various multimedia content sites like Reddit, Travel blogs, etc. for fetching the content for rewards in user selected categories. Twilio and other reward APIs have not been incorporated in this version of the app. The messages and rewards are directly pulled from a database where they are stored. In the final

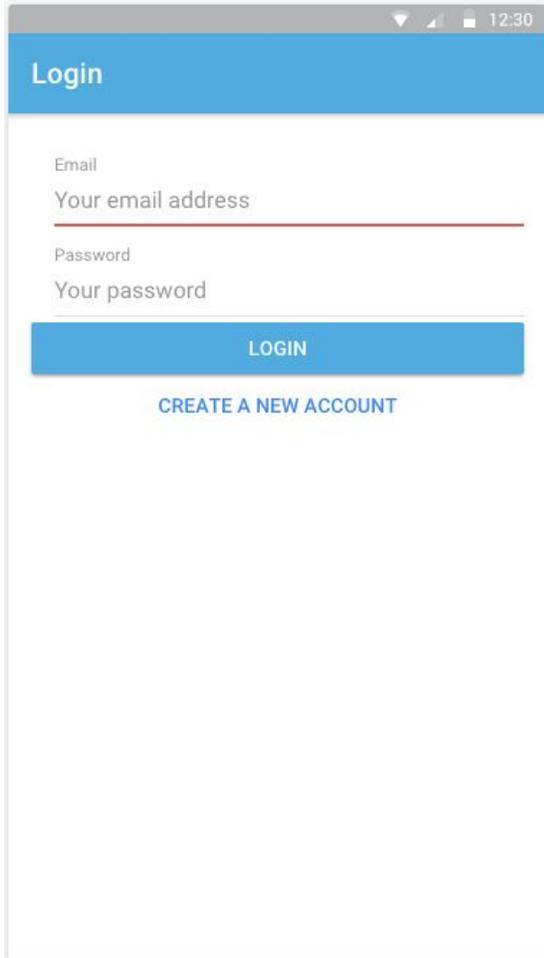
product, all of these features would be integrated with APIs and would pull content directly from an API.

Workflow

The app has two main workflows.

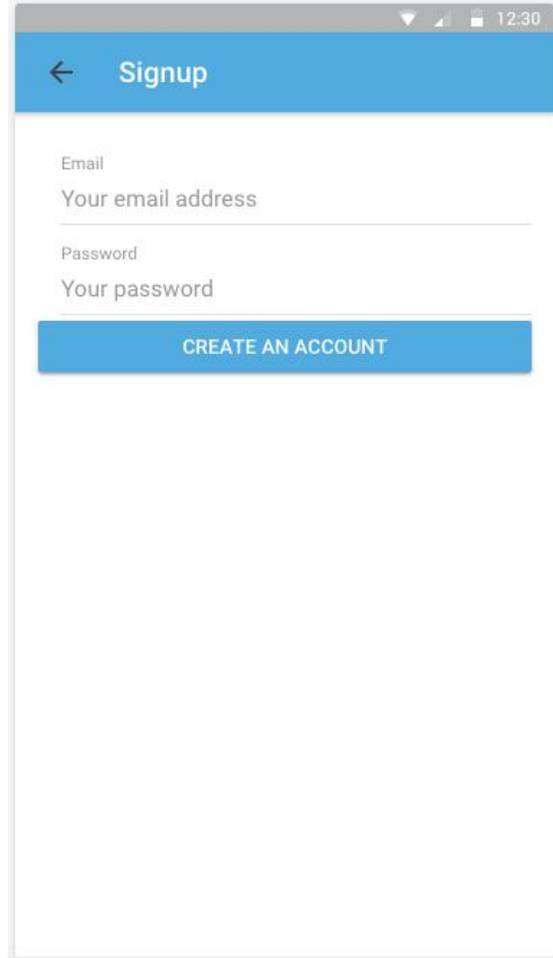
1. User downloads and starts using the app for the first time.
 - a. User is greeted by the Login page
 - b. User navigates to a Signup page. Here she is prompted to enter an email id and a password in order to signup.
 - c. After signing up, the user goes to the “Today” page of the app. Since this is the first time she has entered the app, there is no record of any medications. The user gets an option to either import medicine from EPIC or to enter it manually.
 - i. On choosing EPIC, user is taken to another page where she has to enter her first name, last name and age. This information is used to make a request to the EPIC system to fetch user medication information. If information is found, the medication record is automatically created for all of the medicine found on EPIC in the app.
 - ii. If the user chooses to enter medicine manually, she is taken to the medicine cabinet where she can add medicine one by one.
 - d. The user can add rewards by going to “Manage Rewards.” She can select the categories of things she is interested to add in her “Favourites.”

