

Ola Diabetes Care

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I. Value proposition

Ola is Hawaiian for life, health and well-being. Our goal with Ola is to provide real time context aware care for chronic disease patients through technologies such as smart wearable devices and advanced data analytics (machine learning). We hope Ola will enable patients to live a normal life without ever having to worry about their conditions and medication.

II. Team Members

Manager: Ian Holmes

Design: Tang Zhang

Development: Ian Holmes, Tang Zhang, Albert Chen

User testing: Ian Holmes

Documentation: Albert Chen

III. Problem and solution overview

Currently, chronic disease patients (such as diabetics) typically receive treatment update only when they visit their doctor (once every 3 to 6 months). They also have to self-administer numerous measurements/treatments each day to maintain their health. Finally, the devices which patients use for their day-to-day health are expensive, hard to use and requires proprietary software to view/download historical/raw data. Our solution is to enable real time context aware care for chronic disease patients via technologies such as inexpensive smart wearable devices and advanced data analytics (machine learning).

IV. Contextual inquiry customers

C.T. is a second year PhD student in Geology at Stanford. He is 23 years old and was diagnosed with type 1 diabetes when he was 10. C.T. was recruited when he responded to our recruitment email. As a type 1 diabetic, C.T. checks his glucose level multiple times a day, usually before meals and whenever he feels uncomfortable. He was the only person we interviewed who did not wear an insulin pump, but preferred to administer insulin injections instead. For each meal, he also has to gauge the amount of carbohydrate intake and inject the appropriate amount of insulin to counteract the resulting sugar. C.T. fits our target customer profile as he is dealing with a long term condition that requires constant monitoring and treatment. We interviewed C.T. at Old Union in Stanford during lunch, and bought him pizza as an incentive for the interview. As C.T.'s apprentice, we observed him taking a glucose measurement and the resulting

insulin shot after lunch (see Figures 1 to 5). We listened to his stream of consciousness and asked questions whenever we had any difficulty understanding his actions/reasoning.

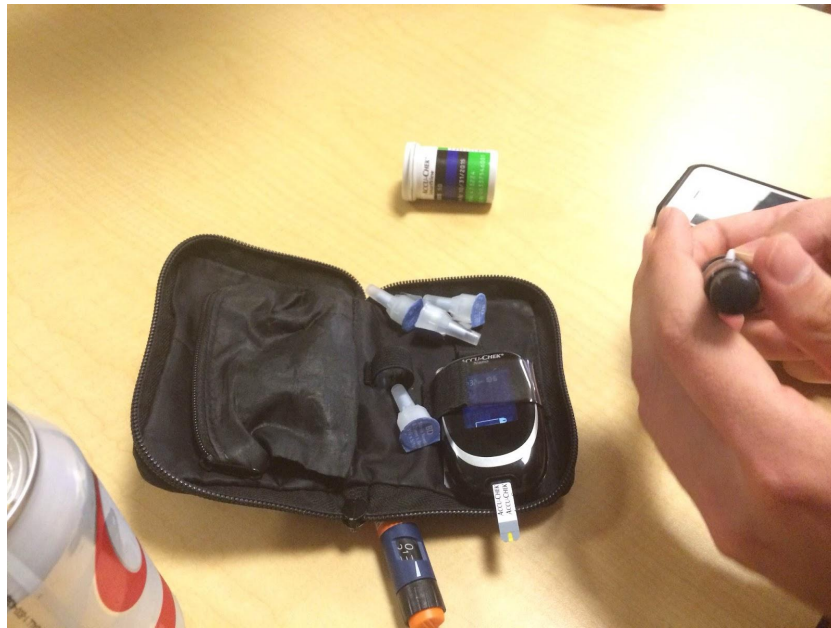


Figure 1 - C.T preparing for glucose measurement



Figure 2 - C.T measuring his glucose level



Figure 3 - C.T.'s insulin pen



Figure 4 - C.T. preparing for insulin shot.



