Tentative design

Our system is composed of two components: a portable insulin watch and a notepad sized device.

Insulin Watch:

The portable insulin watch provides the following functionalities:

1) Blood glucose level test
2) Blood ketone level test
3) Cholesterol level test
4) Blood pressure test
5) Pulse rate
6) Injecting insulin

Alongwith providing values for these tests, the watch:

1) Stores values of past one month
2) Shows trend of health statistics
3) Sends the health statistics to doctor regularly
4) Determines the state of unconsciousness
5) Alarms when user is about to get in the situation of unconsciousness
6) Informs some close relatives by sending an alert signal in the case of unconsciousness
7) Informs emergency service

Notepad sized device:

This component of our system is not portable. It is in user's home. The functionalities provided by this component are:

1) Meal planning
2) Exercise planning
3) Motivation assistance
4) Taking snapshots of patients body parts such as eyes, wounds etc and sending to doctor for checkup

Here we only discuss the design of our insulin watch.

Design of Insulin Watch

We are designing a portable system which diabetic patients can use to carry out different tests as well as for insulin intake anytime, anywhere. A diabetic patient has to test different health parameters such as blood pressure, glucose level, ketone level, etc to determine health situation. Different instruments are available in market for such purpose i.e. a glucose tester, a keton-level tester, a blood pressure apparatus etc. These separate devices are difficult to manage. We are trying to provide our users with a device that integrates all these devices in one. We have

decided on an insulin watch that has the capabilities of all these testers i.e. glucose tester, cholesterol tester, ketone tester, and blood pressure tester. Alongwith that, we are integrating insulin injection facility in our watch as well so that user does not have to carry injection and all associated modules in his pocket.

Here we provide our observation of different devices available in market for different diabetes test. We are suggesting our design as well at the end of each analysis.

1. Designing a device to inject insulin efficiently

Models Available in Market

Different devices are available in market for measuring glucose level in blood. We analyzed them and determined what can be improved in these devices to make an optimum instrument for glucose checking.

a. Syringes

Figure 1: Syringes

Pros:

i. Syringes are still the least expensive option
ii. They are easy to learn to use.
iii. They are easily available everywhere.

Cons:

i. Only as accurate as the patient using them. Dosage errors can occur easily, especially if a patient has problems seeing the graduations or lacks fine motor skills.
ii. Requires a certain amount of care with filling and delivery in order to prevent getting injected with air!
iii. Inconvenient to carry around while travelling, or on even at work or in school. There are too many bits and pieces to take care of.

b. Pen

An insulin pen looks like a writing pen. Pen contains an insulin cartridge. A short needle is attached to the end of pen. Clicking a button on the pen injects insulin. The amount of insulin can be controlled by rotating a knob on

the pen. One knob turn adds one unit of insulin. So the dosage can be increased and decreased very easily.

Figure 2: Insulin Pen

Pros:

i. More convenient and easier to transport than traditional vial and syringe
ii. Repeatedly more accurate dosages
iii. Easier to use for those with visual or fine motor skills impairments. 'Click' sound helps to measure the required amount of insulin. Successful injecting of insulin is also indicated by a click sound. Less injection pain (as polished and coated needles are not dulled by insertion into a vial of insulin before a second insertion into the skin)
iv. Can be used without being noticed

Cons:

i. Expensive
ii. Pen needles have to be replaced after every use.

c. Pumps

An insulin pump is a small computerized device that delivers small amounts of insulin constantly under the skin through a small plastic tube. The pump is programmed to give small background doses of insulin (basal insulin) continuously throughout the day and night, depending on the individual's needs. Each time the person eats, they activate the pump to give a burst of insulin (or bolus) to cover the amount of carbohydrate that they are going to eat. Insulin pumps are not automatic. They have to be programmed by the user based on four to six blood glucose levels per day (or sometimes more) and careful thinking about food and exercise patterns.

