# Article Title: This Pill Tracks Your Vitals From the Inside

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# Article Content:

Digital health company [Celero Systems](https://12ft.io/proxy?q=https%3A%2F%2Fwww.celerosystems.com%2F) is developing an electronic pill that can measure heart rate, breathing rate, and core temperature—from inside the human stomach. As a first step, the company envisions people with ongoing conditions using the digital capsule to monitor their vital signs at home. But in the future, they hope to use it as a kind of internal alarm system for drug-related overdoses.

In a [small clinical trial published](https://12ft.io/proxy?q=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS2666998623001849%3Fvia%253Dihub) in November, the company tested the device on people with sleep apnea, a disorder in which breathing occasionally stops and starts at night. To get a proper diagnosis, people often need to spend the night in a hospital, where they get covered in electrodes that measure their heart rate, breathing, muscle twitches, and brain activity: a comprehensive evaluation called [polysomnography](https://12ft.io/proxy?q=https%3A%2F%2Fwww.mayoclinic.org%2Ftests-procedures%2Fpolysomnography%2Fabout%2Fpac-20394877%23%3A~%3Atext%3DOverview%2Cmeasures%2520eye%2520and%2520leg%2520movements.). This is a recipe for a crappy night’s sleep, whether you have apnea or not.

Patients can instead opt for an at-home test that involves wearing a breathing monitor on their finger overnight. But this can still [cost hundreds of dollars](https://12ft.io/proxy?q=https%3A%2F%2Fwww.sleepfoundation.org%2Fsleep-studies%2Fat-home-sleep-apnea-test), and it’s not always accurate. These wearables can’t measure respiration directly, just variations in heart rate presumably caused by breathing. But a pill inside the stomach can’t fall off, and it can measure lung movements internally.

Celero’s monitoring pill isn’t really a “pill” in the traditional sense—it’s a biocompatible plastic capsule, roughly the size of a big multivitamin, stuffed with tiny sensors, a microprocessor, a radio antenna, and batteries. Prior to working at Celero Systems, CEO Ben Pless primarily worked with medical implants, including one of the [first implantable defibrillators](https://12ft.io/proxy?q=https%3A%2F%2Fpubmed.ncbi.nlm.nih.gov%2F8269293%2F%23%3A~%3Atext%3DThe%2520implantable%2520pulse%2520generator%2520is%2Cas%2520antitachycardia%2520and%2520bradycardia%2520pacing.%29). But ingestible devices, or digital pills, always intrigued him because, he says, “you could get inside the body without surgery.” Ingestibles offer many of the same benefits of implantables—they’re unobtrusive and you can’t forget to wear them—“except you implant it with a glass of water rather than a surgeon,” he says.

The capsule remains intact throughout its digestive system journey, keeping all of its electronics safely contained until it winds up in the toilet a couple of days later. Meanwhile, all the measurements are wirelessly transmitted to a laptop, where a researcher, doctor, or even the patient can access them. As far as Pless knows, Celero’s ingestible device is the first to monitor cardiac and respiratory activity in humans.

For the study, 10 sleep apnea patients at West Virginia University (WVU) Medicine Sleep Evaluation Center swallowed the pill prior to their regularly scheduled sleep studies so researchers could see how the pill’s measurements compared to a polysomnogram, the current gold standard. It was nearly as accurate, only off by about one breath per minute—more than capable of detecting respiratory depression. No one reported any side effects or discomfort, and post-study scans confirmed that all of the pills were safely passed within a few days.

The most interesting thing about this pill is that it can record vitals at all, says Khalil Ramadi, an assistant professor of bioengineering at New York University who was not involved in this study. Our gastrointestinal tracts are undulating constantly (don’t think about it too hard), so it can be tricky to measure basic vital signs from inside them. Heartbeats cause micro-movements in blood vessels and breathing causes movement in the belly, both of which get picked up by the capsule’s built-in accelerometer. The gut makes so much noise that it can drown out the micromovements the pill is trying to measure, but the Celero team’s signal processing techniques were able to separate heartbeats and breaths (which happen many times per minute) from much slower waves coming from the digestive system.