Figure 5 - C.T. self-administering insulin shot

S.K. is a 21-year old junior studying Human Biology diagnosed with type 1 diabetes when she was 11 years old. We got in contact with her via our survey. She was studying abroad in Paris this quarter, so we set up a Skype meeting with her. She uses an insulin

pump and continuous blood glucose monitor. She told us that she manages her own condition and has made adjustments to her dosages on her own since she was in high school. She showed us the device to connect to the blood glucose monitor, and how it would alarm her whether by ringing or vibrating whenever her blood sugar is out of normal range. We asked about her experience of the alarm, and she told us that it just happened the night before during her sleep when her blood sugar dropped below the normal line. As S.K.'s apprentice, we observed how she accesses her blood sugar history from her glucometer and asked questions about the user interface and associated proprietary software (see Figures 6 to 8). S.K. fits our target customer profile as she is dealing with a long term condition that requires constant monitoring and treatment.



Figure 6 - Observing S.K. accessing her glucose level history



Figure 7 - Observing S.K.'s insulin pump

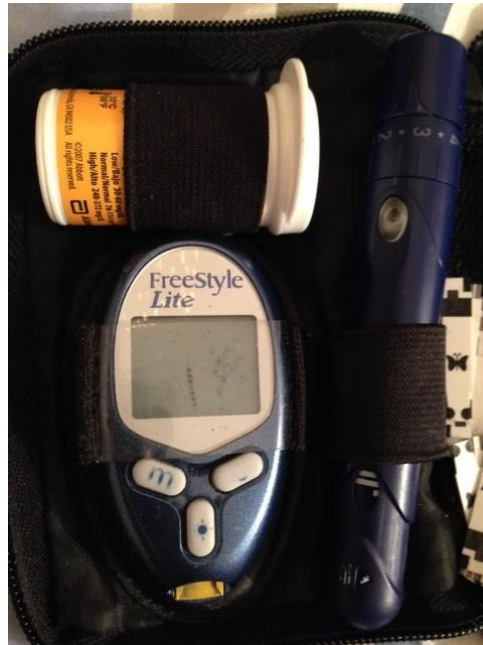


Figure 8 - S.K's glucose measurement kit

A.B. is a 21 years old student at Stanford University. His major is STS, and he plays catcher position for the Stanford baseball team. He was diagnosed with type 1 diabetes when he was 13, and was hospitalized for two weeks. He was losing weight at that time while eating and sleeping more. Then he spent 3 days in hospital and learned about diabetes since then. He got his pump in his senior year in high school when he was 17. He showed us the user interface that he used for injecting insulin as well as measuring blood sugar (see Figures 9 and 10). He felt very confident to take care of himself by learning through his previous experience, and managed his blood sugar pretty well. We got in touch with him as he expressed his interest while filling in the survey form we sent. We scheduled the interview in Old Union on Wednesday evening, and brought him cookies and milk. During the interview, we discussed his experience since he was diagnosed and talked about the devices that he is currently using and considering for future use. A.B. fits our target customer profile as he is dealing with a long term condition that requires constant monitoring and treatment.



Figure 9 - A.B checking the glucose monitor and insulin pump



Figure 10 - We observed A.B. getting an insulin injection through his attached pump

V. Contextual inquiry results

General Things We Learned

- Diabetics need to measure their glucose level multiple times a day and have to take an insulin shots after every meal.

- Diabetics need to learn how to count carbs.
- It is stressful to remember to carry all the stuff needed for on-the-go care [food for treating low blood sugars, glucose meter, insulin, and glucagon].
- Active people do not like to have units attached to their body.
- It is important for diabetics to let people around him/her know of his condition in case of emergency.
- Unsurprisingly, people do not like shots.
- People with diabetes see their doctor on average once every 3 to 6 months.
- People who have had diabetes for a long time tend to be comfortable making decisions about changing their dosages.

From C.T.

C.T. was the first to tell us that he usually did not consult his doctor before making changes to his insulin dosages. He plays sports, so he avoids monitor/treatment devices that could interfere with or encumber his active lifestyle. While he is very good at estimating changes he needs to make to his medicine dosages, the features of the tools he uses are limited. For example, in order to review his recent blood sugar numbers, he must click through his history one-at-a-time. He does not have access to graphs or analytics that many pump systems offer.

We also asked C.T. about his smartphone habits. He told us that he has many apps on his iPhone, but does not use all of them. They are not sorted in any particular order (fig. 1). This encouraged us to think about designing an app that would be easy to open and use without difficulty (such as by sending push notifications, or giving the ability to swipe upward to open the app such as with the iPhone camera app).

From S.K

S.K. was the only interviewee who uses a continuous blood glucose monitor (CGM), which measures blood sugar levels from an on-body sensor every five minutes. She uses software she found online to see incredibly detailed graphs about how her blood sugar has changed by time of day over the past three months.

