The first wearable device for diabetics that integrates biometrics to alleviate the stress of managing the disease.

Designing for Diabetics | Hector Silva

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2015 MDes, Industrial Design

Abstract

Flore is the first wearable device for diabetics that integrates biometrics to alleviate the stress of managing the disease. It is a small wearable device that serves not only as a glucometer, but also as a motivation to make healthier choices in nutrition and physical activity. It allows for diabetics to live a normal life despite the disease. Flore consolidates each individual action that a diabetic performs on a daily basis into one device. It can be worn as a stand alone device or as a clip with the optional silicone sleeve jacket. Flore serves as a tele communicator with your provider, sending updated health data on a regular basis. It also has the capability to communicate your health status to your loved ones. In the event of a dangerously high or low glucose level, Flore would notify emergency personnel.

The breakthrough feature that sets Flore apart from other diabetic devices is that it prevents any type of discomfort associated with painful pricking of the finger to draw blood. The back of the device is equipped with a finger scanner that uses near infrared spectroscopy technology to detect your blood glucose level. It eliminates the need to carry lancets, draw blood, and connect an external testing strip to the device. Flore is here to help you manage your diabetes in the least obstructive way, and allows you to live the most normal life possible.

Table of Contents

Section 1: Background

What is Diabetes? Diabetes is a disease in which the body does not produce or properly use insulin, a hormone that is needed to convert sugar, starches and other food into energy needed for daily life.

Why you should care

Diabetes has turned into a global pandemic. It is important that we educate ourselves about the disease, to know about its effect on the body and how to prevent onset. In an age consumed by technology, where information is at our fingertips, we must learn to take control of our own health and motivate ourselves to live healthy lives.

Diabetes is categorized as either type 1, type 2, gestational or pre-diabetes. If left untreated, each type of diabetes can cause astronomical harm. As all but type 1 diabetes are preventable, knowing how to reduce the risk of developing the disease is a crucial aspect of living a long and healthy life.

Why you should care

According to the American Diabetes Association (ADA), 371 million people across the world have been diagnosed with diabetes, 29.1 million of which live in the United States. And additional 5.7 million Americans are unaware that they have developed the disease. A diagnosis of diabetes is a simple blood sugar test. It involves the use of a glucometer, a small device that detects blood sugar levels. The test can either be self-administered in the home or by a physician.

Don't treat Diabetes to your eyes.

Diabetic Retinopathy is the leading cause of blindness in the working population of the world. So, visit your doctor regularly and protect your vision.

Don't give Diabetes that fat chance.

Obese people are more prone to insulin resistance and therefore diabetes. Don't let the sugar level increase beyond 140 mg/dL.

Check for Diabetes in case of obesity.

BREAKING DOWN DIABETES

your body needs insulin to transform glucose into energy

1 TYPE 1 DIABETES

when the pancreas doesn't produce insulin

2 TYPE 2 DIABETES

when the pancreas doesn't produce **enough** insulin (or the insulin cannot be processed)

3 GESTATIONAL DIABETES

when the insulin is less effective during pregancy

4 PRE-DIABETES

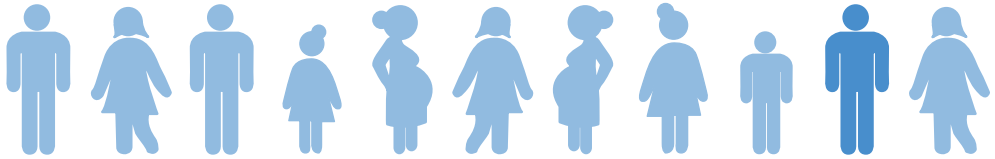
the blood sugar level is higher than normal but not yet high enough to be classified as type 2 diabetes

29.1
MILLION
IN THE USA

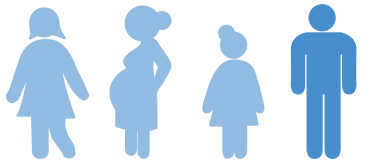
371
MILLION
WORLDWIDE

DIABETES

29.1 million people have diabetes.



That's about 1 out of every 11 people.



1 out of 4 don't know they have diabetes.

86
MILLION
IN THE USA

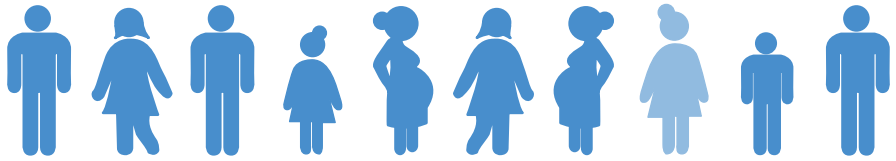
30%

PRE-DIABETES

86 million people have pre-diabetes.

More than 1 out of 3 adults have pre-diabetes.

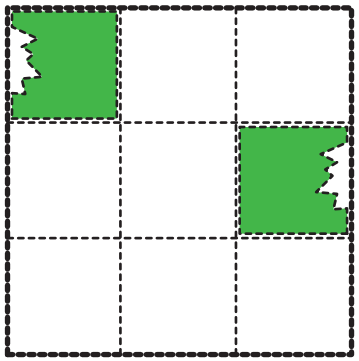
15-30% of people with prediabetes will develop type 2 diabetes within 5 years.



9 out of 10 don't know they have pre-diabetes.

TYPES OF DIABETES

TYPE 1



BODY DOES NOT MAKE ENOUGH INSULIN

Can develop at any age

No known way to prevent it

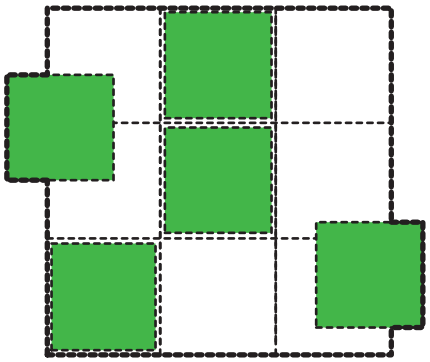
MORE THAN 18,000 YOUTH ARE DIAGNOSED EACH YEAR IN 2014 AND 2015

In adults, type 1 diabetes accounts for approximately

5%

of all diagnosed cases of diabetes

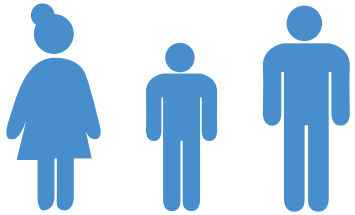
TYPE 2



BODY CANNOT USE INSULIN PROPERLY

Can develop at any age

Most cases can be prevented



Currently, at least 1 out of 3 people will develop the disease in their lifetime

COMPLICATIONS

People who have diabetes are at a higher risk of serious health complications:

STROKE

NERVE DAMAGE

LOSS OF VISION

KIDNEY FAILURE

LOSS OF TOES, FEET, OR LEGS

LOWER LIMB DAMAGE

HEART DISEASE

Section 2: Research

User centered design type of research was done through this process in order to get the most accurate information from the users and digest their feelings and experiences into a final product.

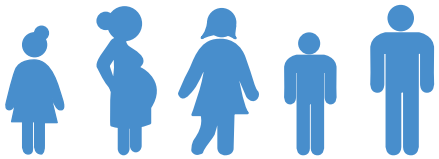
Ethnographic Research

The University of Illinois at Chicago (UIC) is part of the Illinois Medical District (IMD). The IMD consists of over five hundred acres of medical research facilities, hospitals and various specialized clinics. As a graduate student with a healthcare-based thesis, I was able to utilize all of these resources. Ethnographic research was conducted at the UIC Outpatient Care Center with patients who had been diagnosed with either type 1, type 2 or gestational diabetes.

Demographics

Diabetes does not discriminate. It affects anyone and everyone, from children to the elderly, all around the world. However, decades of research has shown that in the United States, diabetes is more prevalent in minority populations. Those at most risk are of African-American, Hispanic and Native American descent. Diabetes is a high priority for The Office of Minority Health (OMH), because racial and ethnic minorities have a higher burden of the disease, poor control and are therefore more likely to experience complications from diabetes. According to the OMH Director, Jonca Bull, M.D., "For minorities, poverty, lack of access to health care, cultural attitudes and behaviors are all barriers to preventing diabetes and having effective diabetes management." As the disease is known to progress more rapidly in minorities, poor prevention and management methods are major contributors to poor diabetes outcomes in minorities.

DEMOGRAPHICS



Diabetes is a disease that affects **everyone**. As young as seven years of age and as old as sixty five and higher.

BY THE NUMBERS

- **PREVALENCE:** In 2012, 29.1 million Americans, or 9.3% of the population, had diabetes. Approximately 1.25 million American children and adults have type 1 diabetes.
- **UNDIAGNOSED:** Of the 29.1 million, 21.0 mission were diagnosed, and 8.1 million were undiagnosed.
- **PREVALENCE IN SENIORS:** The percentage of Americans age 65 and older remains high, at 25.9%, or 11.8 million seniors (diagnosed and undiagnosed).
- **PREVALENCE IN SENIORS:** The percentage of Americans age 65 and older remains high, at 25.9%, or 11.8 million seniors (diagnosed and undiagnosed).

BY RACE/ETHNICITY

The rates of diagnosed diabetes by race/ethnic background are:

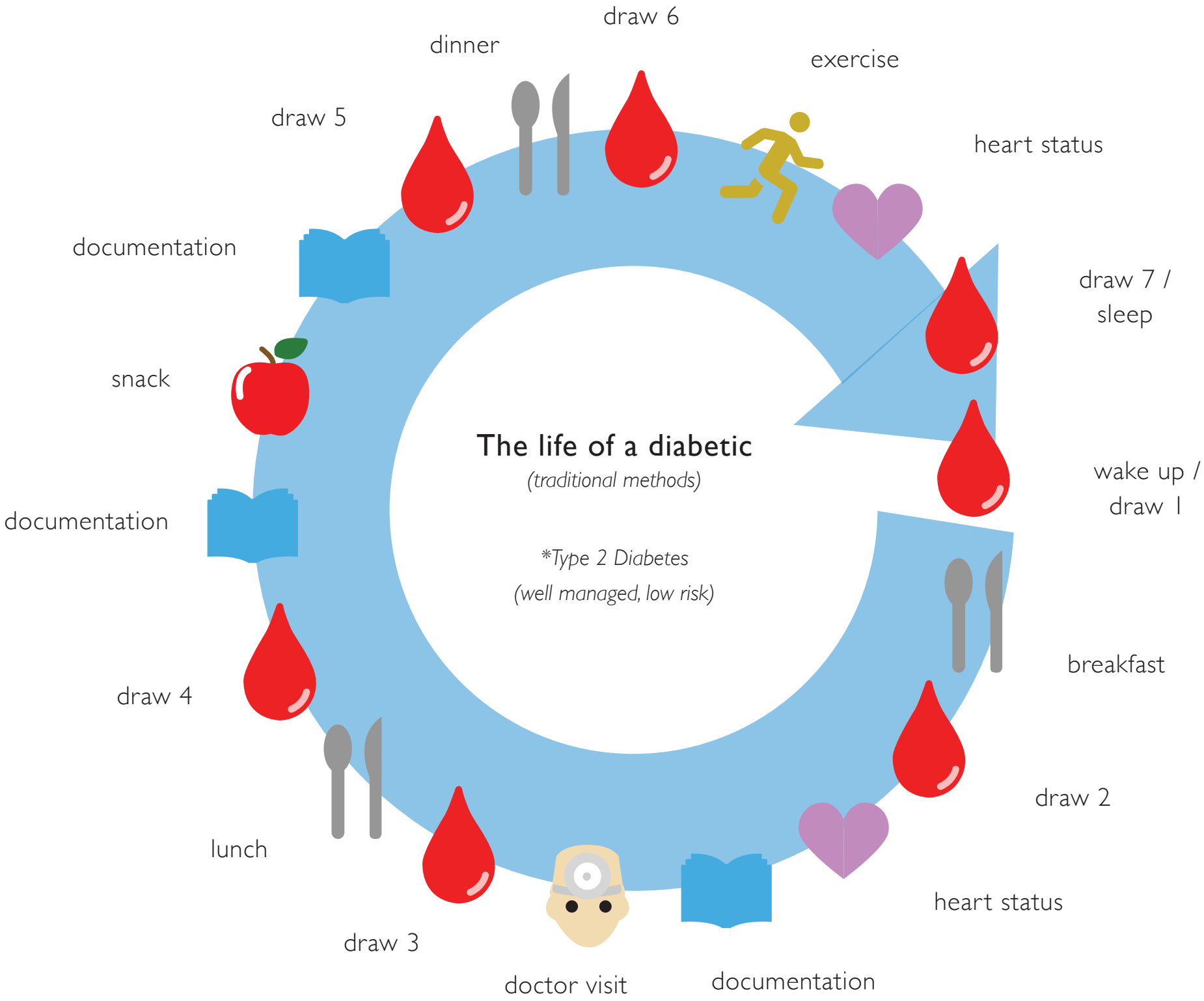
- 7.6% of non-Hispanic whites
- 9.0% of Asian Americans
- 12.8% of Hispanics
- 13.2% of non-Hispanic blacks
- 15.9% of American Indians/Alaskan Natives