Figure 3: Insulin Pump

Pros:

i. eliminates individual insulin injections
ii. delivers insulin more accurately than injections
iii. makes diabetes management easier – if your glucose level is high or you feel like eating, figure out how much insulin you need and push the little button on the pump
iv. allows you to be flexible about when and what you eat

Cons

i. Being permanently attached to a 'machine': Most people cannot adapt to this permanent dependence on a machine.
ii. More blood glucose testing: Pump users need to be prepared to do at least four to six blood glucose tests a day (more initially). This is needed to ensure that the pump rates are correct and to help work out how much insulin to give at meal times.
iii. Pump failure: In case of pump malfunction, people always need to have insulin and syringes available to revert to at any time.
iv. Skin infections or irritation: Because the plastic needle is left under the skin for up to three days, infection or irritation at the site is a potential risk.
v. Cost: Insulin pumps and the tubing and needles are expensive.
vi. Since the insulin pump needs to be worn most of the time, pump users need strategies to participate in activities that may damage the pump, such as rough sports and activities in the water.

d. Jet injectors

Figure 4: Insulin Jet Injector

Insulin jet injectors deliver insulin without the use of needles. Instead, a high-pressure air mechanism pushes a mist of the medication into the body through spaces between skin cells. This provides patients with diabetes an alternative method of insulin delivery, especially for patients who cannot use or are uncomfortable using needles and syringes.

Pros:

i. No needle required.

ii. Simple to use. Just wind, dial, fill, inject.
iii. No disposal problems because there are no needles involved.
iv. No needle removes the danger of needle-stick injuries to a person giving insulin to someone who is unable to do it for themselves.
v. The insulin automatically goes to the correct depth, no more decisions needed on what length needle to use and no chance of intra-muscular injections.

Cons:

i. This definitely tops the list.
ii. Jet injectors may cause bruising, especially for people with less fat under their skin, such as thin people, children and the elderly.
iii. There is more to do in setting up the injector than there is in a syringe, so it takes more time.
iv. These devices require regular cleaning to avoid bacterial contamination – requirements that are not associated with disposable needles and syringes.
v. Some people do not like the noise the injector makes when it delivers its insulin.
vi. Some patients find high-pressure air delivery to be as painful as needle injection.

Our Design

After discussing the pros and cons of different devices, we have decided to take idea from insulin pens. However our pen is small enough to fit in our insulin watch. To overcome the problem of conventional pens: replacing needles after every use, we are providing a reservoir of needles in our pen. After the use of one needle, a new one automatically comes out. The pen contains sufficient amount of insulin to last for 3-weeks. So there is no need to replace the insulin cartridge everyday (a problem of prevalent pens).

2. Designing a device to measure glucose level in blood

Models available in market

Different models of glucose meters are available in market. However all of them share almost same design. These meters are composed of two parts: a pricker and tester. Pricker consists of a needle to prick in finger and get a blood sample. The tester contains many strips. Blood sample is placed on the strip and glucose value is tested.

Figure 5: Glucometer

Our design

The tester is integrated in our insulin watch. A separable prick pen is fitted in the watch. User removes it from the watch at the time of use. The prick pen contains needles and testing strips. There are two buttons on the prick pen. Operating on one button brings forth the pricking needle. Pricking is done to get a sample of blood. The other button is pressed to bring forth the testing strip. Blood sample is placed on it and provided to insulin watch. To provide ease of use, our device consists of reservoirs of needles and testing strips. After the use of a strip and a needle, the used ones automatically get discarded and new ones become available for use.

3. Designing a device to determine cholesterol level

Models available in market

The design of cholesterol testing device is almost the same as the glucometer, consisting of tester and the pricker.

Figure 6: Cholesterol tester

Our design

We are integrating the testing functionality in our insulin watch. However no new component is introduced for this test. Instead the pricker pen used for glucose testing is used here too for getting and supplying blood samples to tester in insulin watch. This will reduce the number of devices a diabetic patient has to handle.