She mentioned that her eating habits can affect her blood sugar levels significantly. While working in India last summer, she said every meal consisted of *roti* (an Indian flatbread) and some sort of vegetable curry. Because her diet was so consistent, she was able to make very detailed carbohydrate estimates, and therefore keep her blood sugar levels in tight control.

On the other hand, since arriving in Paris for her quarter abroad (two weeks before we interviewed her), she said her diet has consisted of many more starches, fats, and sweets (white bread, cheeses, and butter), and so it has been much more difficult for her to stay in control.

From A.B

A.B really likes the idea that there could be some tools to help him calculate the carbs of the meals he is taking. It takes time and effort to learn how to calculate the carbs, and his estimates are not always so accurate. He also mentions that the environment he is in can also affect the pump he is wearing: when the humidity is high, there is a possibility that the adhesive patch for the pump would come detached. Furthermore, high heat can cause dehydration, which also leads to high blood sugar.

A.B. told us that he learned to use his pump because the company (Medtronic) sent a representative to his house to train him on it for a couple hours. (He said he was very impressed with Medtronic because they were able to fix his emergencies efficiently, such as when he received a replacement pump for his broken one in less than 16 hours.) His pump is more advanced than what a newer diabetic would be capable of using, but he likes the functionality it offers him. Even so, the pump's design is imperfect because there are features (e.g. a sine-wave bolus function) that Medtronic told him never to use.

When we asked A.B. what he thought about CGMs, he told us that he thinks they are useful, but he doesn't want another device that he would have to wear on his body. Likewise, he chose his current pump because it carries the most insulin, and therefore requires him to change the unit (which can be painful) less frequently than with other units.

VI. Task analysis questions and answers

1. Who is going to use the system?

People who suffer from chronic diseases that require long term monitoring and care - like diabetes, asthma, allergy, Alzheimer's cancer, epilepsy, glaucoma, heart disease, etc. Effectively, any person that wears one or more monitors for their health could benefit from our communication and care system.

2. What tasks do they now perform?

Specifically considering diabetes, customers currently must

- a. **Deliver insulin**, either by programming their insulin pumps whenever

they eat or exercise, or by administering a shot.

- b. **Make long-term changes to their dosages**, either by consulting with their doctor, or by using the data from blood sugar monitoring and insulin delivery.
- c. **Measure their blood sugar** by testing several times daily, with or without the use of a CGM.
- d. **Educate those around them** about what actions must be taken if they have an emergency (such as delivering a Glucagon injection if they pass out from severe hypoglycemia)
- e. **Count carbohydrates**, both at meals and when eating smaller amounts. This may involve online or book references, but largely consists of trial-and-error estimation on the part of the individual.

3. What tasks are desired?

- a. **Not having to worry** -- All of our interviewees told us they wished they did not have to constantly think about managing their diabetes.
- b. **Viewing all their data in one place** -- Currently, everyone's care is divided among separate devices (e.g. a glucometer cannot talk to a pump if it is of a different brand). Our interviewees told us they wished this data were easier to access.

4. How are the tasks learned?

Our interviewees all initially learned how to care for their diabetes while in the hospital after being diagnosed. A.B. told us a company representative came to his home to train him on his new pump, as did S.K. when she began using her CGM.

5. Where are the tasks performed?

All of the tasks may be performed anywhere, which is why the system would benefit from being as mobile as possible. This may be in the home, while travelling, in restaurants, or even while in transit or being active (e.g. playing sports).

6. What's the relationship between customer & data?

The customers use the data collected on their pumps, CGMs, and glucometers to make decisions about changing their medicine (e.g. insulin for T1D, or levothyroxine to treat hypothyroidism).

7. What other tools does the customer have?

Our Interviewees all used diabetes logbooks in the past to keep track of their blood sugar levels, carb counts, and insulin delivery. Depending on the system they use, they each had hardware-specific (proprietary) software that they could use for collecting and analyzing data (e.g. S.K. downloaded a mac-specific piece of software to collect data from her CGM).

8. How do users communicate with each other?

Patients typically visit their doctors for an appointment once every three to six months. They may call more frequently to report on their treatment and seek advice, but diabetics who have treated themselves for longer periods of time (on the order of 10 years) tend to make most decisions on their own.

