

WEARING YOUR HEART (MONITOR) ON YOUR SLEEVE: WILL DATA BE THE NEW DOCTOR?

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YOUNG REVIEWERS:



ERIC

AGE: 12



GRESHMA

AGE: 13

Imagine wearing a shirt or a wristband that tells you how hard you are exercising or warns you if you are getting sick. These are simple examples of wearable medical devices that could transform healthcare—either by helping people to manage serious diseases that they already have, or by spotting the early signs of a disease so that it can be treated before the person even feels sick. This article will focus on two examples of wearables: one for the management of diabetes and another that may be able to prevent heart attacks. Wearables like these and many others that are being developed could greatly improve human health. However, these technologies come with some big challenges, because they collect a lot of personal data. We need to find ways to protect people's privacy by keeping that sensitive data safe. In the future, wearables will certainly help doctors do their jobs... but might they even replace doctors altogether?

THE FUTURE OF HEALTH IS WEARABLE

Have you ever gone for a long walk or hike and then checked your phone or smart watch to see how far you went or how many steps you got in? Or maybe you have used an app to monitor your sleep patterns or to help you manage your nutrition. These seem like pretty routine things to do these days, right? Now imagine a future in which you put on a tight-fitting undershirt before exercising, to constantly monitor exactly how hard you are working and update your workout in real time, depending on how you are feeling. Or maybe someday you will get up each morning and put on earrings or a wristband that can quickly warn you if you are developing COVID-19 or even cancer—before you feel even the slightest symptom!

Does this sound like it could happen? While many of these technologies are still in the early stages of development, **wearable medical devices** (or wearables, for short) are a hot new development likely to transform the way healthcare works. As you read, you will learn about two examples of wearables: one that currently exists and can help people *manage* a disease that they already have, and one that is still experimental but may help to *prevent* a disease, keeping people healthy. Together, wearables that help manage and prevent diseases may allow many people live longer, healthier lives. But, as you will see, these technologies also give us some complicated issues to think about, particularly in terms of what happens to all the data collected by wearables. Could wearable devices, and all the data they generate, replace actual doctors? You might already have an opinion on this, but keep reading—we will revisit this question at the end of the article, and maybe something you learn along the way will change your mind!

WEARABLE MEDICAL DEVICES

Electronic devices worn on the body to monitor health and medical information, such as heart rate, steps taken, and blood glucose levels.

DIABETES

A condition in which the body has trouble using sugar for energy, causing high blood sugar levels and sometimes requiring treatment with insulin.

GLUCOSE

A type of sugar that comes from food; an important source of energy for the body's cells.

BLOOD SUGAR MANAGEMENT—HOW SWEET IT IS

Diabetes is a condition in which the amount of **glucose** circulating in the blood is too high. About **422 million people worldwide** have diabetes, and it causes at least 1.5 million deaths each year. Cells normally use glucose, a type of sugar, for energy. Normally, the body produces a substance called insulin that “pushes” glucose from the foods people eat into their cells, so the cells can use it. People with diabetes, however, do not make enough insulin, so the glucose stays in the blood where it does not belong. Many people with diabetes must check their blood glucose levels several times a day, to figure out how much insulin to take. This is often done by pricking a finger and squeezing a drop of blood onto a small testing device—ouch! Blood glucose levels can change very quickly, so checking blood sugar only a few times a day might not catch important changes that occur between finger sticks.

CONTINUOUS GLUCOSE MONITOR

A device that measures glucose levels in the body continuously throughout the day and night to help people with diabetes manage their blood sugar levels.

Figure 1

(A) A CGM is a small, stick-on device with a tiny needle, used to track blood sugar levels in people with diabetes. The device connects wirelessly to an app that can provide the user with blood glucose data as often as every few minutes—warning them if levels are too high or low. (B) New wearables may protect people from heart attacks. Unhealthy heart cells release troponin into the blood. The electrodes on the wearable (troponin monitor), which barely penetrate the skin's surface, are “sticky” for troponin. When troponin sticks to them, a signal is generated—warning the wearer to see a doctor. (Figure created by [carlottacat.com](https://www.carlottacat.com)).