4. Designing a device to measure ketone level in blood

Amount of ketone can be tested by measuring in blood as well as in urine. However doctors recommend testing in blood since it is a more accurate measure of ketones. So we are considering only the blood ketone measuring devices.

Models available in market

Figure 7: Ketone tester

The design of this device as well is the same as the glucose meter: consisting of pricker and a tester.

Our design
Here too, we are integrating the testing functionality in our insulin watch in just the same way as we did for cholesterol tester.

5. Designing a device to determine blood pressure

Models available in market

a. Arm Cuff
   The blood pressure band is wrapped around arm. It is used in association with stethoscope. This device is not portable. User cannot determine blood pressure at any time due to the issue of portability. Moreover, user cannot perform the blood pressure test himself. User needs a helper to operate.

Figure 8: Blood pressure monitor

b. Wrist Cuff

A wrist blood pressure band is portable and easy to use. This device performs the blood pressure test procedure automatically at the press of a button. It inflates at the touch of a button. In seconds your blood pressure and pulse are alternately displayed. Electronic digital readout monitors make it easy and convenient for individuals to test themselves.

Figure 9: Blood pressure monitor

Our design

We are integrating this wrist band in our insulin watch. The strap of our wrist watch will provide cuff for checking blood pressure and pulse rate.

Fig 10 shows the diagram of our design.

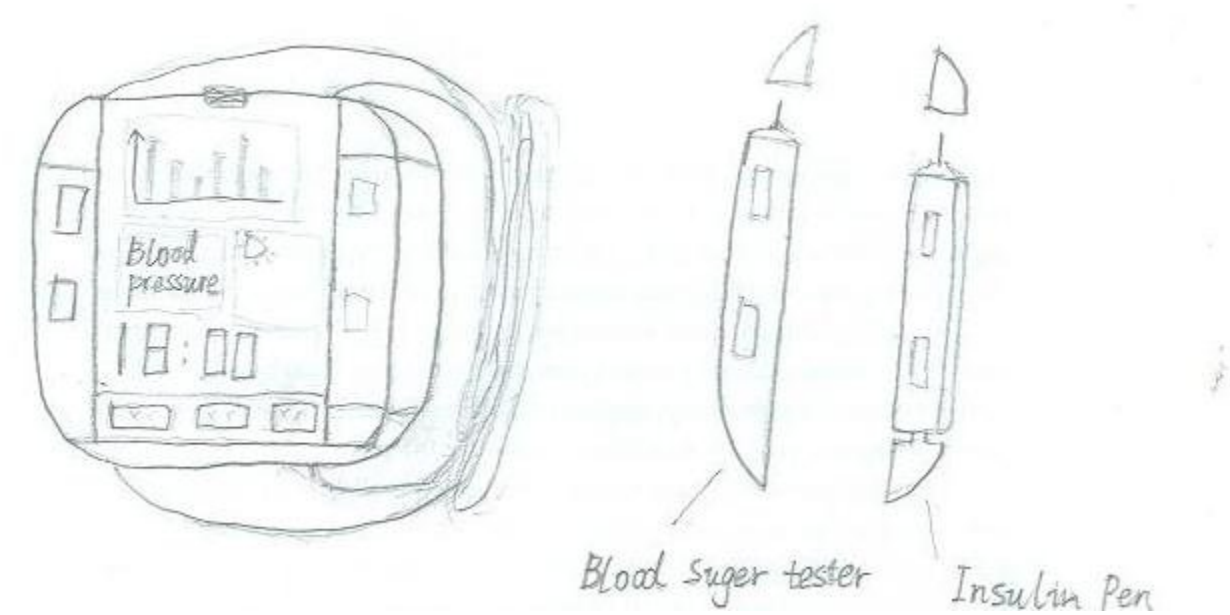

Figure 10: Insulin watch with all components