Those we interviewed rarely consulted with other diabetics about the particulars of their disease. A.B. and S.K. both are members of an informal support group of diabetic students at Stanford, so the infrastructure exists should they decide they want help with anything.

9. How often are the tasks performed?

- a. **Testing blood sugar** -- Users typically test 6-8 times per day, at minimum once per meal, as well as before going to sleep.
- b. **Insulin shots or boluses/temporary basal** -- Same as above, as well as whenever eating or exercising
- c. **Counting carbs** -- Diabetics must count the carbohydrates they eat at every meal or snack.
- d. **Emergency treatment** -- Depends on person. Some have never needed emergency treatment, while others have had multiple incidents
- e. **Changing dosages** -- As needed. Some diabetics only make changes whenever they have their doctor's approval, while others are more liberal about making changes on their own.

10. What are the time constraints on the tasks?

- a. **Taking insulin** must be done within 30 minutes of eating a meal.
- b. **Emergency treatment** for hypoglycemia (i.e. the patient has lost consciousness) must be administered as quickly as possible (i.e. within minutes), or else serious injury or death may occur.
- c. **Blood sugar measurement** must be taken before eating, or whenever the diabetic is feeling unwell.

11. What happens when things go wrong?

- a. **For treating low blood sugar**, patients carry food (sugary drinks and snacks) in order to bring their blood sugar up to an acceptable range.
- b. **For treating high blood sugar**, patients must take extra insulin, exercise, or drink water to help bring blood glucose levels down.
- c. **For emergency lows**, diabetics must rely on those around them to take appropriate action (e.g. administer a Glucagon injection when having passed out from severe hypoglycemia).
- d. **For malfunctioning or lost devices**, Customers must call support phone numbers for assistance or replacements.

Representative tasks:

1. Doctors collect data from patients to make adjustment (simple, moderate frequency, moderate importance)

Doctors need to see all the history data about each patient's blood sugar and insulin injection amount in graphs or charts. By analyzing these related data, doctors could easily determine how the patient is doing and provide recommendation or instructions regarding on patient's situation directly and immediately.

This task is chosen because currently, the communication between patients and doctors is not so efficient. As mentioned in our user interview, they only communicate by appointment in most cases, even though there is a need for the patients to change the dosages between.

2. Counting carbohydrates when eating food (simple, high frequency, high importance)

Counting carbs is one of the most important things that people with diabetes would do everyday. Whenever they want to eat something, they have to estimate the carbs in the food in order to inject proper amount of insulin. The estimation is mostly done based on previous experience, and sometimes not so convenient and accurate.

This task is chosen because the impact of inaccurate estimation of carbs could be huge. If the estimation is higher than reality, too much insulin would be injected and may result in low blood sugar. If the estimation is lower, the amount of injected insulin would not be enough to cover the carbs and would lead to a high blood sugar level. Thus diabetics need a more convenient and accurate way to

count the carbs.

3. Treating severe hypoglycemia in emergencies (moderate, low frequency, high importance)

The likelihood of suffering an emergency situation due to severe hypoglycemia varies by patient; none of the three diabetics we interviewed had ever lost consciousness due to low blood sugar, but other acquaintances we know have had as many as 12 emergency situations in up to 10 years of having lived with diabetes. In relatively rare cases, severe hypoglycemia can contribute to “dead in bed” syndrome, in which a seemingly well diabetic person is found dead in the morning as a result of nocturnal hypoglycemia. Each year, severe hypoglycemia amounts to about 300,000 emergency room cases.

In such an emergency where the diabetic person is unconscious, he is reliant on the assistance of those around him to administer proper care: finding and preparing the Glucagon injection, delivering it, and calling 911. If no Glucagon pen is available or no one is around the patient, their life may be seriously endangered.

4. Making changes to one’s dosages (complex, low frequency, high importance)

Currently, if a diabetic person decides to make changes to her dosages (which only experienced diabetics are comfortable doing), she must either call her hospital in order to report her current dosages and blood glucose numbers and wait for a response, or she must make decisions based on her own ideas about how her management has been in the recent past. This trial-and-error approach is difficult to learn and often prone to lacks of meaningful data (such as charts that convey the correct information over the time period of interest).