HEART ATTACK

A serious medical emergency when blood flow to the heart is blocked, causing damage to the heart muscle.

Then, in 1999, the first **continuous glucose monitor** (CGM) was approved for use, and it has made life a lot easier for people with diabetes [1]. A CGM is a small, stick-on device, about the size of a quarter, that measures glucose using a tiny needle that reaches just under the skin (Figure 1A). The CGM, which can stay stuck to the skin for up to 2 weeks, collects glucose data every *few minutes* and sends the data to an app on the wearer's phone—and even to a family member, if needed. The app can create graphs that show trends in the wearer's glucose levels and can alert the wearer with an alarm when glucose levels are too high or too low. CGMs can make managing diabetes so much easier and more effective. More advanced wearables can do more than just monitor. For example, people with diabetes can wear a CGM with an insulin pump that actually administers insulin whenever blood glucose is too high!

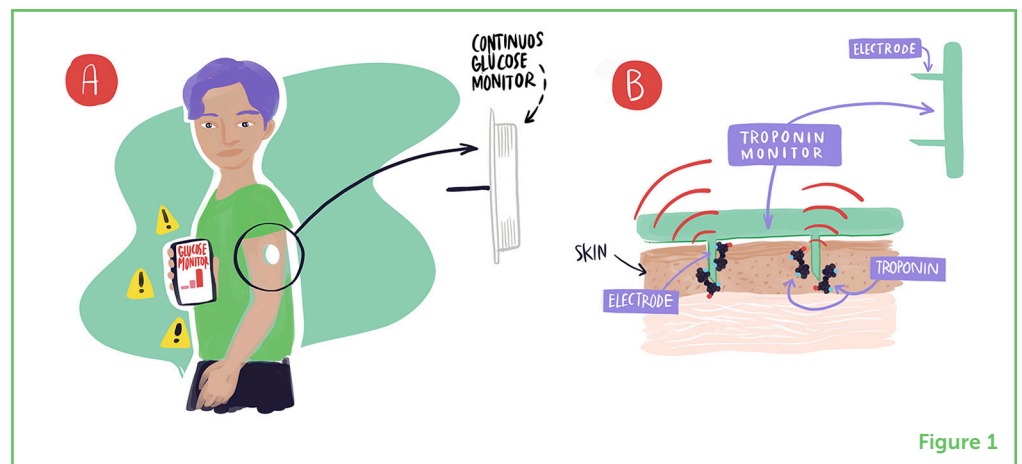


Figure 1

PREVENTING HEART ATTACKS—EARLY DETECTION SAVES LIVES

What if you are healthy and just want to avoid getting sick? Well, other cool wearables are being developed that monitor wearers constantly, while they are healthy, to detect small changes in certain chemicals or vital signs (heart rate, blood pressure, temperature, etc.) that might indicate the very early stages of an illness—before wearers feel even minor symptoms. Early detection can help doctors start treatments early, which can help to prevent many illnesses and deaths.

Heart attacks are a good example of a health problem that could be preventable by a wearable. A **heart attack** happens when the heart does not get enough oxygen due to a blockage in one or more blood vessels. Without oxygen, heart muscle cells start to die, which can lead to permanent heart damage and even death. However, many heart attacks could actually be prevented. How? Heart cells contain a protein called **troponin**, which is not found in the blood when the heart is healthy. When heart cells start to get sick, some of them break open and release troponin into the blood stream [2]. Blood tests can detect

TROPONIN

A type of protein found in the heart muscle. When the heart is damaged, troponin is released into the blood and can be measured to help diagnose a heart attack.

troponin in the blood—even long before patients have any signs of a heart attack. If troponin is found, doctors can quickly treat patients to prevent heart attacks from happening. But even if doctors check their patients for troponin during their normal yearly check-ups, there is a whole year between visits when things could go wrong!