- e. The user can add members to her support group by going to “Manage Support Group.” She can add friends and family from her contact book. Once she is done adding, she can designate a selected contact to be her favourite. These are the contacts who would receive a notification if she misses her medication.
- f. She can manage individual medication by going to the Medicine Cabinet and selecting settings for each. She can switch off or change the sound on different medication notifications. Also, she may switch off the support group feature on selected medications if she wishes to have inconspicuous notifications.
- g. The user can look at a stats page for the medicine to see how many people across the world are taking the medicine.



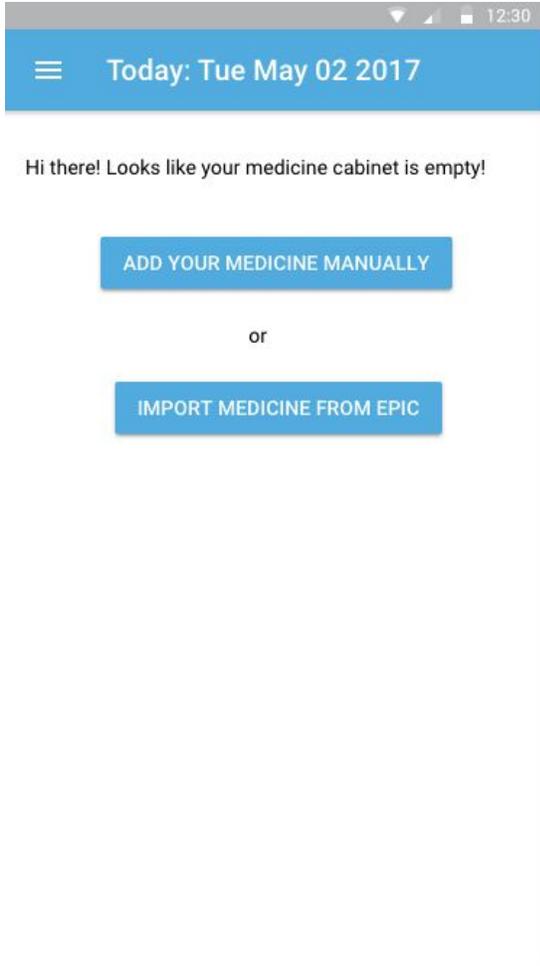
The Login screen features a blue header with the title "Login". Below the header, there are two input fields: "Email" with the placeholder text "Your email address" and "Password" with the placeholder text "Your password". A blue button labeled "LOGIN" is positioned below the password field. At the bottom of the screen, there is a link labeled "CREATE A NEW ACCOUNT". The status bar at the top shows the time as 12:30.

Login Screen

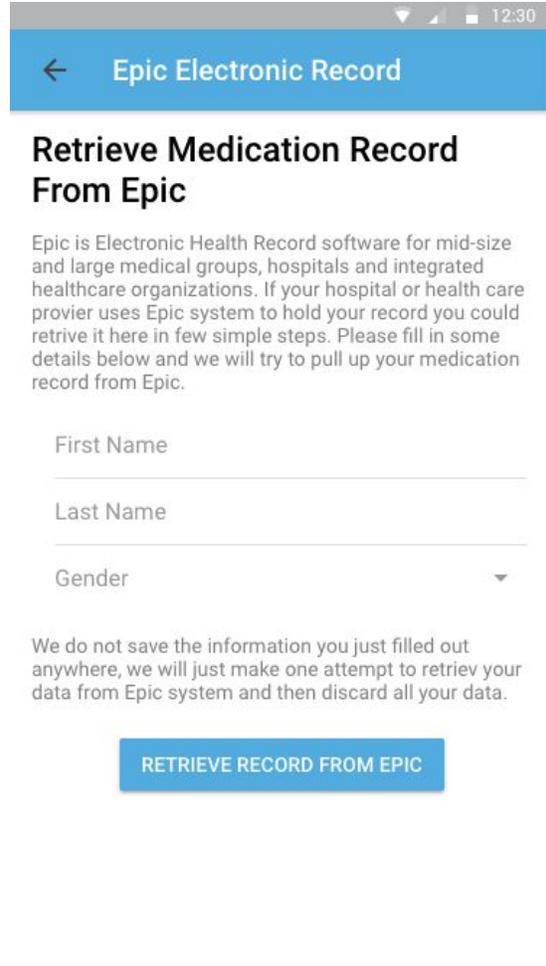


The Signup screen features a blue header with a back arrow and the title "Signup". Below the header, there are two input fields: "Email" with the placeholder text "Your email address" and "Password" with the placeholder text "Your password". A blue button labeled "CREATE AN ACCOUNT" is positioned below the password field. The status bar at the top shows the time as 12:30.