VII. Three best application ideas

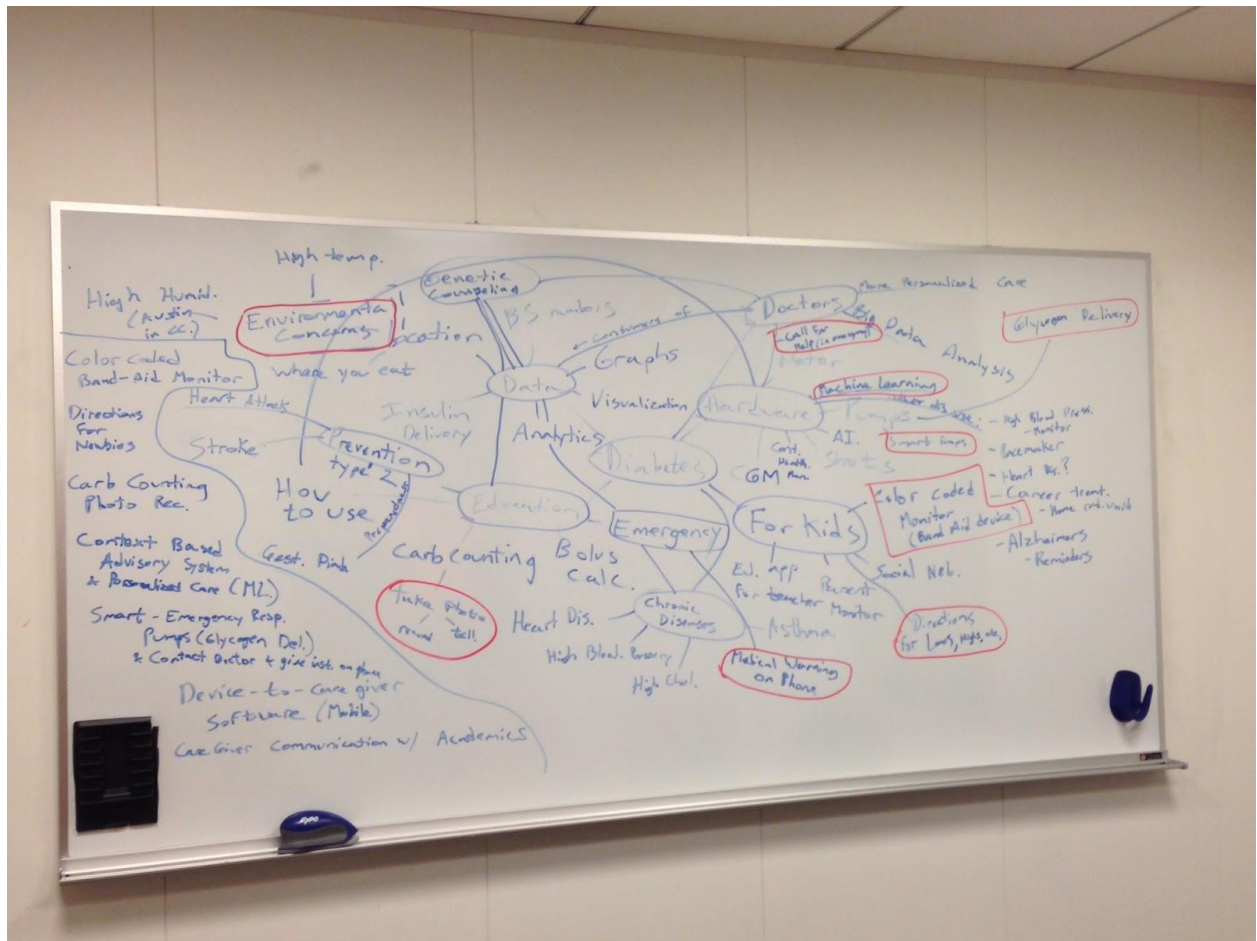


Figure 11 - Brainstorm (concept map)

Idea	Significance	Feasibility	Interest
Color-Coded "Band-Aid" Monitor	High	Med	Med.
Directions for Newbies	Med.	High	Low-Med
Carb Counting Photo Rec.	High	Med-High	Med-High
Context-Based System	High	Med-High	High
Smart Pump Emergency	High	High	High
Mobile D2CG Software	High	High	Med-High
Data for Academics	High	High	Med.

Figure 12 - Brainstorm (prioritization matrix)

1. Context aware care system

A system that delivers optimal medication based on the user's genetic makeup, current location, body condition and environmental information.