The breakdown among Asian Americans:

- 4.4% for Chinese
- 11.3% for Filipinos
- 13.0% for Asian Indians
- 8.8% for other Asian Americans

The breakdown among Hispanic adults:

- 8.5% for Central and South Americans
- 9.3% for Cubans
- 13.9% for Mexican Americans
- 14.8% for Puerto Ricans


The life of a diabetic
(traditional methods)
*Type 2 Diabetes
(well managed, low risk)
wake up / draw 1
breakfast
draw 2
heart status
documentation
doctor visit
draw 3
lunch
draw 4
documentation
snack
documentation
draw 5
dinner
draw 6
exercise
heart status
draw 7 / sleep

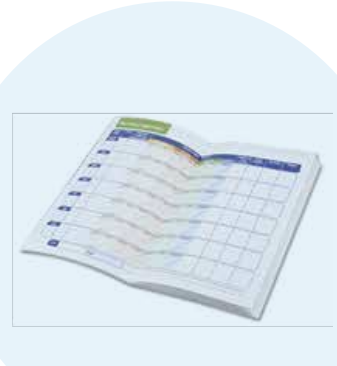
Step by step

Living with diabetes can be a very stressful. The graph on the left serves as a visual representation of all of the actions performed on a daily basis by an individual with well-managed, type 2 diabetes. A type 1 diabetic typically undergoes a more rigorous daily routine.

Diabetes Applications

Wearable Technology

Glucose Monitors



Manual: Notebooks, Diaries

Opportunity

Diabetics are faced with the difficult decision of managing their disease on their own. It couldn't be more difficult, you have a dozen applications on your smartphone that can help you, wearable devices screaming to be worn, your typical diabetic management devices and a more traditional way of keeping track of yourself, a notebook.

There are so many options to manage the disease, but a lot of these options offer very little help. They often confuse the user and require the same amount of steps that a current diabetic takes to manage their disease. There is no solution to the current problem. After comparing all of the options, I found common ground and an opportunity presented itself. Perhaps consolidating all of these services into one device can be the answer?

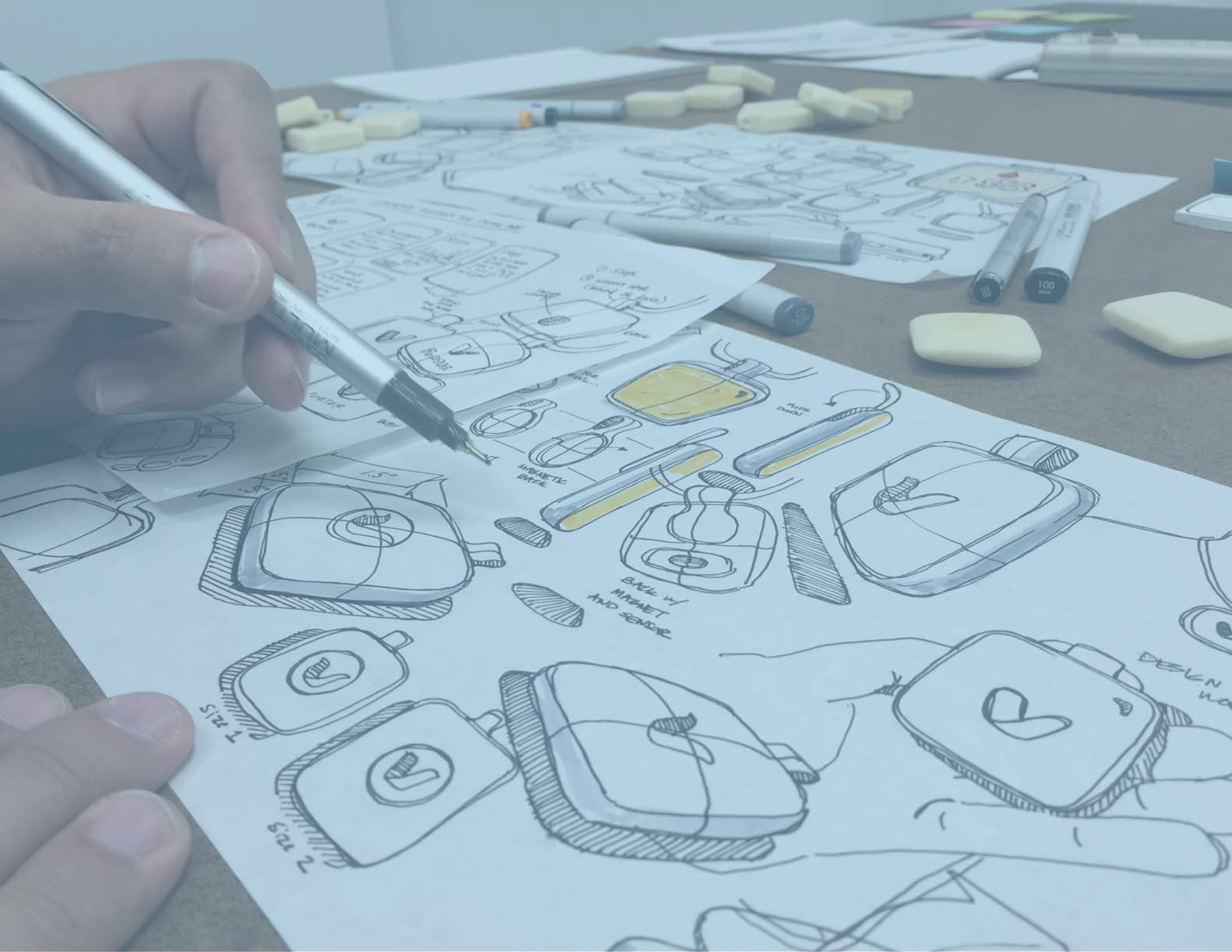
Diabetes Applications

Wearable Technology

opportunity

Glucose Monitors

Manual: Notebooks, Diaries


MAGNETIC BALL
BALL W/ MAGNET AND SENSOR
SIZE 1
SIZE 2

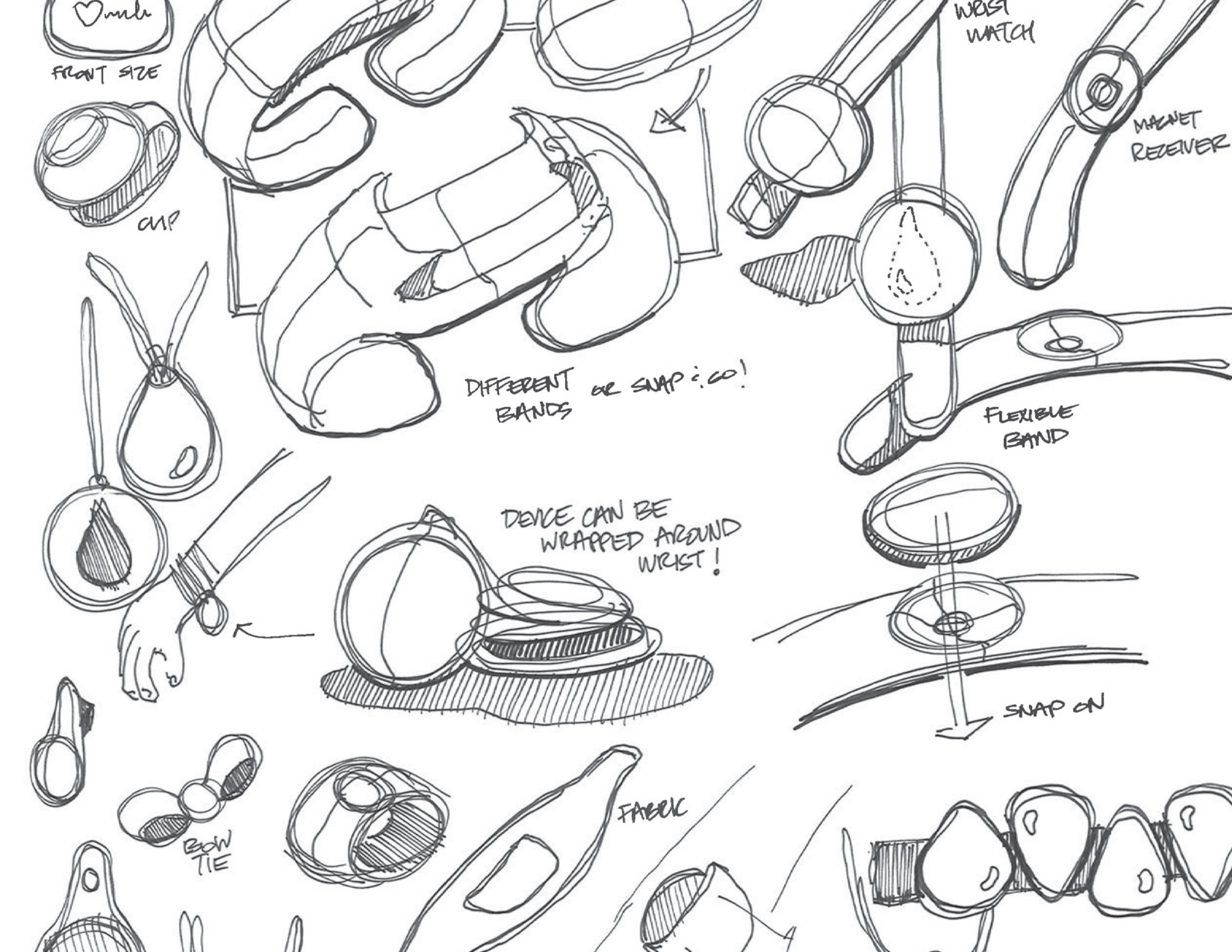
Section 3: Initial Ideation

After the data was broken down into graphs and story boards, the ideation phase began, giving rise to the preliminary sketching.

Brainstorming

During the brainstorming phase, the initial research was broken down into a variety of categories, one of which was lifestyle. How could this product improve the life of a diabetic? Most importantly, how would this device be worn, and how would it interact with the user? Inspirational visuals and current iconic products, such as Apple's iPod and the simplicity of Dieter Ram's Braun products were used as aesthetic references during the brainstorming process.


TEXTURE
ALIVE
1.
2.
3.
MATERIAL
ATTACHMENT
125
CLASSIC


FRONT SIZE
CAP
DIFFERENT BANDS
OR SNAP & GO!
WRIST WATCH
MAGNET RECEIVER
FLEXIBLE BAND
DEVICE CAN BE WRAPPED AROUND WRIST!
SNAP ON
BOW TIE
FABRIC

Concept Generation

Brainstorming is a technique by which creative efforts are made to find a conclusion for a specific problem by spontaneously gathering a list of possible solutions. Concept generation filters all of the brainstormed ideas into a variety of avenues in which to continue. The concept generation phase allowed me to sculpt the skeleton of the object.

User Centered Design & Emphatic Modeling

User centered design research was implemented throughout the process to obtain the most accurate information from users in order to incorporate their feelings and experiences into a final product.

Withings iHealth Align
Diabetic Management Device

30 Day Design Challenge

This graduate thesis has given me a unique perspective on the disease process and lifestyle of diabetics. I had the firsthand experience of living a diabetic lifestyle for thirty days. I experienced the finger pricking, the documention, the activity reminders and the struggle with maintaining a meticulous diet. I found it difficult to live with the disease, because the current management methods require a variety of actions and devices.