Signup Screen



Option Screen



EPIC record screen

12:30

← Add Medication

Name

Times per day One ▾

Set Time 7:00 AM

Days of week Monday, Tues... ▾

No of Days 7





ADD TO MY CABINET

Add Medication Screen

12:30

☰ Medicine cabinet



Ibuprofen

3/7 ▬

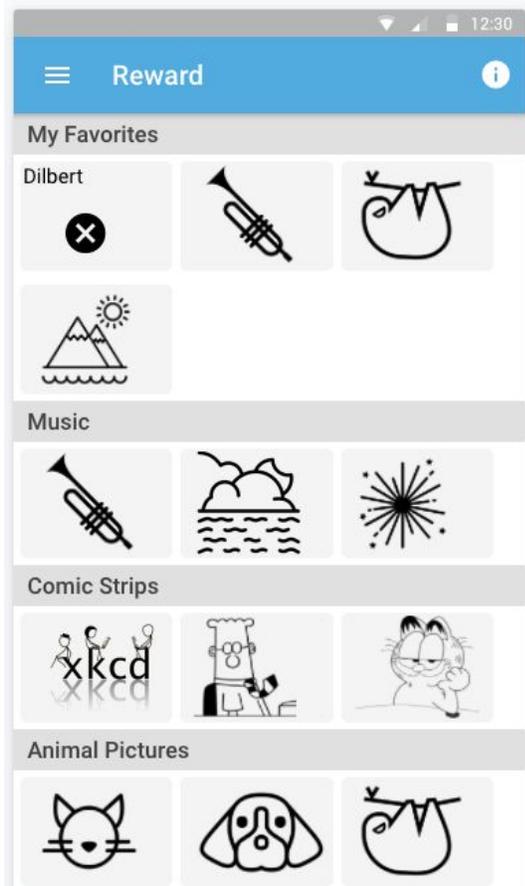


Livocetrizine

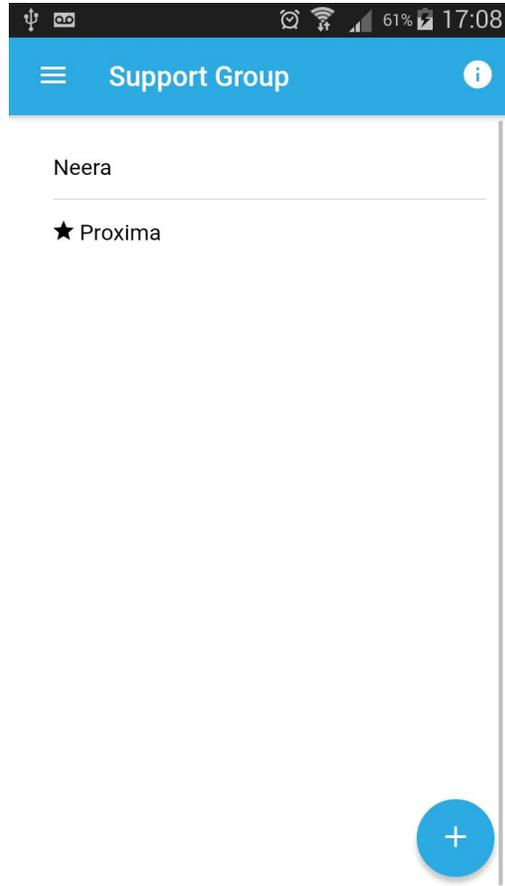
2/7 ▬

+

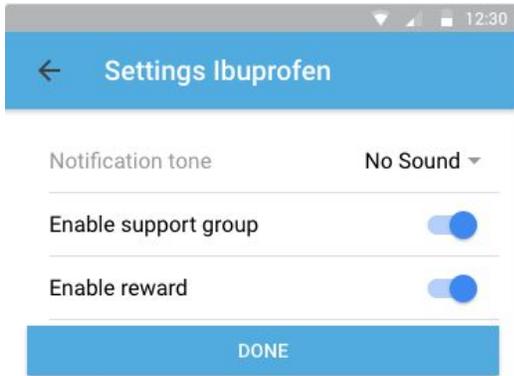
Medicine Cabinet Screen



Manage Reward Screen



Support Group Screen



Settings Screen

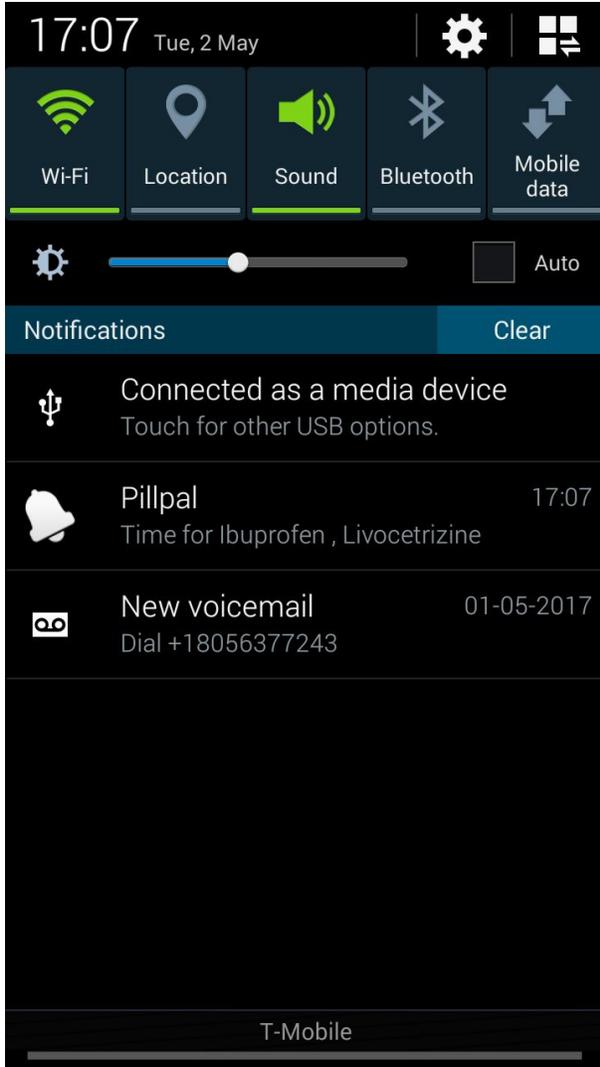


Each dot on the map shows people taking Livocetrizine around the world. 9,657 people around the world are taking the same medication.