2. Smart emergency pump

A smart wearable device that continuously monitor the user's health and deliver the appropriate response/medication as needed during emergency. It also alerts first responders and user's physician.

3. (Mobile) Data direct to caregiver

A smart wearable device that continuously monitor and upload the user's health measurements to the caregiver. This enables rapid response by doctors to a patient's changing condition and facilitates patient data analysis.

The application idea we choose to pursue further is the "context aware care system". We chose it because it addresses the representative tasks most comprehensively. Also, with careful design, it could handle the usage scenarios that were intended for "smart emergency pump" and "(mobile) data direct to caregiver". Finally, we chose "context

aware care system” because of we think it has the most impact to chronic patients’ lives (significance) - as it can alleviate their manual burden of constant health monitoring and adjusting/administering treatment. We hope this system will enable patients to live a normal life without ever having to worry about their conditions and medication.

Context aware care system addresses the representative tasks as follows:

- **Doctors collect data from patients to make adjustment**
The system will continuously monitor and upload the user’s health measurements. This enables rapid response by doctors to a patient’s changing condition and facilitates patient data analysis.
- **Counting carbohydrates when eating food**
The system can automatically identify allergens and calculate the amount of carbohydrates contained within foods. This information will then be used automatically to adjust the medication (e.g. insulin) levels.
- **Treating severe hypoglycemia in emergencies**
The system will continuously monitor the user’s health and deliver the appropriate response/medication as needed during emergency. It also alerts first responders and user’s physician.
- **Making changes to one’s dosages**
The system will automatically calculate the optimal dosage/medication based on the user’s genetic makeup, current location, body condition and environmental information.

VIII. Sketches

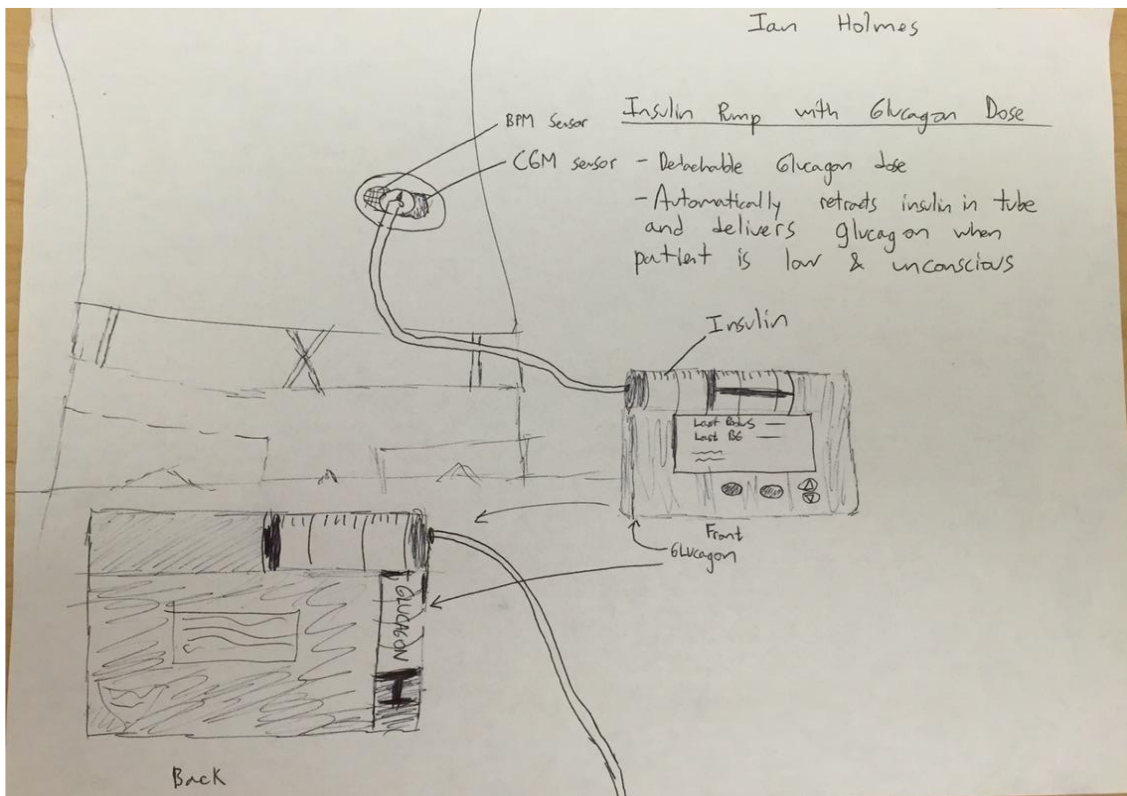


Figure 13 - Smart pump (Ian Holmes)