Carrie Klima, PhD, CNM
Clinal Associate Professor, UIC

Laurie Quinn, PhD, RN, FAAN, FAHA, Clinical Professor, UIC

Cynthia Fritschi, PhD, RN, CDE, Assitant Professor, UIC

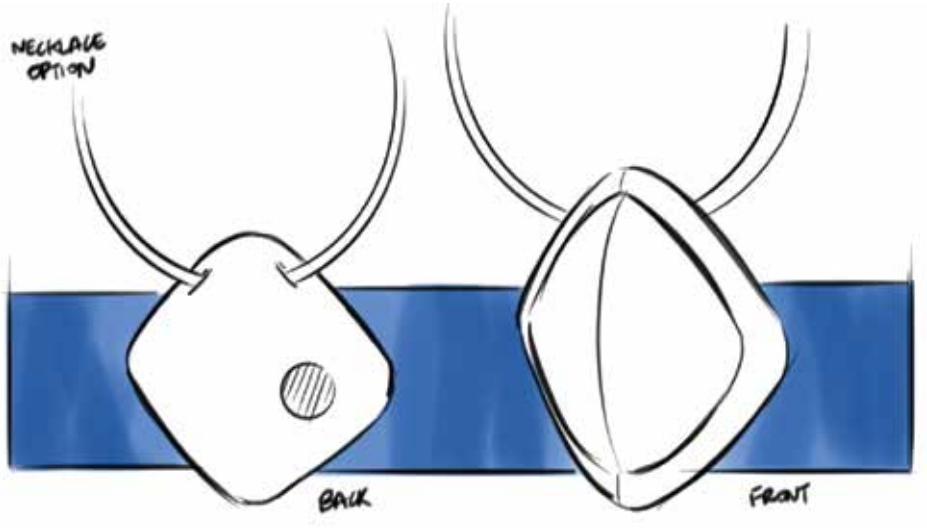
Ali Cinar, PhD, Professor of Chemical Engineering, IIT

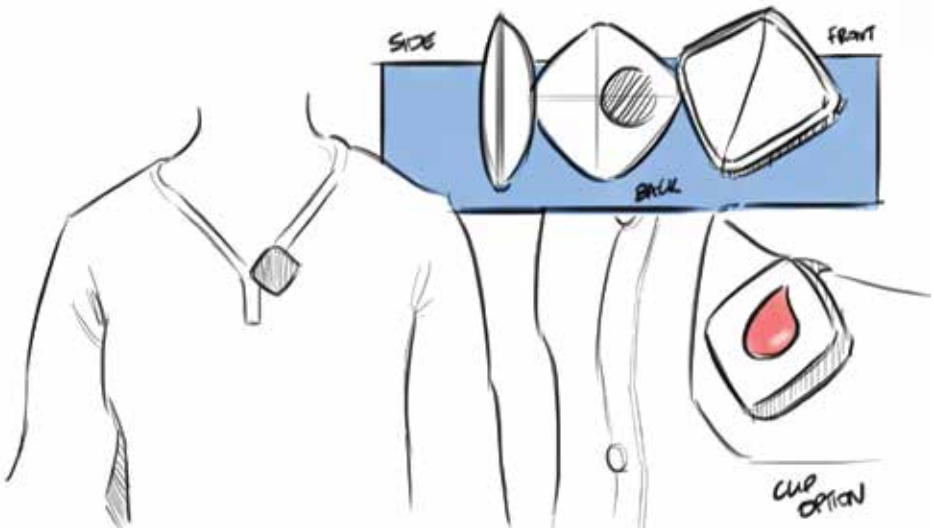
Heidi K. Leftwich, DO, Maternal-Fetal Medicine at UMass Memorial Medical Center

Jeanette Flom, Executive Director at American Diabetes Association in Chicago, IL

Meet the professionals

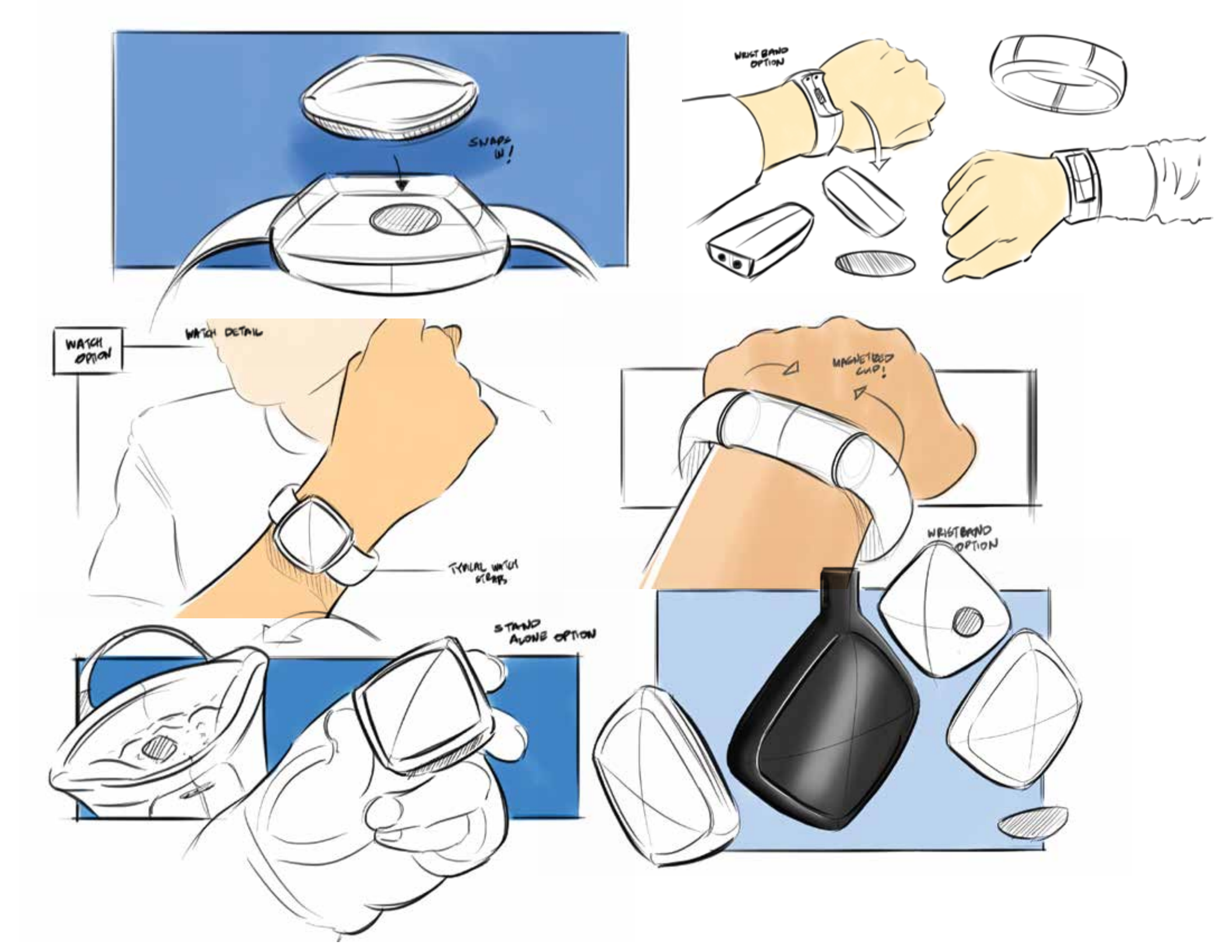
I met with several professionals who have dedicated their entire career to diabetes research. Meeting with professionals in the field validated my design and concept of consolidating all of the individual actions that diabetics carry out on a daily basis in an effort to maintain a healthy lifestyle. Illinois Institute of Technology (IIT) professor, Ali Cinar, commented, "Once the technology is stable and is made mainstream, it will be open season for all medical corporations. It's impressive that you are one of the very few to have figured out a way to utilize this technology and create an environment where diabetics can put your design to good use."





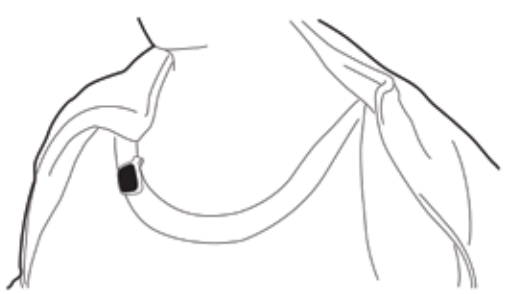
Refinement

After meeting with the intended users (diabetics), researchers, educators and professionals in this field, I was able to advance my concept generation to a more refined state. Drawing feedback from both parties and then applying them to the refinement stage to deliver weareble concepts and other user product options.


SNAPS IN!
WRIST BAND OPTION
WATCH OPTION
WATCH DETAIL
TYPICAL WATCH STRAP
MAGNETIZED CUP!
WRISTBAND OPTION
STAND ALONE OPTION

1

Device with clip silicone jacket



2

Device with wrist strap

3

Device as a watch

4

Device as a necklace

Refinement

After various refinements, four possibilities for user interaction emerged. The four options allowed for a closer examination of the user experience, specifically, how this device would enhance the lives of diabetics. Flore can be used as a stand-alone device, to be held or placed in a pocket. Users also have the option of clipping it on their person with the use of a silicone jacket, or wearing it around their wrist or around their neck with a wrist strap or necklace, respectively.

Prototypes

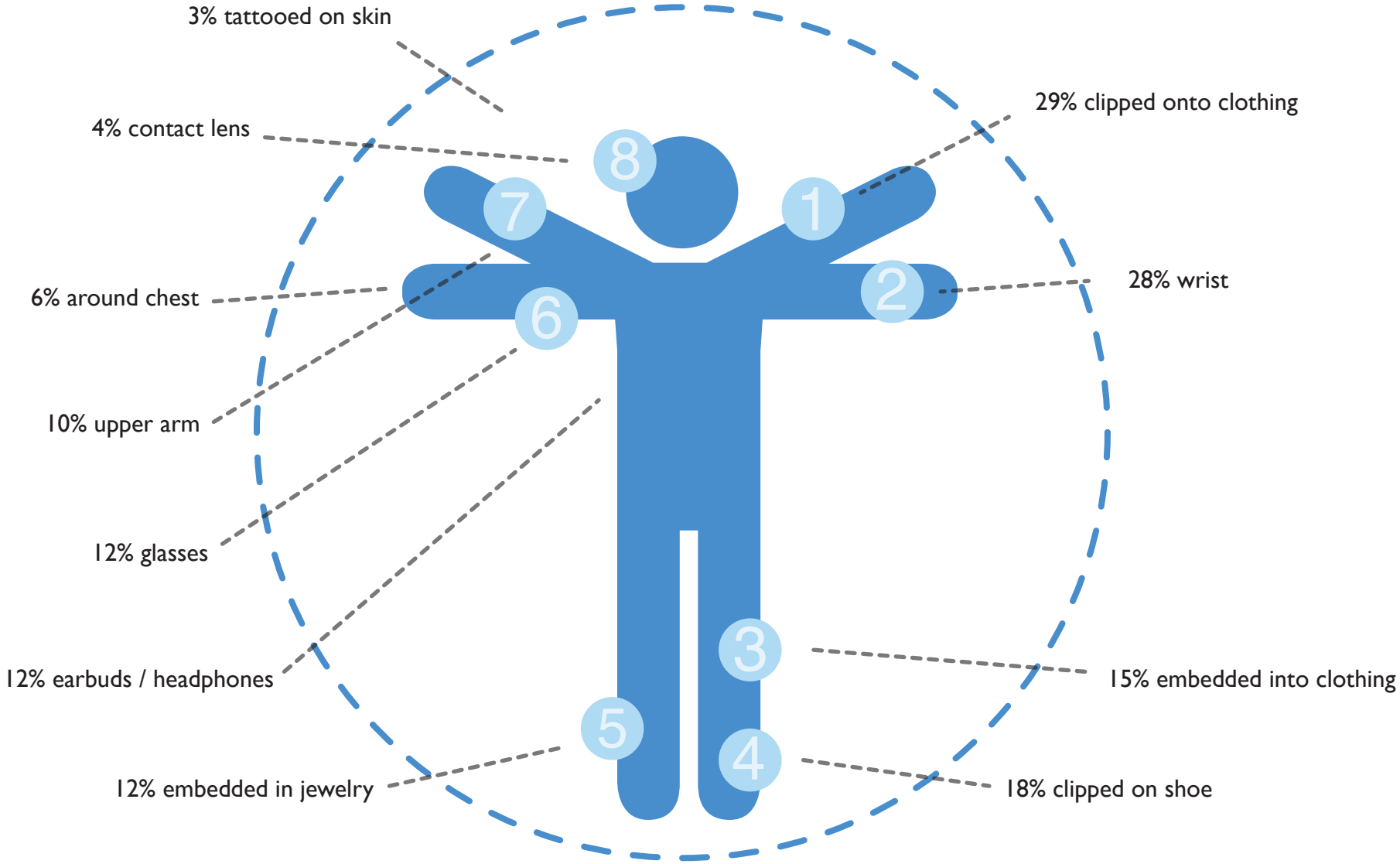
New developments in technology have allowed designers to transform rough sketches into three-dimensional prototypes within minutes. During this process, I created over forty prototypes of various sizes and materials. Potential users were allowed to interact with the prototypes to provide feedback on the size, comfort, visual aesthetic and convenience of the device.