Fortunately, a company called **WearOptimo** is creating a wearable that may make heart attacks a thing of the past. The new wearable, which is still being tested, has tiny electrodes coated with a detector substance that can bind to troponin, like two Lego bricks sticking together. When the wearable is placed on the skin, the tiny electrodes barely penetrate the skin's surface (**Figure 1B**). If troponin is present and sticks to the electrodes, a signal is produced. An app analyzes the data and can warn the wearer if troponin is discovered, so the person can then go immediately to the doctor for treatment—hopefully long before a heart attack begins.

Other cool examples of wearables that help people avoid getting sick include one that can measure **body chemicals associated with anxiety and stress**, and one that can tell wearers if they are **properly hydrated**. Wearables that can measure more and more things are constantly being developed, and these devices are also getting smaller and more convenient to wear.

Figure 2

New health technologies like wearables are generating a flood of health data. Data are saved in large data-storage centers, where researchers and companies can often access data for their own purposes. All these data are generating many questions that scientists, lawmakers, and companies are still struggling to answer. Who “owns” health data, and who should get to use it? How do we keep health data safe and protect people’s privacy? And of course, the big question: will wearable devices and the data they generate eventually replace human doctors? Do you think this might happen? Would it be good or bad? (Figure created by carlottacat.com).

A FLOOD OF DATA

From step trackers to the most advanced wearables, new health technologies have one thing in common: data—and *lots* of it. Just imagine: if a CGM collects blood glucose data every 5 min for 2 weeks, that equals 4,032 data points—for just ONE health parameter for ONE person! When thousands or even millions of people are wearing monitors that track *multiple* health parameters all day, every day of their lives, this rapidly becomes a tsunami of health data (**Figure 2**).

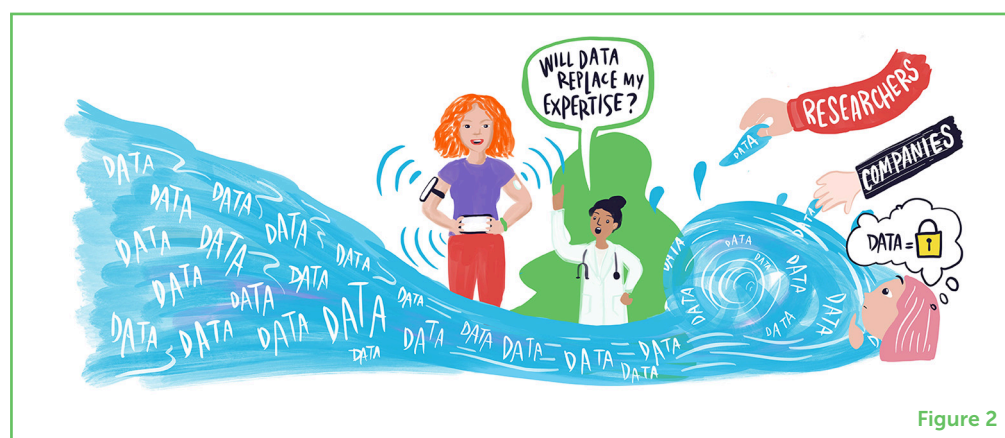


Figure 2

Data collected from health apps or wearables do not just sit there on your phone. Most apps transfer data to data-storage centers where it is saved on servers, sometimes forever. Companies and researchers can get permission to access and use that valuable information, for example to target their advertising campaigns at certain groups of people; and researchers may use health data to study diseases or treatments.

Do you think the data generated from your health apps or wearables are yours—do you own those data? You might think you should, since those data come from *you*! If you own a physical object, like a car, you usually get to make decisions about who drives the car, or where to park it so it will be safe and not get stolen. But even if you think you should own your data, you generally cannot control where the data from your wearables are stored, or exactly which companies or researchers can use those data. Furthermore, if you sold a car that you owned, you would get the money. Should you also get some of the money when researchers or companies buy your data from the company that makes your favorite fitness-tracking app?

Researchers, companies, and lawmakers are currently wrestling with complicated questions like these, and there are still no clear answers. These issues are complicated because we know that the more data we have, the better we will understand diseases and thus be able to develop preventions and treatments—but at the same time, we need to make sure sensitive data are managed in ways that most people are comfortable with. What do you think? Is it OK for companies to use your health data to develop or sell new products and services? What about researchers—is it OK for them to use your data, if their goal is to improve public health?

