Diabetes Forecast System (DFS)
Deliverable One: User Needs

Introduction

With type 1 diabetes the body does not produce insulin. A person with type 1 diabetes, therefore, is tasked with simulating the insulin production of a healthy pancreas through insulin shots. The balance between sugar intake and insulin is delicate and can be very difficult with mistakes causing potentially deadly results. If one takes too much insulin they can become hypoglycemic (low blood sugar levels) or hyperglycemic (high blood sugar levels). The tools currently available on the market give a person with diabetes the ability to accurately measure their current blood sugar levels which is a tremendous help in keeping blood sugar regulated. However, that measurement is just a snapshot in time and does not give the user any indication to where their glucose level is heading nor does it help the user decide what actions should be taken to correct their condition if/when it becomes necessary.

Our proposed system will offer our users this advantage. It will take into account the four major factors in glucose levels (carbohydrate intake, insulin intake, level of activity, and current blood glucose level) to give the user a prediction of where their blood glucose level will be in the near future and it well help them make healthy decisions to keep it in the normal range. The device would even notify the user if they have forgotten to test their glucose level recently and may be in danger of falling outside healthy limits.

We hope to create a tool that targets diabetic users of almost all ages, sexes and races. Ideally it would be a tool with “universal usability” among type 1 diabetics. One of the member’s of our group has type 1 diabetes and served as one of our main subjects for real-life tasks that diabetics need to perform to monitor and maintain their BGL.

Tasks

User: Brian, a 28 year old Caucasian male. An experienced user.
task: Eating

Brian wakes up around 8 or 9 am, checks his glucose levels, and takes insulin as needed (long acting - 12 hour). He usually takes fast acting insulin, too, for breakfast, but some days he’ll skip breakfast if he’s running late. He normally checks his levels again 1-2 hours after taking the long acting insulin. He will typically eat lunch around 2 or 3, and take insulin for this. He'll check his levels about 2 hours after lunch. Dinner is usually 8 or 9 pm, when he takes long acting insulin and fast acting insulin, too. Most of the time he eats most at dinner, so I'll take he will test his BGL again before bed, which is 1-3 am. Occasionally, he feels like his BGL is low, so he'll eat something. Taking his BGL with this level of frequency is very important.

User: Brian, a 28 year old Caucasian male. An experienced user.
task: Testing BGL

Sometimes he forgets to take his BGL reading on time and waits 3-4 hours after a meal before testing. He’s not great at remembering to do this exactly an hour after he eats. Sometimes he does remember but is in the middle of an exam or in Church or some other place where he’s embarrassed to get up and test. He hardly ever tests in public, because he’s not sure what people will think when they see him drawing blood out of his finger. It is important that he can run his test quickly, quietly and from any given location or time.

User: Brian, a 28 year old Caucasian male. An experienced user.
task: exercise
When he exercises, he wants to know his BGL before he works out, so he knows if he'll need to eat something before he runs or bikes. If he goes to the gym, he brings Gatorade with him and drinks 8 oz every 15 minutes he does cardiovascular work. If he runs outside, he'll just run, but if he goes out for a run which will last > 45 minutes, then he'll bring some change or a couple of dollars and run near convenience stores where he can stop to buy some orange juice if he feels like he needs it. From testing his BGL after a run, he'll know that it is usually higher or no more than 5 points lower than when he left, even if he had nothing to eat or drink. That has given him confidence that he shouldn't worry too much about passing out on a run from a low BGL. Since exercise has a secondary effect on BGL, it can increase insulin’s effectiveness, so checking after workouts is of moderate importance.

User: Brian, a 28 year old Caucasian male. An experienced user.
task: traveling to another time zone

He has only ever crossed 2 time zones (on a trip to Colorado, MST) by plane since he was diagnosed 6 years ago in October. He put off his injection of long acting insulin until dinner at 5 (or 7 pm EST), which was actually 14 hours after he took insulin in the morning. He figured it would be easier to do that than take insulin at 3 pm everyday -- he might forget to take it altogether. Sometimes he thinks he’s taken it and so he doesn't take another dose, which wouldn't be lethal, but could cause some bad low readings. Dealing with testing and injecting insulin on the plane is a little stressful, he normally does both right in his seat, but the thing he fears the most is having a low reading, because he can't really run into the kitchen and drink a soda or juice. He brings a lot of snacks with him and tries not to take a lot of insulin on that day of travel (He preorders the diabetic meal that airlines offer when he buys his ticket). He also tries not to exercise that morning (if he has a late flight) or the night before if the flight is the next morning, to avoid hypoglycemia. After taking the return flight home, he took insulin at the usual time, which was two hours early. They say that overlapping by up to 2 hours is okay because the previous injection (basal rate) is weak at that time and the new basal injection won't be very strong for an hour or two.