Prototypes validated the size and feel of the object. 3D printing at its best.

Section 4: Technology

Technology is drastically changing the way we communicate with each other, the way we exercise, eat and sleep. I believe technology can have meaningful impact in healthcare, specifically helping everyone who is diabetic or might be at risk of getting diabetes. Diabetics have to consistently monitor their glucose levels on a daily basis, they have to eat a healthy balanced diet that consists of breakfast, lunch, and dinner and about three or four snacks in between - technology can ease the stress of all of these actions.

Prime real estate for wearable technology.

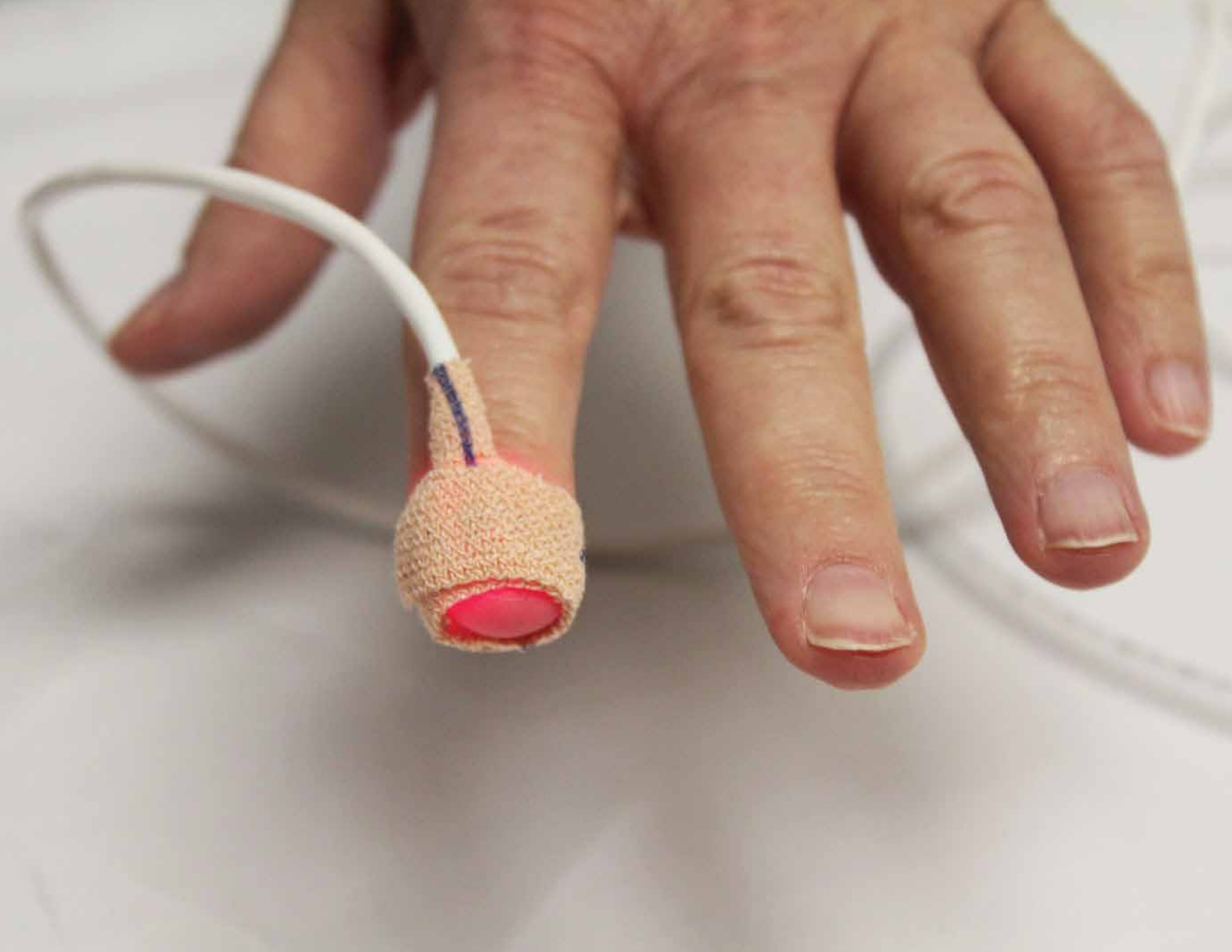


This graph is based on a survey by Forrester

Research, surveyed 4,657 online adults (18+)

Wearable technology

What is wearable technology? According to Vandrico, Inc. a Vancouver research based firm that does in-house research and user centered surveys on wearable technology, they define wearable technology as "a new and emerging field in the technology sector. It can be defined as computing devices with ergonomic designs, made to be worn by the 8 user at all times. This can include wristbands, watches, glasses, belts, rings and many other functional pieces." Designers are constantly answering questions on what the future is going to hold and what the next generation of products will bring us. It's astonishing to see that an iPhone 5S has more power than all of the computing power NASA used to put a man on the moon. The microchip has changed everything, and is allowing designers and engineers to bring conceptual ideas to life.

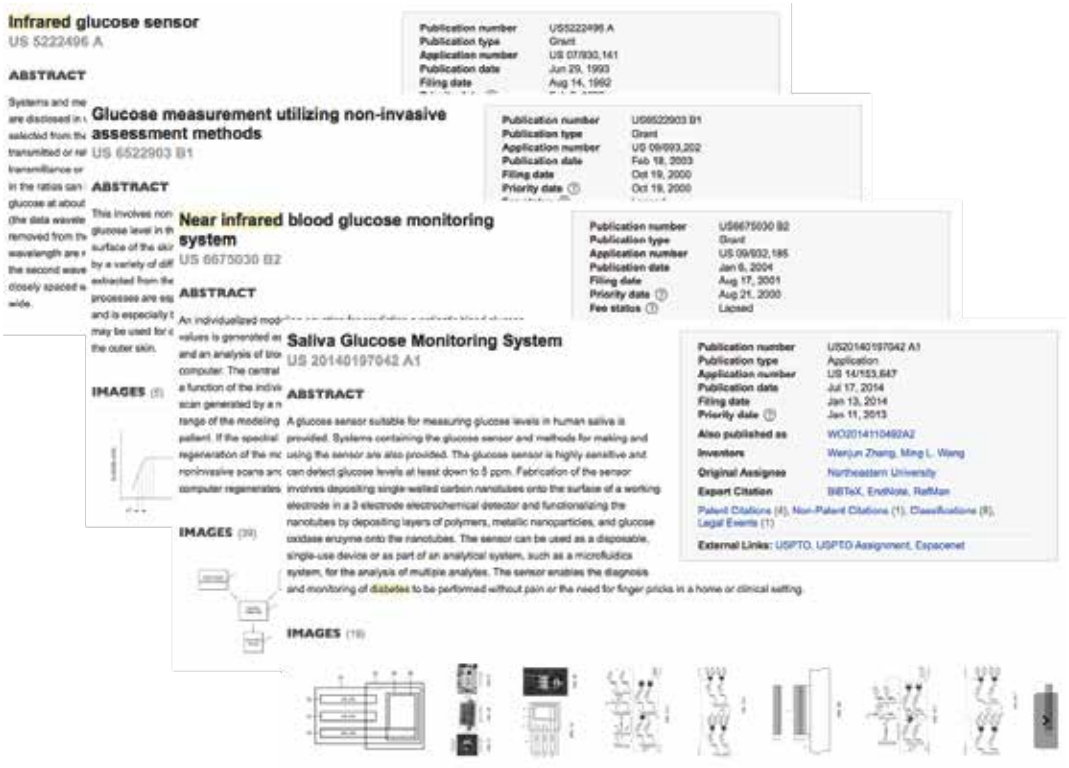


Near-infrared Spectroscopy

Near-infrared Spectroscopy is a spectroscopic method that uses the near-infrared region of the elctromagnetic spectrum. This technology is the breakthrough feature that sets Flore apart from other diabetic devices is that it prevents any type of discomfort associated with painful pricking of the finger to draw blood. The back of the device is equipped with a finger scanner that uses near infrared spectroscopy technology to detect your blood glucose level. It eliminates the need to carry lancets, draw blood, and connect an external testing strip to the device. Typical applications include pharmacuetical, medical diagnosis (including blood sugar and pulse oximetry).

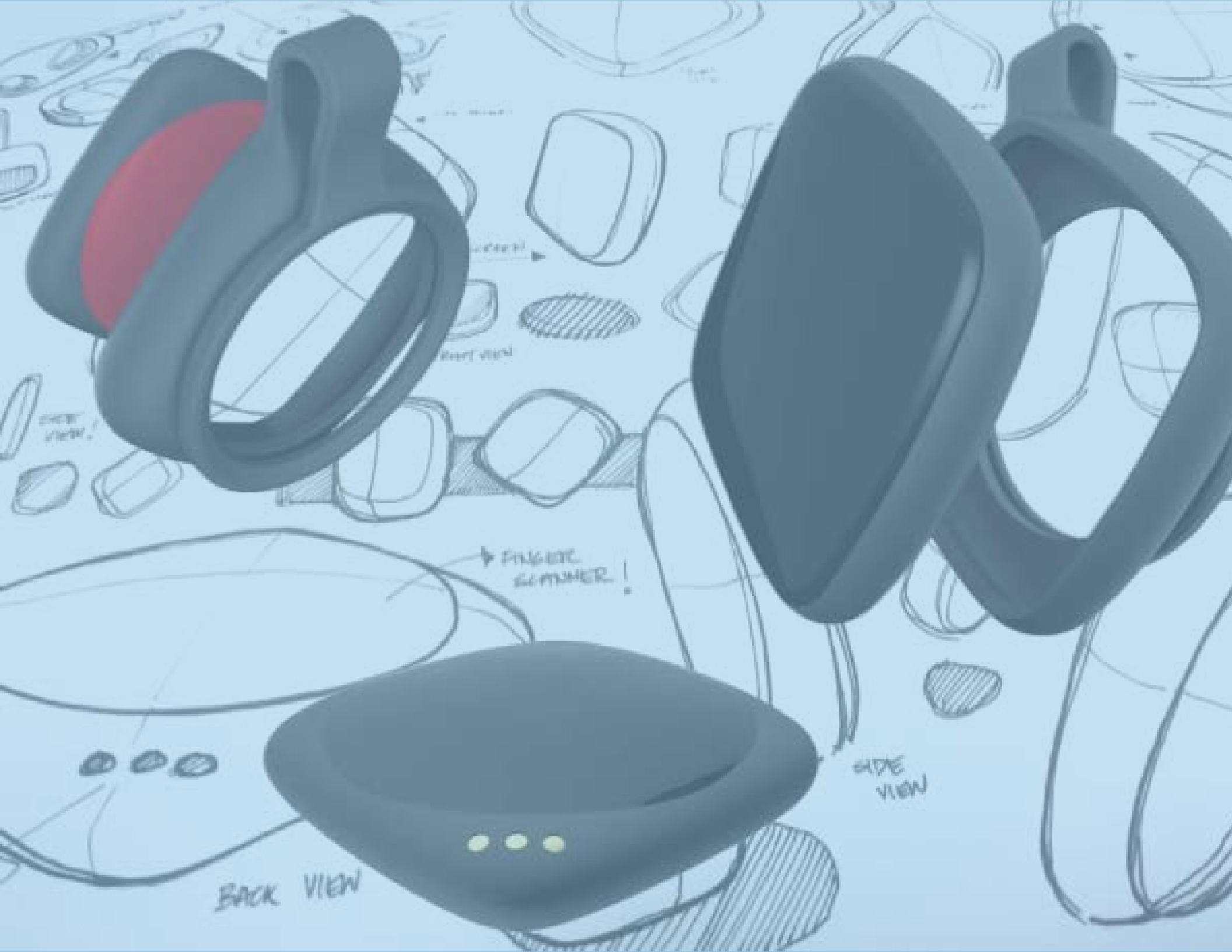
Comparisons

Pulse Oximetry is a procedure used to measure the oxygen level (or oxygen saturation) in the blood. It is considered to be a noninvasive, painless, general indicator of oxygen delivery to the peripheral tissues (such as the finger, earlobe, or nose). Pulse Oximetry is a technology that is simple, accurate and portable. Near-infrared Spectroscopy is being compared to Pulse Oximetry because it does the same thing, expect it would measure blood sugar levels instead of oxygen levels.