HEY, THAT IS PRIVATE!

Most of us do not want the world to know our health details—we would rather keep certain things private. You might not want everyone at school to know that your doctor removed a big hairy wart from your bum, for instance! Fortunately, there are laws to protect the privacy of medical information, preventing doctors from sharing medical records without the patient's permission. But the regulations are not so strong for data collected from health apps or most wearables.

Maybe you are thinking, "Who cares if the world knows how many steps I took this week?". But as wearables begin to track many aspects of health, this problem becomes more serious. For example, what if life insurance companies could access troponin data and then refuse to insure anyone who has ever had troponin in their blood, because people with heart issues might be at greater risk of dying young and costing the insurance company money? Or what if employers could access data from wearables and decide not to hire people

with certain conditions, like high blood glucose or high cholesterol, because they think those people might get sick and take too many days off?

Even if laws are eventually created to fully protect the privacy of health app and wearable data, we all know that servers can be hacked by criminals who want to use or sell people's personal information. To keep private health data safe and to help users to trust their wearable products, companies must have strong data security measures.

PROTECTION OF HEALTH DATA

Luckily, there are already some **common practices** in place to protect the privacy of health data collected from fitness apps and wearables, with more **protections** likely to appear as these technologies become more popular. For example, have you ever tried to install a new app and been prompted to read the company's privacy policy and click "I agree" before the app installs? A good privacy policy should spell out what data the app will collect, how the data will be kept private, and how the company intends to use the data—including who they plan to share it with. This allows you to make an informed decision as to whether you want the app on your device.

Once the app or wearable has your data and transfers it to a server, one common strategy to protect the privacy of health data is called **data de-identification**. This involves removing any personally identifiable information (such as name, email address, and home address) from the data before storage. That way, researchers and companies (and possibly hackers!) will only see anonymous data that cannot be traced back to any one person. Unfortunately, hackers are getting better at finding ways of re-identifying data, so even stronger security measures must be developed. **Encryption** is another privacy method commonly used in healthcare. Encryption is like converting data into a secret code, so that it is unreadable to anyone who does not have the "key".

DATA: THE NEW DOCTOR?

Are doctors about to be replaced with health apps, wearable medical devices, and maybe even artificial intelligence? Could it be that someday you will never need to visit a doctor again? While the number and types of things that wearable devices can do will certainly continue to grow, wearables alone will probably never totally replace doctors because doctors need to check many things that can only be done in person. However, the health data generated by wearables can *definitely* make doctors' jobs easier and patients' visits more efficient and effective. Perhaps, in the future, the combination of data and

DATA DE-IDENTIFICATION

The process of removing personal information from data to protect people's privacy.

ENCRYPTION

A way to keep information private and secure by using a special code to scramble it. Only someone with the key can unscramble it.

doctors will provide patients with the best possible healthcare—what do you think?

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YOUNG REVIEWERS



ERIC, AGE: 12

My name is Eric and I live in Adelaide, Australia. I am 12 years old and have just finished year 6. I have a passion for science and technology, and since early childhood I have been interested in all the latest technology. I was always exposed to these topics as my parents are scientists who are active in medical research. I think that science and technology are integral for development and improving lifestyle. The recent advances have hugely impacted our way of life and is the reason I find science very interesting and my passion will only continue to grow.



GRESHMA, AGE: 13

Hello! My name is Greshma, and I am in 8th grade. I love reading, playing tennis, traveling, and hanging out with my friends. I hope to be a forensic scientist someday!

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MICHAEL SNYDER

Dr. Snyder is a professor and Chair of Genetics at Stanford University. He is a pioneer in personalized and precision medicine and was the first to use watches like the Fitbit and Apple watch to monitor health and detect disease. Mike tracked his own health and found a risk factor for diabetes. After he then got diabetes, he tracked his health while he took medications and did lifestyle interventions to reverse his diabetes. He also detected his own Lyme disease with a smartwatch. In his free time, he enjoys working out and spending time with his family and two dogs.