Pless believes that this sleep apnea study is just one of many potential applications, and that it could eventually be used outside of a clinical setting. Unobtrusive at-home monitoring could be valuable whenever doctors are trying to catch a heart- or breathing-related event that only happens occasionally, as is the case with asthma, cardiac issues like vagal atrial fibrillation, and neuromuscular disorders like amyotrophic lateral sclerosis (ALS). “Catching it in a hospital study may be difficult,” says Pless. In the future, Pless imagines that doctors could simply mail a pill to their patients and track their vitals remotely.

“We have a solution that’s relatively simple and enables access broadly,” says study coauthor Giovanni Traverso, an associate professor in the Department of Mechanical Engineering at MIT and gastroenterologist at Brigham and Women’s Hospital. “I think that can be really transformative.”

The most transformative thing they think their pill can do is detect drug overdoses. When someone overdoses on a drug like fentanyl, their breathing slows down, sometimes life-threateningly so. Over 80,000 people [died](https://12ft.io/proxy?q=https%3A%2F%2Fwww.cdc.gov%2Fdrugoverdose%2Fdeaths%2Findex.html) of [opioid overdose](https://12ft.io/proxy?q=https%3A%2F%2Fwww.wired.com%2Fstory%2Foverdose-reversing-drug-research-fentanyl-fentalogs%2F) in the United States in 2021—and most of them [died alone](https://12ft.io/proxy?q=https%3A%2F%2Fwww.cdc.gov%2Fmmwr%2Fvolumes%2F69%2Fwr%2Fmm6935a1.htm%3Fs_cid%3Dmm6935a1_w). Medications like [Narcan](https://12ft.io/proxy?q=https%3A%2F%2Fwww.wired.com%2Fstory%2Fnarcan-festivals-summer-prevent-overdose%2F), naloxone nasal spray, have the power to reverse an overdose, but only if someone is around to administer it. If a device could sense breathing disruptions and send out a call for help, fewer people might die.

Since the pill sends measurements at regular intervals to an external transmitter (and then on to a laptop), it can trigger an alert whenever the number of breaths recorded per minute falls below a given threshold. Pless thinks this might be useful for a person in recovery during high-risk periods, like after being discharged from the hospital following an overdose, or if they are prescribed opioids after a surgery. “It’s like being able to wear a helmet if you want to ride a motorcycle,” he says.

As part of the November study, the team tested the pill on a pig that had been dosed with fentanyl. The pill successfully detected the ultra-slow breaths characterizing a potentially fatal overdose, and researchers administered medication in time to revive the pig.

The company hasn’t yet tested the pill’s ability to catch overdoses in people, but the team has conducted a preliminary study of safety and efficacy in human volunteers. That study is not yet published, but coauthor Ali Rezai, neuroscientist and director of the Rockefeller Neuroscience Institute, says the results are very promising: Ten participants in a residential treatment program for substance use disorder at the WVU Center for Hope and Healing swallowed the pill, and it successfully monitored vitals in all of them, without side effects.

James Messenger, who works as a peer recovery support specialist and participated in the study, said the team warned him that the pill would be large, but he was pleasantly surprised to find that swallowing the capsule was “absolutely painless.” Once it was inside his body, he couldn’t feel it at all. “It’s a very seamless process,” he says.

Messenger has heard people argue that such a device would enable continued opioid use, but he strongly disagrees. “Where I am in my recovery today, it would be another safety blanket,” he says. “Knowing that you don’t need to carry Narcan with you everywhere, just having that extra layer of support, would be worth it.”