Marketability

Even though the technology is being tested for stability and accuracy, this is not stopping inventors, designers, engineers and big companies from patening their ideas and technology behind monitoring your glucose levels. Some patents have expired, while others have just been applied for. These patents range from checking your glusose levels through checking your saliva or other non-invasive methods.


FINGER CLEANER !
BACK VIEW
SIDE VIEW

Section 5: Final Design

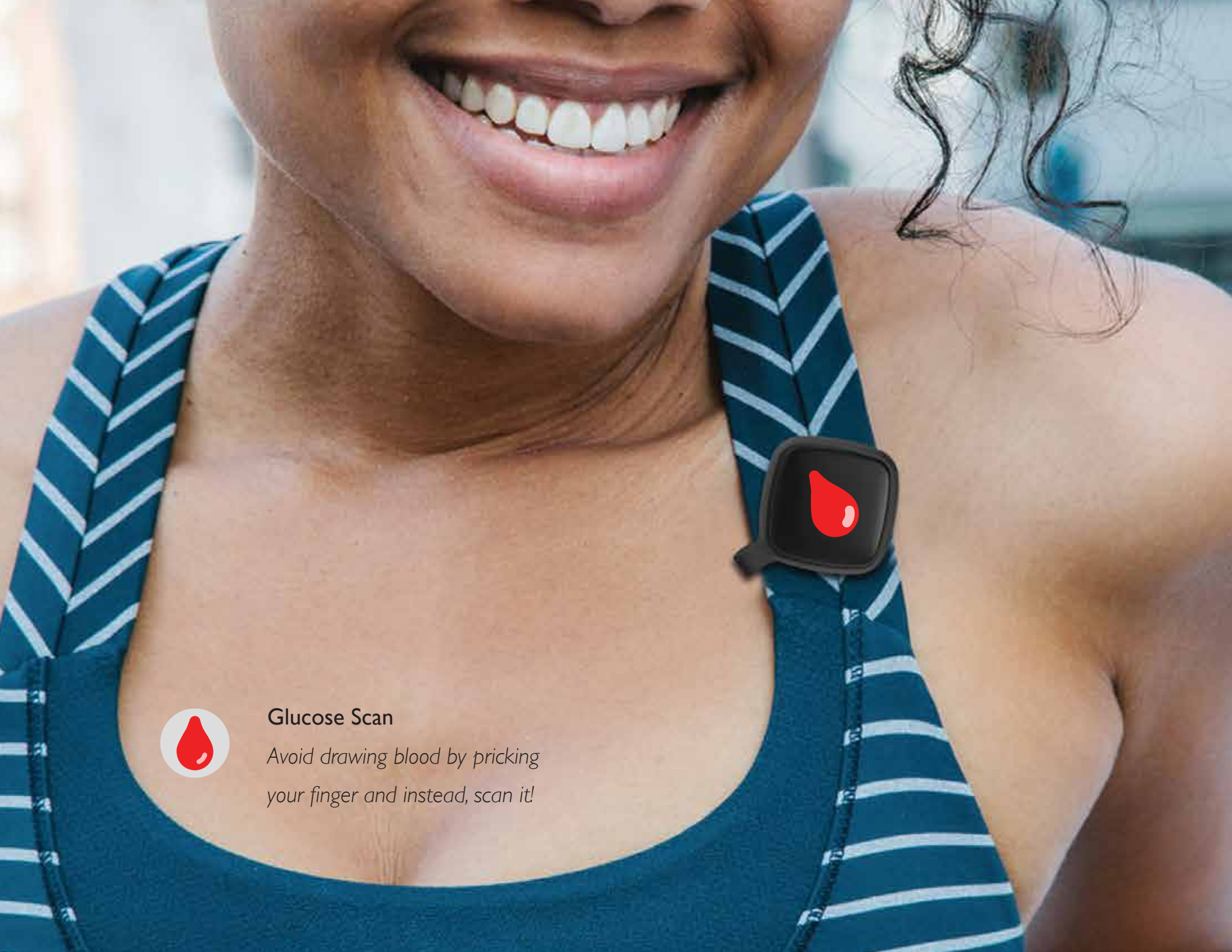
The final design direction was a result of agressive primary and secondary research, refine concept generation and participartory activities with the user, taking all of their needs into consideration.

Meet Flore.

The first wearable glucose monitor device for diabetics integrating biometrics and a health tracker app to alleviate the stress of managing the disease.

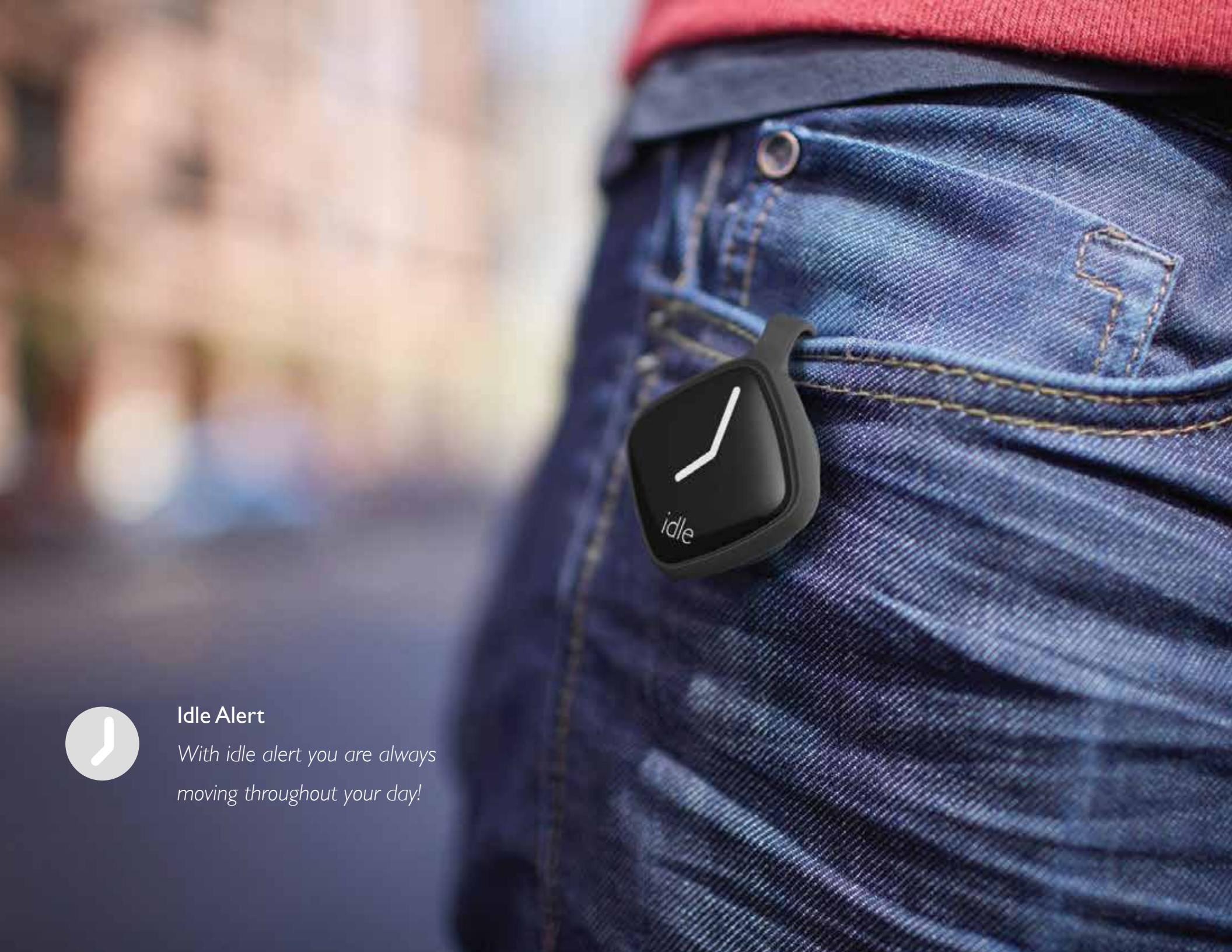
Smart Alarm

With idle alert you are always moving throughout your day!



Glucose Scan

Avoid drawing blood by pricking your finger and instead, scan it!



Idle Alert

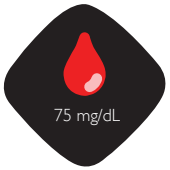
With idle alert you are always moving throughout your day!

Morning Alerts and Reminders

morning greeting

sleep stats

first reminder



immediate feedback

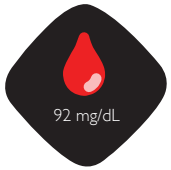
heart rate stats

breakfast reminder

medication reminder

second reminder

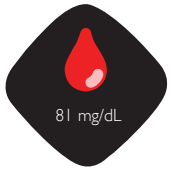
Afternoon Alerts and Reminders



immediate feedback

nudge to get up and move

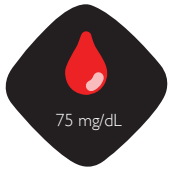
third reminder



immediate feedback

lunch reminder

fourth reminder



immediate feedback

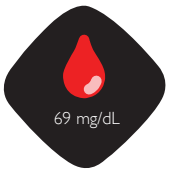
exercise mode

Evening Alerts and Reminders

precise data

snack reminder

fifth reminder

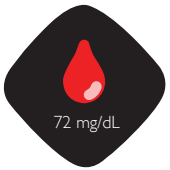


immediate feedback

words of encouragement

dinner reminder

sixth reminder



immediate feedback

snack reminder

medication reminder

seventh reminder

immediate feedback

preparing for bed

Note: *This is the UI of a device used by a well-managed type 2 diabetic.*

User friendly

The biggest obstacle in the development of this device was the user interface (UI). I was motivated by Apple's UI success in eliminating the need for user control and decided to adapt this approach with Flore. The user does not need to swipe the screen for information, as the device notifies and alerts the user throughout the day according to the user's behaviors and daily activities. All of the data and detailed information can be found in the app, which automatically syncs with the device via Bluetooth.