Easy & painless health monitor



Red color: Status bad



Green color: Status Good

Figure 14 - Health monitor bandages with color coding (Albert Chen)



Figure 15 - Context aware care (Albert Chen)

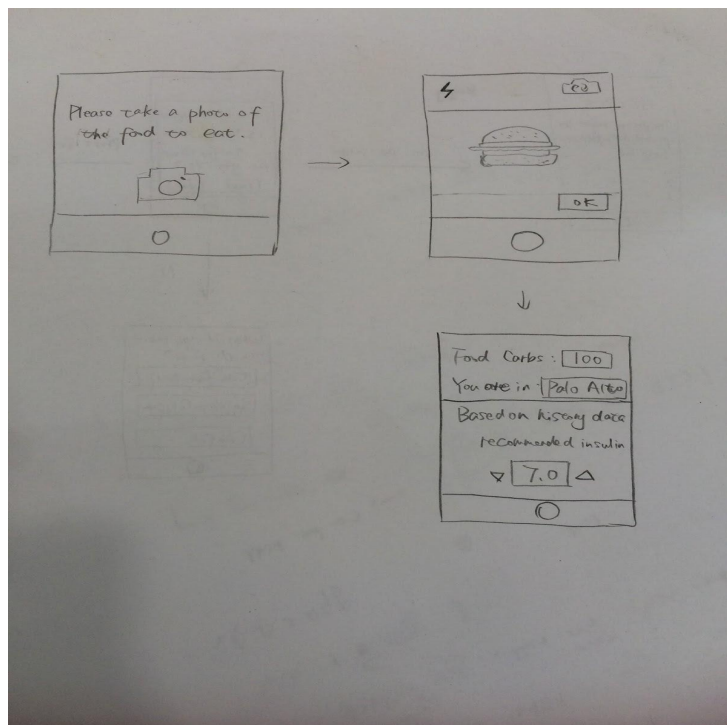


Figure 16 - Meal coverage to count carbohydrate (Tang Zhang)

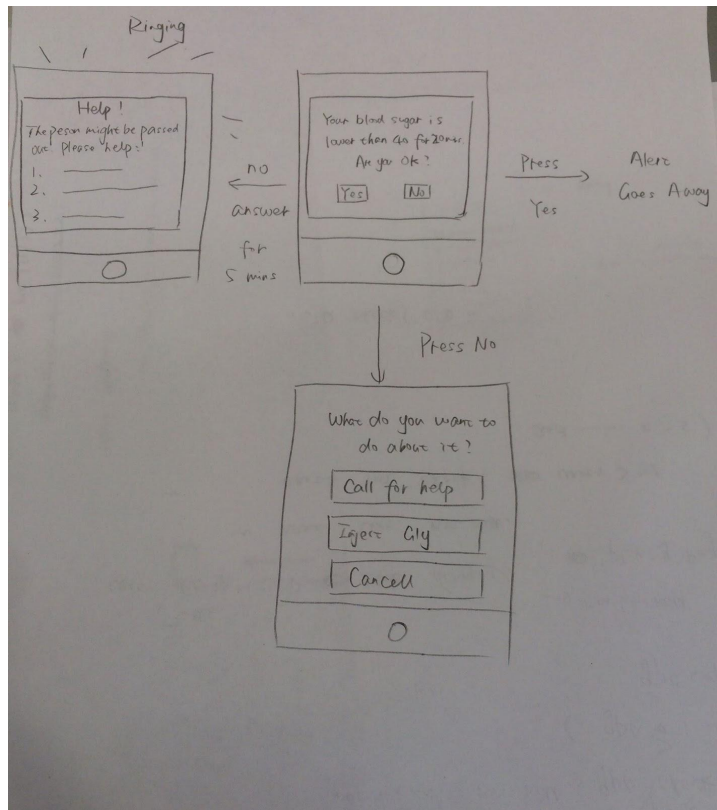


Figure 17 - Emergency treatment (Tang Zhang)