A digital tracking pill isn’t totally unprecedented. Ingestible devices that [track medication use](https://12ft.io/proxy?q=https%3A%2F%2Fwww.fda.gov%2Fnews-events%2Fpress-announcements%2Ffda-approves-pill-sensor-digitally-tracks-if-patients-have-ingested-their-medication) and [take pictures of your insides](https://12ft.io/proxy?q=https%3A%2F%2Fnews.medtronic.com%2F2021-11-15-Medtronic-announces-510-k-clearance-for-PillCam-TM-Small-Bowel-3-HOME-endoscopy-procedure%23%3A~%3Atext%3DNov%252015%252C%25202021-%2CMedtronic%2520announces%2520510%28k%29%2520clearance%2520for%2520PillCam%25E2%2584%25A2%2520Small%2CBowel%25203%2520%2540HOME%2520endoscopy%2520procedure%26text%3DMedtronic%2520plc%2520%28NYSE%253AMDT%29%2C%25E2%2584%25A2%2520Small%2520Bowel%25203) have already been cleared by the US Food and Drug Administration. But despite decades of research, digital pills haven’t quite taken off on the market. Proteus Digital Health, for example, [led the ingestible device market a few years ago with Abilify MyCite](https://12ft.io/proxy?q=https%3A%2F%2Fwww.wired.com%2F2017%2F11%2Fpharma-wants-put-sensors-blockbuster-drug%2F), an antipsychotic medication that could be tracked via a sensor and a phone app to determine whether someone had taken the pill. But Proteus [filed](https://12ft.io/proxy?q=https%3A%2F%2Fwww.fiercehealthcare.com%2Ftech%2Fproteus-digital-health-could-exit-bankruptcy-15m-stalking-horse-from-otsuka%23%3A~%3Atext%3DOnce%2520valued%2520at%2520%25241.5%2520billion%2C11%2520bankruptcy%2520protection%2520June%252015.%29) for bankruptcy protection in 2020 after struggling to sell its product to physicians and insurers.

“People like the idea of being able to understand their own bodies,” says former Proteus CEO Andrew Thompson. But he adds, “whether there is a significant market for this type of device, I don’t know.”

After all, in a world filled with [Fitbits](https://12ft.io/proxy?q=https%3A%2F%2Fwww.wired.com%2Freview%2Ffitbit-charge-6%2F) and [Oura Rings](https://12ft.io/proxy?q=https%3A%2F%2Fwww.wired.com%2Freview%2Foura-ring%2F), one might wonder why someone would opt to swallow a battery to track something as basic as their heart rate. “I don’t think it’s an unmet need,” says Giovanni Di Napoli, who is president of medical device company Medtronic and leads their endoscopy business but was not involved in this study. Medtronic makes one of the most prominent ingestible devices on the market—PillCam, which takes pictures of the gastrointestinal tract in lieu of invasive endoscopy procedures.

“The biggest thing impeding the implementation of these pills is not necessarily their technology, but rather the context where they’re applied,” says Ramadi. If there’s an existing, effective way of getting something done, people likely won’t jump at the opportunity to swallow some electronics instead.

Messenger, for one, thinks there’s an advantage to having your wearable inside your stomach, where you can’t forget it—especially if you’re battling an active addiction. “Remember, this is a population of people that normally lose things,” he says with a chuckle. “The pill is in your body. You can’t be like, ‘Oh, I don’t want to wear it.’”

And the Celero Systems researchers aim to go a step further, using the pill to deliver an overdose-reversing drug. In [2021, the Stanford Lancet Commission](https://12ft.io/proxy?q=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS2667193X21000235%3Fvia%253Dihub), experts who gathered to propose solutions to the opioid crisis, specifically recommended the development of systems that could automatically deliver an opioid antagonist during an overdose. Celero Systems has already tested a prototype of a pill that releases medicine in animals, and human trials are planned for 2024.

For now, their next moves will be refining their tests on sleep apnea: testing the pill in more participants (the November study, for example, only recruited one woman) and learning how to make it stay in the body, safely, for a longer period of time. Additional studies are already underway, and Rezai is hopeful that the pill will be available on the market within the next couple of years. This capsule, he believes, “has significant potential to transform the way we are monitoring, diagnosing, and potentially treating disease.”