Food Reminer

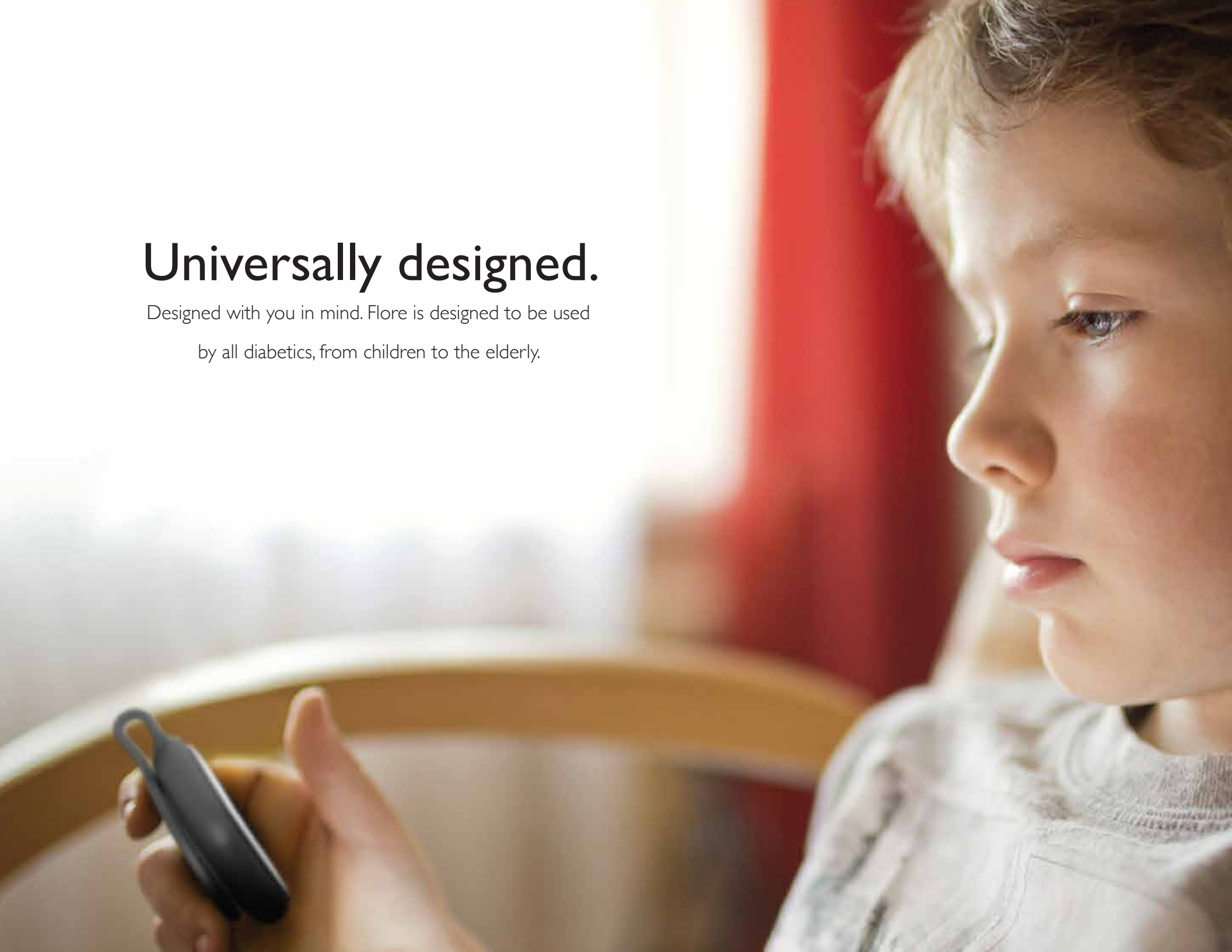
This reminds you to eat on time and healthy!

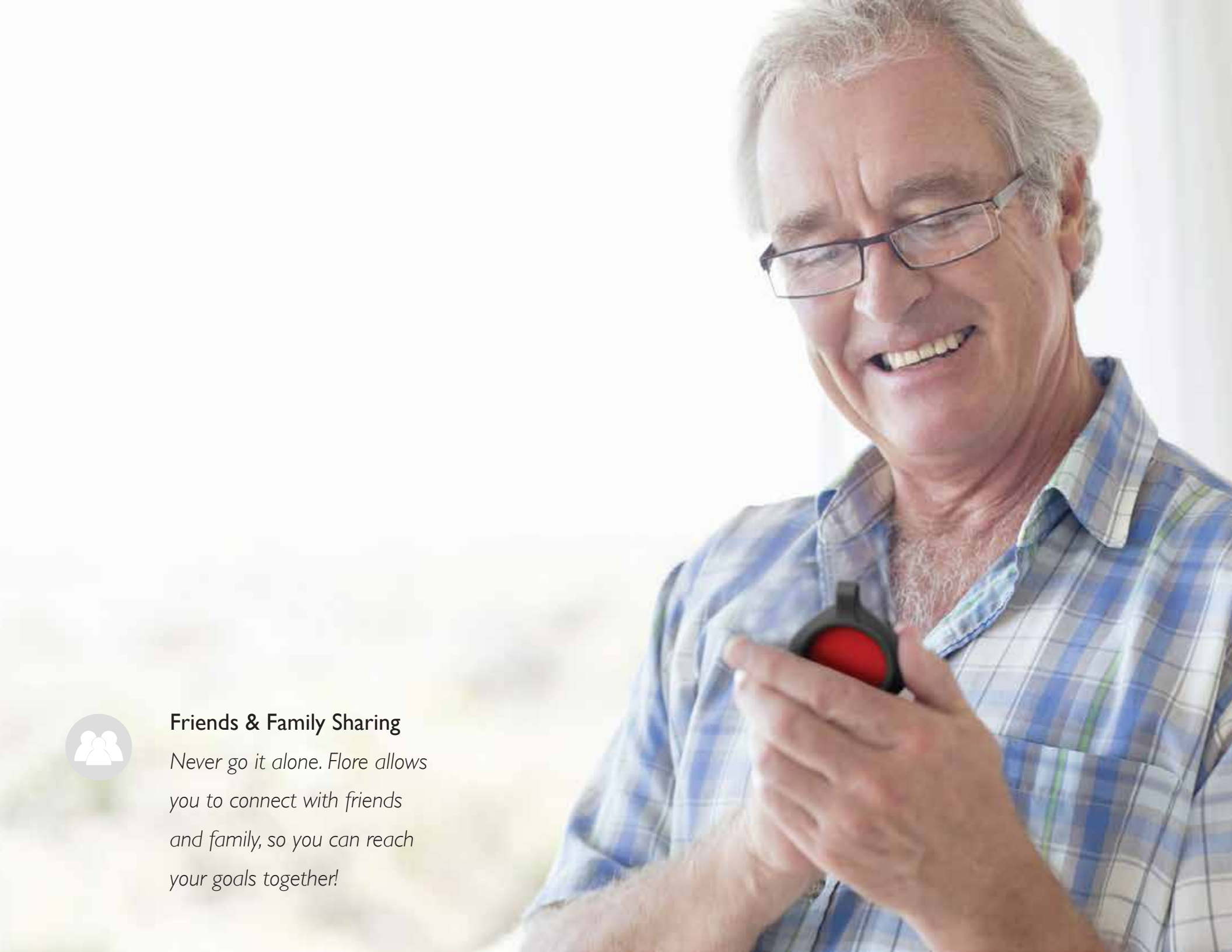
Splash-proof

Rain or shine, Flore is robust and ready for your adventure!

Universally designed.

Designed with you in mind. Flore is designed to be used by all diabetics, from children to the elderly.





Friends & Family Sharing

Never go it alone. Flore allows you to connect with friends and family, so you can reach your goals together!

A touch of comfort.

The back of the device is equipped with a finger scanner that uses near-infrared spectroscopy technology and a heart rate sensor to detect your blood glucose level and your heart rate.

Glucose Scan

As easy as touching the back of the device for an accurate glucose check!

Glucose Scan

Heart Rate

Bolus Calculator

Activity Tracking

Calories Burned

Idle Alert

Food Reminder & Logging

Care Provider Sharing

Continuous Updates

Smart Alarm

Sleep Tracking

Friends & Family Sharing

Splash-proof

Goals

Motivation

Milestones

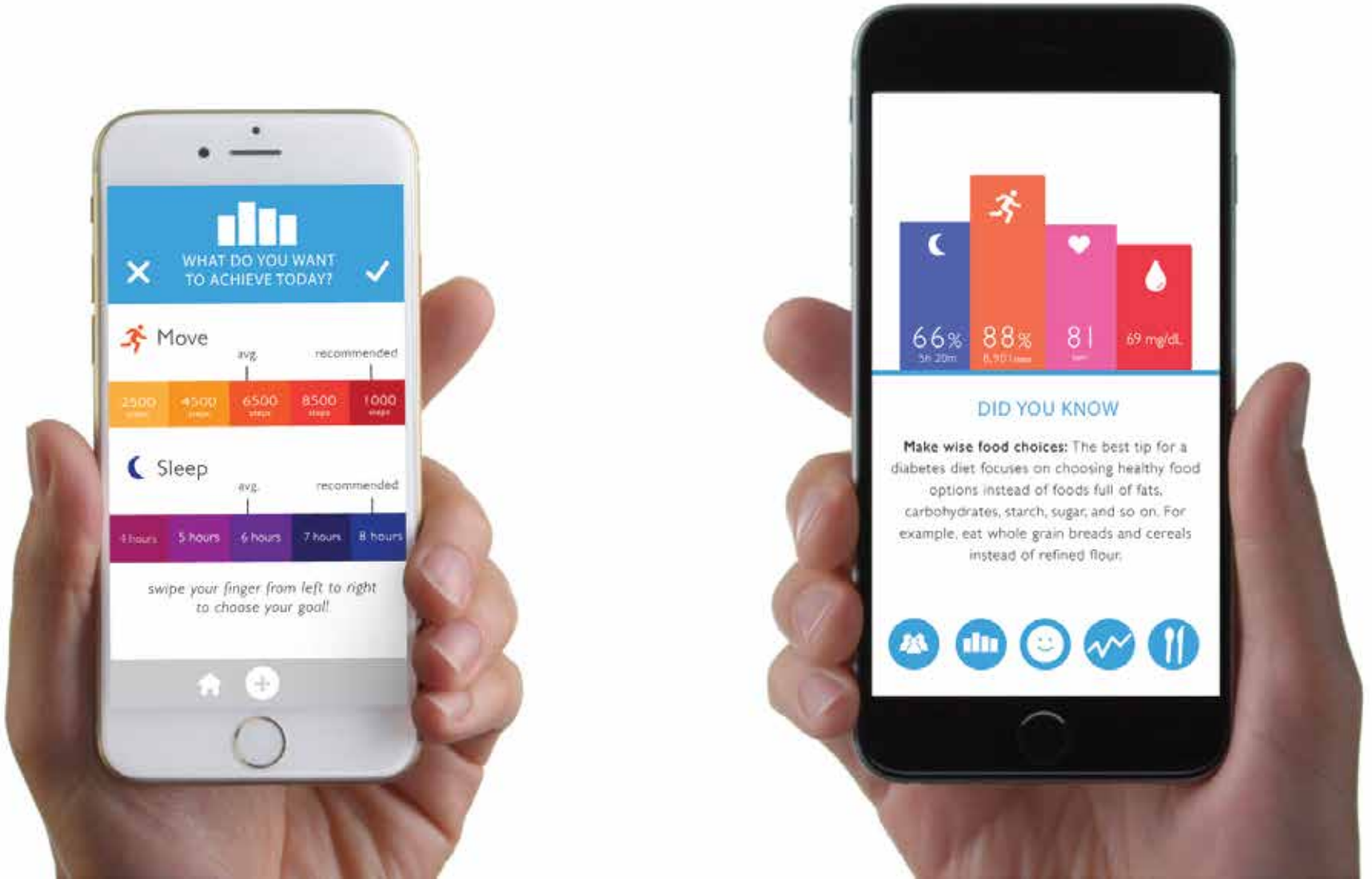
Features you'll love.

Flore has over a dozen features that will motivate you to have a healthy lifestyle. It comes with a collection of features so intuitive, simple, and fun - you'll wonder how you ever did without.

Keep track of yourself.

An entirely new way to keep all of your daily data stored

and share it live with your loved ones and your primary provider.