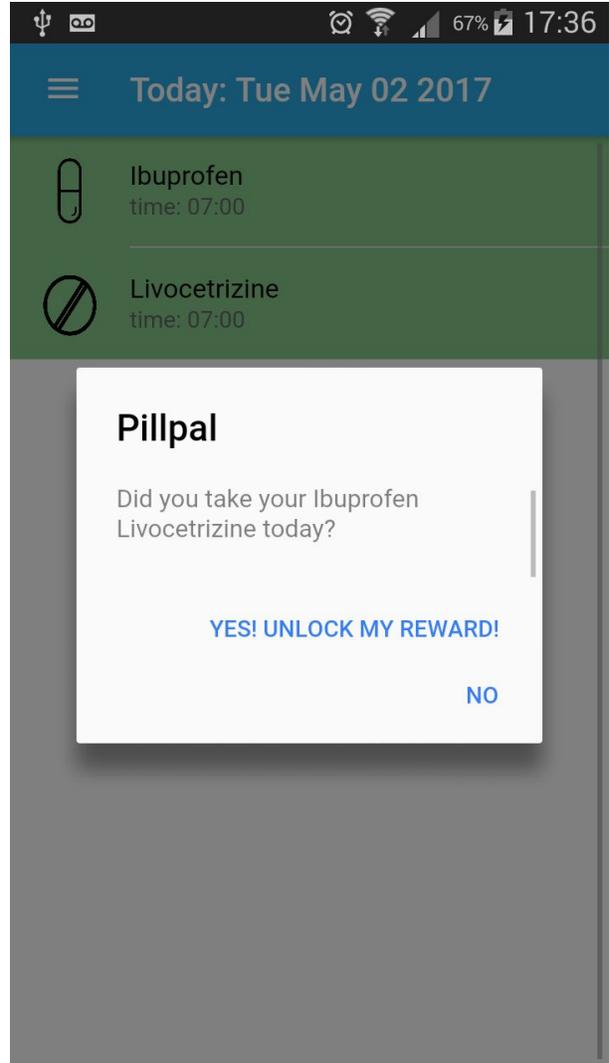
Medicine Stats Screen

2. A user gets a notification when it is time to take medication

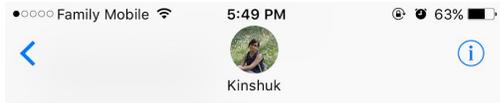
- h. The user gets a notification indicating that it is time to take her medicine.
- i. She may choose to dismiss the notification, but if she clicks on it, she goes to the app.
- j. The app prompts her to indicate if she took medicine or not.
 - i. If she indicates “Yes” she is taken to reward page, where she either gets a message from her loved one or she receives a random reward from one of her favourites categories.
 - ii. If she indicates “No,” her designated favourite contact gets a message that she missed her medication.
- k. User can go to report page and monitor their medicine taking history.



Notification on Phone



Self Reporting



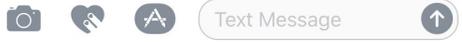