User: Brian, a 28 year old Caucasian male. An experienced user.
task: visiting a foreign country

He took a trip to Guadalajara, Mexico in 2000 for 5 weeks to study Spanish from the source. He stayed with a family that spoke no English and prepared a variety of foods he had never heard of, even after translating them to English! There were some things like beef tongue tacos that were not terribly appetizing but hr was able to know that the tongue, like all meat, had no carbohydrates, and the taco probably had 15 - 20 based on its size. Items like horchata de arroz, a cold rice drink, left him baffled when trying to guess their carbohydrate content, and he tried to avoid them or just drink very little of such things. Since hot peppers were used a lot more he had to be careful of them. He wasn't sure what to think, but he guessed they didn't have many carbohydrates like most vegetables don't. The trick was trying to find out whether or not they affected one's BGL indirectly, such as by raising the blood pressure or creating stress on the body. There was no internet access at the house, and he didn't have a doctor there, either, so he was left guessing about that one and decided to eat as few peppers as possible. Coffee was something he tried to avoid if possible because it tended to raise his BGL, but this became hard because he didn't want to refuse the food that La Senora of the house was preparing for him. He had explained to her that he was diabetic, but he doesn't believe she ever really understood that (simply by the way she strongly encouraged his eating of tortillas with every meal -- even if just with soup!). Soon into the trip, he decided to take less insulin than normal because he figured it was better to have high BGL's than low ones and pass out. He tested more frequently (probably twice more per day) and tried carefully to test an hour after each meal. There was a grocery store nearby which he went to and stocked up on cookies and juices (for unexpected lows at home) that aren't sold in the States. He was able to translate the “carbohidrato” amounts, though, which was the carbohydrate amounts that he was used to dealing with, so he was able to get by understanding how to read nutrition labels despite the language and metric system barriers (they used grams there like we do). One thing that surprised him is that my insurance didn't cover purchases directly, so he bought insulin (sold in smaller vials) and syringes (longer and thicker needles) and then submitted receipts upon his return. He ate at the same time everyday which they say helps your body maintain steadier BGL's, and he tried to run at regular intervals to help with preventing high BGL's. He became more stressed on an average day there than he does here, though, because of the language barrier
and because he was trying to go to school at the same time as he was becoming used to another culture altogether. This was something he had to take small, usually one unit, doses of fast acting insulin for because stress raises BGL.

A great trip all around, but he’s glad that he saw his doctor before going. A couple times, pharmacies ran out of insulin and he had to wait a day for it. He was able to manage that on the vials he still had, but if he did the trip again he would buy refills a week in advance, just to be safe.

User: David, an experienced but forgetful user
Task: Alert

David is an autistic diabetic. He also suffers from hypoglycemia unawareness, which means he does not suffer the symptoms of hypoglycemia and can’t tell when his blood sugar is low. This would be manageable if he kept regular tabs on his glucose levels. But he has a tendency to forget or ignore this responsibility which can lead to him losing consciousness and being completely unable to call for help. David needs close monitoring to make sure he is diligent in monitoring his blood. Calling for help should be an infrequent task, in fact one hopes that its never needed, but in this unlikely event it is very important.

User: Mary, a child
Task: Lunchtime Glucose Guess

Mary is a second grade elementary school student. Since she does not like the typical BGL monitor device due to its size and design, she usually has her parents do the BGL test for her to determine how much insulin she has to be injected with before she goes to school. Mary has to wake up early and have breakfast before going to school. In the morning, Mary’s parent will check the glucose level, and inject insulin. However, the parents do not go to school with Mary, nor does she bring an insulin pump or glucose monitor. Mary’s parents prepare the lunch box for her according to how many carbohydrates she should eat on a normal day, but she is unable to adjust her diet due to unforeseen circumstances. Sometimes Mary will get to eat some unknown food such as classroom snacks from her friends or the teacher in school. Without the glucose monitor, Mary does not know her BGL and thus it might result serious outcome if Mary does not have access to food information. Mary is a child and has less control over the structure of her day, she also is prone to misunderstanding or forgetting about her condition.