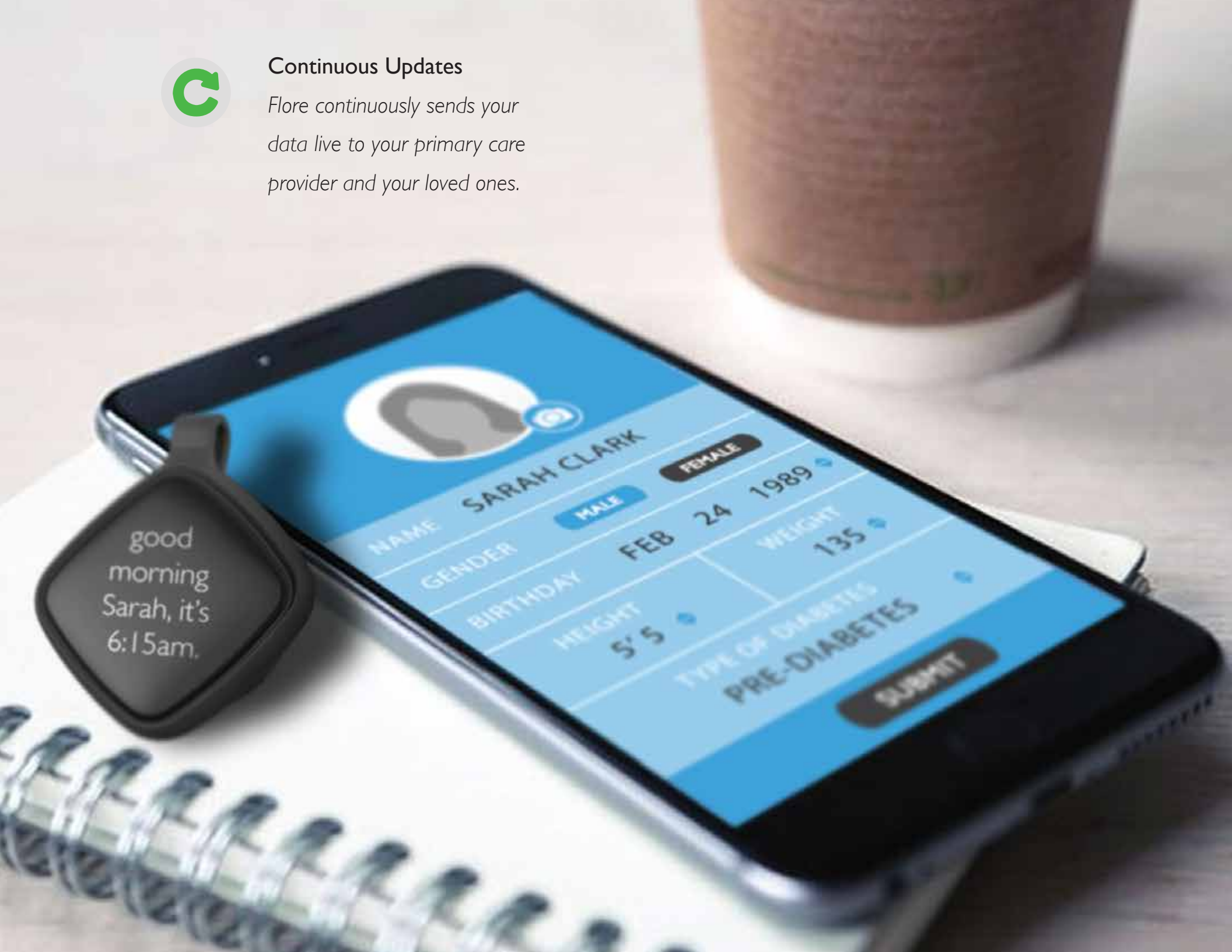
Information at your fingertips.

Quickly view your most recent health and

fitness data in one dashboard.

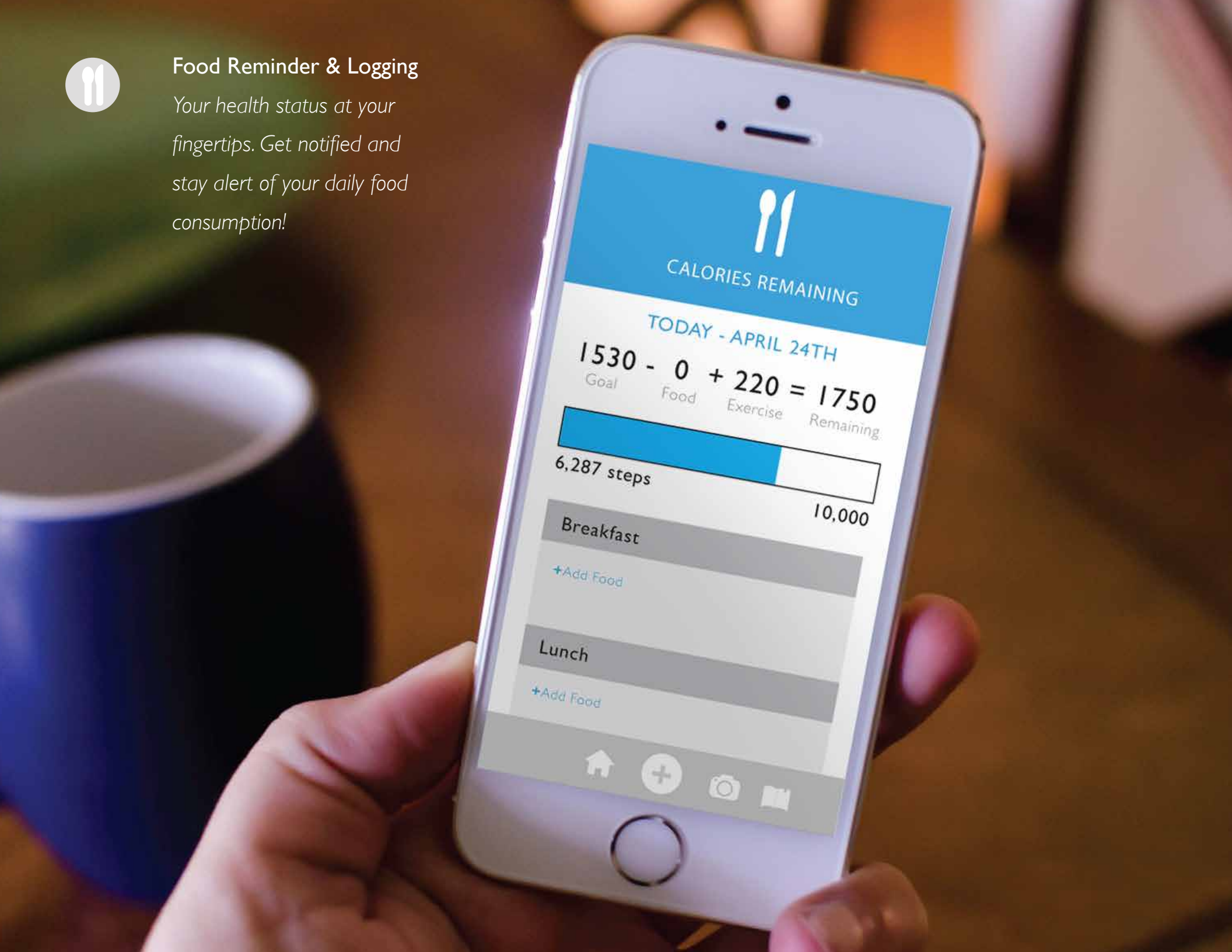
Continuous Updates

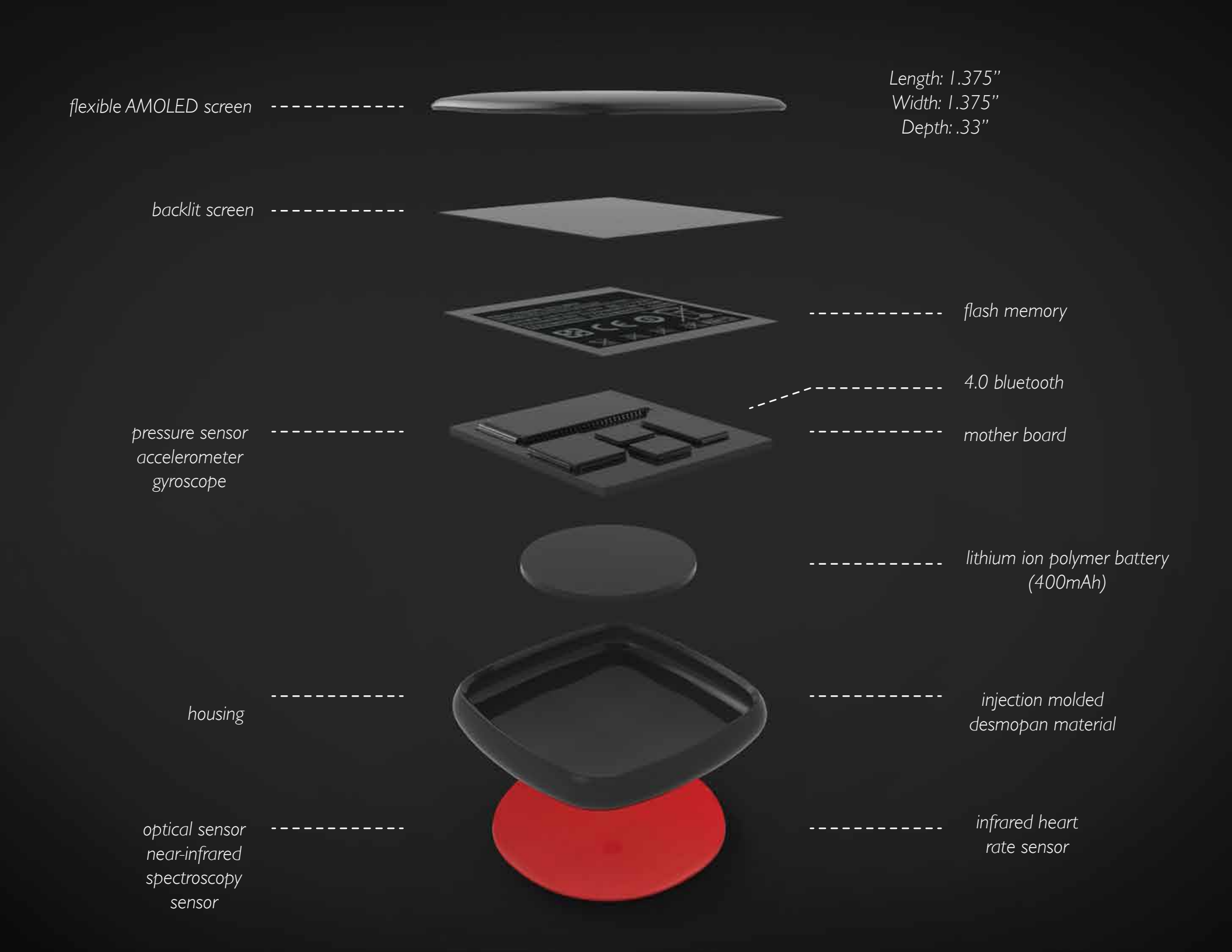
Flore continuously sends your data live to your primary care provider and your loved ones.



Food Reminder & Logging

Your health status at your fingertips. Get notified and stay alert of your daily food consumption!




flexible AMOLED screen
Length: 1.375"
Width: 1.375"
Depth: .33"
backlit screen
flash memory
4.0 bluetooth
pressure sensor
accelerometer
gyroscope
mother board
lithium ion polymer battery
(400mAh)
housing
injection molded
desmopan material
optical sensor
near-infrared
spectroscopy
sensor
infrared heart
rate sensor

Exploded

Just as much thought was put on the exterior of the device, the interior is just as important. In order to design and create a truly "wearable" device that will be used all day in all environements, it would have to be equipped with the best technology. Flore is injected molded and made with high grade desmopan material.
This allows Flore to be robust and ready for any type of wearable action. All of the data it gathers gets transfered over via Bluetooth and is powered by a 400mAh lithium ion battery which gives you three days of battery without charging. Flore is equipped with the most updated technology so that the user can focus on the most important part of this experience, their health.

Section 6: Conclusion

Diabetes affects everyone, even if you don't have the disease, someone you know might be diabetic: a relative, a friend or a co-worker. It's a disease you can't run away from, but you can do something to prevent it. There are many inventors, designers and researchers with amazing innovative ideas on this topic - but you can't wait for them to bring these ideas to market, it starts with you! Educate yourself, learn how to live with the disease and most importantly, take back your life!

COST

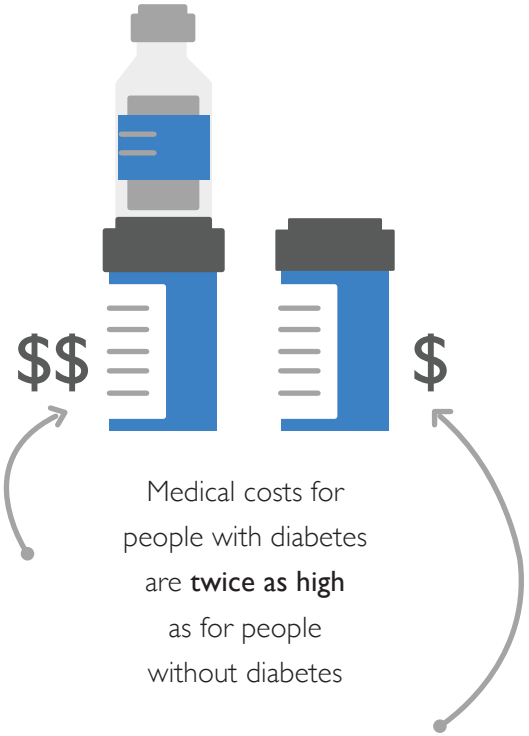
$245 BILLION

Total medical costs and lost work and wages for people with diagnosed diabetes.

Risk of death for adults with diabetes is

50% HIGHER

than for adults without diabetes



Medical costs for people with diabetes are **twice as high** as for people without diabetes

Financial burden

According to the American Diabetes Association (ADA), the economic burden of diabetes in America continues to climb, exceeding more than $322 billion in excess medical costs and lost productivity in 2012, or more than $1,000 for every American, according to a study being published in the December issue of Diabetes Care that also includes a state-by-state breakdown of the prevalence and costs associated with diabetes. Additionally, increased costs associated with prediabetes and undiagnosed diabetes highlight the growing importance of prevention and early intervention.