Yesterday 12:27 PM

Hey there! I am using this new app to keep record of my medication regime. Help me in this endeavour by sending me some encouraging or humorous messages! Thanks!

Today 5:08 PM

Hey there! I am using this new app to keep record of my medication regime. Help me in this endeavour by sending me some encouraging or humorous messages! Thanks!

Oh no! I missed my medicine today! Help keep me on track.



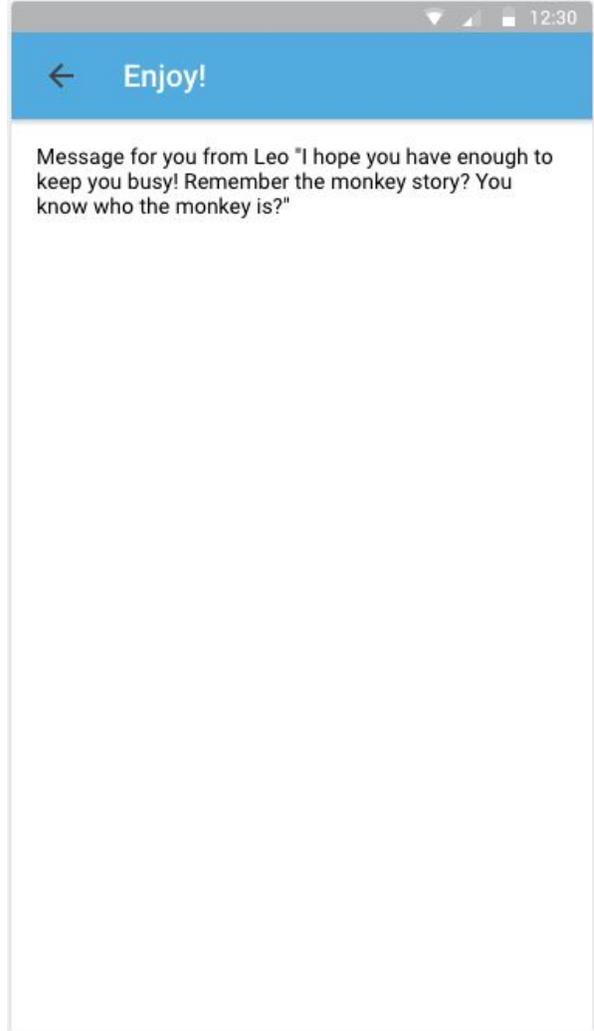
SMS to contact from the app



Sample reward received upon taking medicine



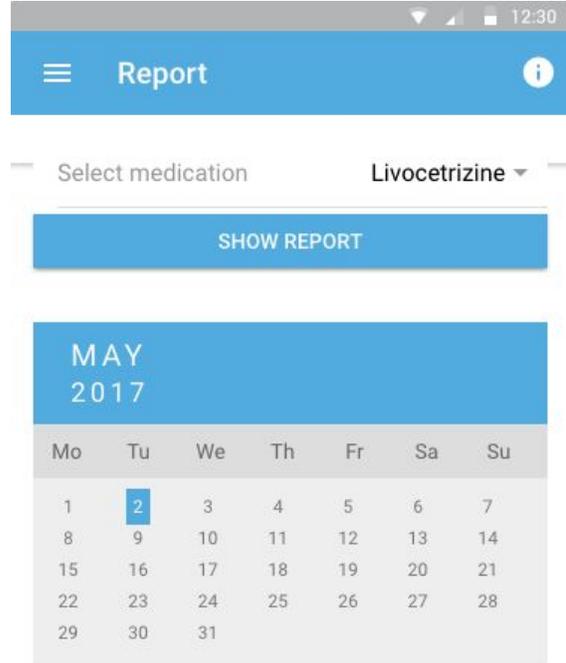
List of medications to be taken today



Personal message/ inside joke from a loved one



Side Menu



You took Livocetrizine 2 times on this day **According to your medication history, it looks like you tend to miss most medication on weekends.**