User: A Spanish single mom
Task: Morning glucose test

Maria is a single mom with type 1 diabetes, who speaks little english. She measures her sugar level every morning before she decides what to have for breakfast. This is a very important task since her busy schedule makes it to find free time to adjust to her needs throughout the day and she must have a solid framework from which to start or she might have trouble finishing strongly. Other than her mom, she doesn't know anyone else who has diabetes, so she relies on her mom a lot when she needs recommendations in choosing a diet. She has to check herself 5-6 times a day and when she does, she follows the guidelines that her mom has explained to her. There are few translations in Spanish and everything she knows about it is based on her mom's teaching. While Maria is working, her mom monitors her by calling Maria's cell phone and checking whether she is tired or if she needs something to eat. When she checks herself, she looks for the reading and then she has to make a decision in what kind of doses is needed. Her mom has made a table of translations with different marks for Maria to understand what each measurement is needed in order to avoid overdoses. She has also followed the counsel of her mom in bringing a snack just in case she needs to eat something in order to balance her sugar levels.

User: Spanish Youth
Task: glucose test
Pedro is a 10 years old boy who has had Type I diabetes since he was 5. His parents has helped him understand his condition since day one, however in the beginning it was very difficult for Pedro to understand. As a regular spanish boy, he likes to play a lot of soccer, yet his condition make him withdraw pretty easy unless he prepares himself for the particular game. He has learned that when it's sunny, he needs to eat a bit more so he can have enough energy to play. It is still pretty difficult for him to not confused the difference between when he is tired for too much playing and tired because of his sugar levels. His parents help him a lot, however as they monitor him constantly as they maintain a record of his sugar levels and try to randomly forecast his needs. His parents have to keep in good contact with Pedro's teachers to provide good feedback in how he is doing in class and whether he is physically doing ok. Pedro usually begins his day as a regular boy trying to sleep more than needed, however his parents always fight the confusion of understanding whether that is a problem in his sugar levels or his desires to sleep a bit more. Reading his sugar levels is a very important thing for his parent in order to understand Pedro better. Meals always depend on Pedro's mom. She always packs a snack with a special note reading "for emergencies only". This helps Pedro remember that he can't be eating that meal for fun, but only when his body will need it. Although Pedro is a lot more mature than his friend, it has taken a lot of work for his parent to have him work with his condition.

**Systems requirements:**

Based on our user’s task we have determined that our system must read the glucose levels of the user. It must be able to record the user’s carbohydrate and insulin intake as well as the users’ exercise schedule. This information is necessary in making an accurate prediction of the users future BGL. The system must be able to make this prediction and notify the user so that the user can make a more informed decision. This is the most basic functionality that is required of the system.

Different items should also be included in the system. Some sort of networking (wireless, possible) to allow information to be shared with doctors, family members (in the case of children) or institutions in order to provide better pattern analysis, if permitted by the user. Output devices such a speakers, vibrator and/or messaging system for reminding the user of missed dose should also be included in the product. DFS should support different languages such as Spanish, English and Chinese. It should also be able to export data and provide an interface to be used in a web browser to provide the user with a longer history than the device’s memory allows. These features allow us to come closer to universal usability and make for a much more complete product, but would not render the product useless if they were removed from the design.

DFS could also include different themes to provide customized look and feel for users of different ages, a text reader for the visually impaired, a heart rate monitor built in to provide real-time track of current workout in order to provide more accurate patterns and forecast predictions. Also, DFS could include a database of nutritional information to help make sensible suggestions for future meals based on their current levels and forecast analysis. The database could also help the user figure out the amount of carbohydrates in meal they have already eaten. These features provided very interesting possibilities that flesh out the usefulness and universal usability of the device, but are not necessary and may even hinder attempts to streamline the system.