Dialog by Artefact,
a wearable device for epileptics

How is wearable technology affecting the medical field?

The first product that comes to mind is the infamous life alert by Alert1 that provides immediate assistance in any kind of emergency with just the push of a button. There are many concepts that are emerging in the market that help monitor patients through the use of wearable technology. One of these concepts was recently featured in FastCompany and created by Seattle-based Artefact Group. FastCompany is calling it "an iWatch for epileptics" and the concept features a brilliant user interface. The Artefact Group designed a band and patch that connect with an application and it allows sufferers the ability to track, manage, and predict their seizures.

"Artefact wanted to create a platform that would not only help people better understand their condition but live with it as well" according to the company. The design is called Dialog, and it consists of a small, quarter-sized wearable device connected via Bluetooth to a nearby smartphone application, Dialog can help epilepsy sufferers remember to take their medications, warn them about seizures before they happen, as well as alert friends, family or even caregivers if a seizure does happen. I feel this is a perfect example of how wearable technology can be applied to people who are diagnosed with a disease. This is a perfect example of managing a disease and this type of design and application can be applied to diabetics.

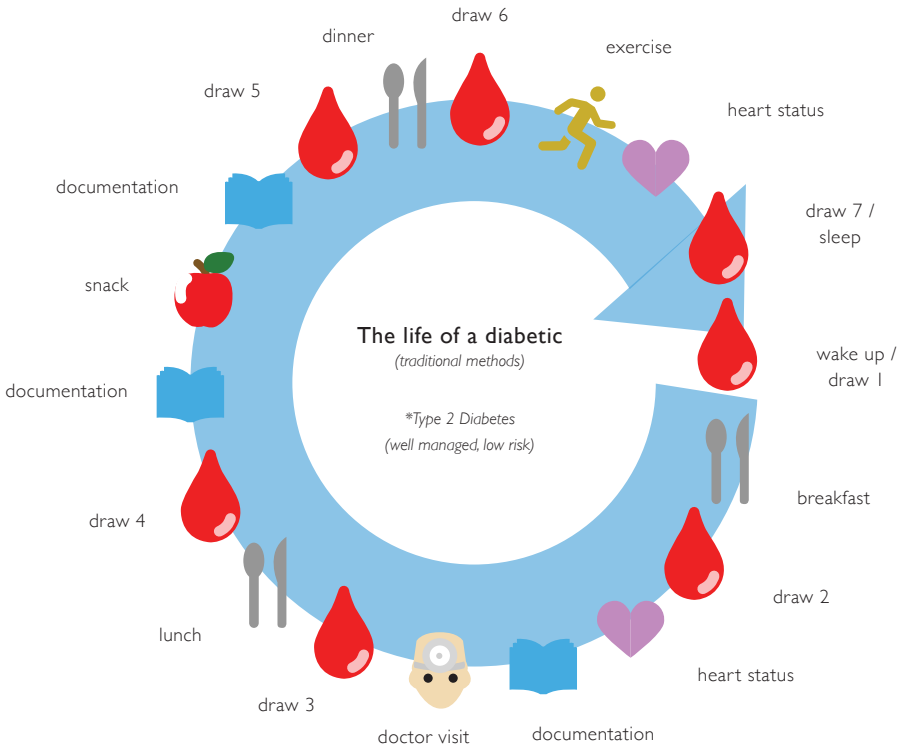

Medial Thigh
Medial Calf
Medial Ankle
Lateral Ankle
Lateral Thigh
Lateral Calf
Inner Thigh
Inner Ankle
Inner Calf

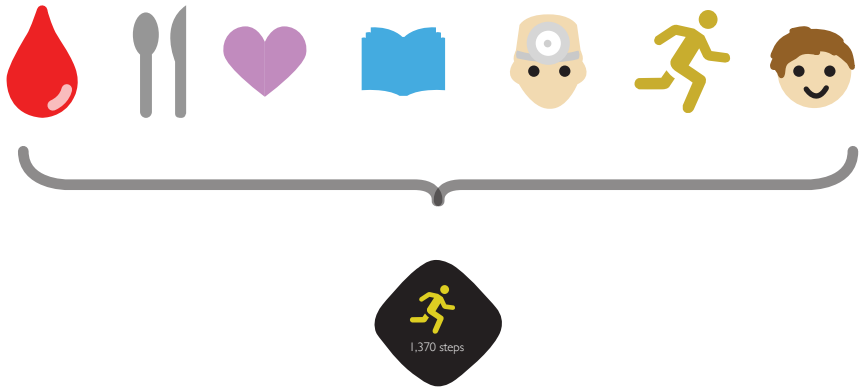
Communication with our providers

Applications have also changed the way we educate us and communicate with others. An article by Maria Heroux Ponds of the Sun Sentinal is a perfect example of how applications are helping us connect with caregivers. Dr. Ariel Soffer was on an airplanewhen one of her patients was desperately trying to reach him. Through his clinical photography application, his patient was able to text the doctor a photo of her leg after a recent varicose vein surgery. The doctor was able to connect to the airplanes wireless internet and reassure her patient that she was going to be okay, saving her patient a trip to the doctor's office or event the hospital. This is an example of how technology and design is shaping the future of how we communicate with our healthcare providers.

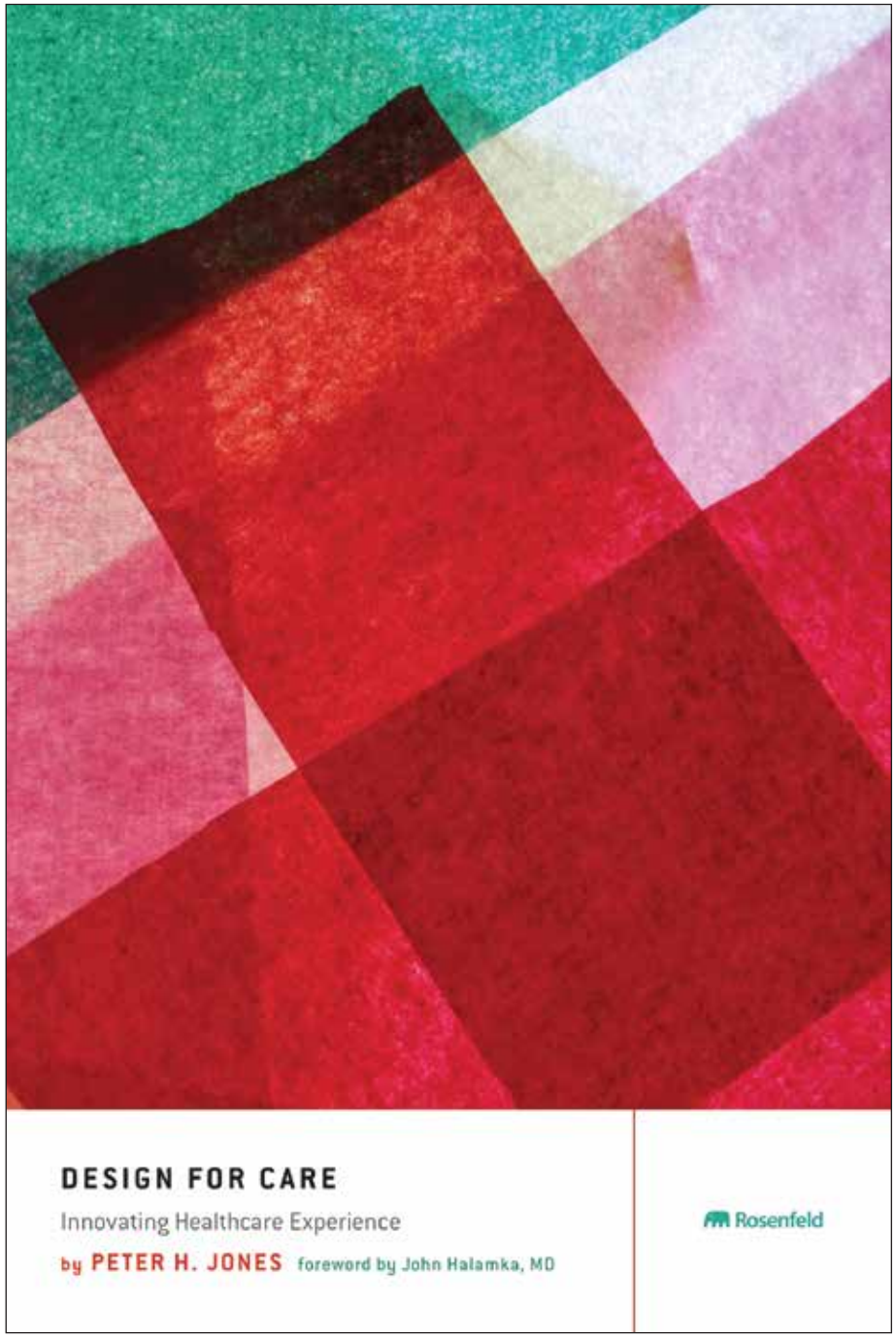
Simple life.

On the left you have the life of a well managed diabetic with type 2 diabetes. The individual actions that they take a day is absurd. Their life changes as soon as they begin to use Flore (graph on the right). All of the individual actions are consolidated into one device, giving the diabetic a healthy and simple life.





The life of a diabetic
(using Flore)



Design for Care is a book written by Peter H. Jones and he states that "the innovator's challenge in healthcare is not a technological fix – it is more to understand and preserve core values of human care while changing practices for durable social and economic benefit."

Perhaps technology is not a solution for healthcare, but I believe it can be a supplement.

References

Alan E. Guttmacher, M. D. 2004. Managing Gestational Diabetes: A Patient's Guide to a Healthy Pregnancy. U.S. Department of Health and Human Services,.

Brownlee, John. 2014. An iWatch for Epileptics, With A Brilliat UI. FastCompany (March).

Cooper, Carol. 2003. Johnson's Mother & Baby, ed. Paula M. Elbirt. New York, New York: DK Publishing, Inc.

Fehrenbacher, Katie. 2014. 5 Technologies That Are Shaping the Future of Design. Gigaom.

Hernandez, Daniela. 2014. Gadgets like FitBit are Remaking How Doctors Treat You. Wired. March 6.

Heroux Pounds, Marcia. 2014. Smartphone App Lets Doctor See What's Bothering You. South Florida Sun Sentinal, March, 2014.

Jones, Peter H. 2013. Design For Care: Innovating Healthcare Experience. Brooklyn, New York: Louis Rosenfeld.

MD-Individual Practice Association, Inc Optimum Choice, MAMSI Life and Health Insurance Company, and LLC Alliance PPO. 2005. Guideleine For Routine Prenatal and Perinatal Care. Rockville, MD: MD-Individual Practice Association; Optimum Choice, Inc.; MAMSI Life and Health Insurance Company; Alliance PPO, LLC, .

Rutherford, Jesse Jayne. 2010. Wearable technology: Health-care solutions for a growing global population. IEEE Engineering in Medicine and Biology Magazine. May.

Smith, David. 2007. Smart Clothes and Wearable Technology. Ai & Society 22, (1) (September 1).

Sun, Albert. 2014. The Monitored Man. The New York Times, March 10, 2014.

Tufts Health Plan, and Health Programs Department. Prenatal Care: A Women's Guide. Tufts Health Plan.

Klima, Carrie. Interview by Hector Silva. In person. Chicago, IL, January 23, 2014.

Leftwhich, Heidi. Interview by Hector Silva. In person. Chicago, IL, February 12, 2014.

References

Website References:

http://www.diabetes.org/diabetes-basics/statistics/cdc-infographic.html

http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm389919.htm

http://thelifeofadiabetic.com

http://www.nirsoptix.com/what-is-nirs.php

http://www.hopkinsmedicine.org/healthlibrary/test_procedures/pulmonary/oximetry_92,p07754/

https://www.google.com/?gws_rd=ssl#q=google+patents+near+infrared+spectroscopy

Image References:

www.google.com/images

www. apple.com

www.flickr.com

www.fitbit.com

www.jawbone.com

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American Diabetes Association, Chicago

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ARABLE DEVICE
AT INTEGRATES
O ALLEVIATE
MANAGING
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DIABETICS THA
BIOMETRICS TO