Report

Conclusions

The results and findings from extensive user research heavily guided the development of the app and continue to do so. The findings from the survey and interviews shaped many features in the app, and we are in the process of continuously modifying Pillpal now that we have feedback from usability tests from version one of our app.

During our interviews, we learned that the overall response to tying positivity to medicine taking was very well-received. It also came to light that different individuals derive joy from different sources. We learned that categories of things like humour or inspiring quotes might be well received by some but might not be as enjoyable for others. Apart from the discussion about rewards during the interviews, we decided to reach a broader audience in a creative way. For this, we posted a very vague and simple question “What brings you joy?” in South Hall on UC Berkeley’s campus, and we got a lot of interesting responses. In the future we want to expand on categories of things that users would want to see when they take their medication. We want to give them more options based on things that bring them joy. We also want to make it customizable so that the reward actually provides incentives to all who use it.

Lastly, we imagine that one day, Pillpal could be one tool at patients’ disposal within a system that works to help patients better adhere to their medication-taking regimens. Medication adherence is a complex issue that will certainly not be solved with a single silver bullet. Here’s one illustration of why a system of many apps and products is a better option. One concern that we often heard, mostly from the doctors that we interviewed, was one around the accuracy of self-reported medication adherence data. Medication adherence patterns can provide potentially

very useful information. For example, they can let a doctor know whether a medication is ineffective, or if a patient simply isn't taking the medication correctly.

However, especially for those with complicated medication regimens, is it realistic to expect that patients will correctly report their medication-taking history every single time? We try to make self-reporting in our own application as easy as possible by asking a binary question — did you take your medication, yes or no? There are other products that passively collect this data instead. Proteus Digital Health, the company that makes ingestible sensors, tracks medication-taking data upon a patient's consumption of a pill. Other solutions include electronic pill bottles which monitor whether a container was opened and if a pill was removed. In an ideal world, Pillpal would integrate with solutions like these to improve the medication adherence problem through multiple approaches. A system, rather than one tool, is likely to best equip patients to tackle the thorny issue of medication adherence. We hope that organizations looking to make the biggest impact in this space work together to provide such a system for patients.

Future Work

All of the user research that we did in this phase was generative or formative (apart from the usability test). We would want to do more summative research on a pilot app to improve the product for future versions. For the next phase, we want to learn about all of the functional problems and usability problems that people face with this app so that we can make the next version more user friendly. But the biggest thing we want to learn in this phase is if the intervention is actually working to improve medication adherence. We could approach it in two ways: we can do a controlled experiment with a control (people not using the app) and treatment

group (people using this app) to quantitatively study any difference in medication taking habits.

Another way, and perhaps more useful for us, would be to do a qualitative study. This could be a diary study that would last for a period of time — a week or two — to understand users' emotions around the reward and support system. What sets the app apart from other scheduling apps is the attaching of positive affect and a support system to a normally neutral to negative experience. A qualitative study would be useful in understanding the emotions around this experience.

Another direction we explored with this project was making the whole product IoT and home devices friendly. For example, home device-delivered sound, light and scent could be used as medication reminders. We had this vision in mind when we were considering homebound patients who take medicine. We realize we would have to do more focused research with this population to understand their environment before we could take this direction. We feel it would be important to explore this direction, as it would make our product more accessibility-friendly, thereby opening it up to an entirely new user population.

Finally, we'd like to implement the data model described in the Data Analysis section to provide customized solutions for users. For example, knowing that a less educated user is more likely to run out of medication, we can collect data and provide relevant positive triggers to account for this problem — such as message that remind them to refill their medication, or suggestions to receive medication by mail. This model can help shape how the application looks to each individual user, and provide even more tailored triggers that will give the user a unique, customized experience.

Our Team



The people behind the product (from left to right)

Neera: The people's person and UX researcher of the team

Laura: Healthcare and technology enthusiast and domain expert of the team

Natalie: The data wiz of team

Kinshuk: Problem solver and developer of the team