

Human ECOLOGY

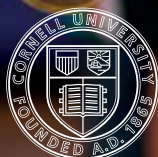
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Cornell University



Smarter Phones, Smarter Solutions

BY OLIVIA M. HALL

Smartphones are so easy to use that even a child can figure them out.

Consider Cornell engineering professor David Erickson's two-year-old: "One day my son stood on a kitchen table, reached for some electrical cords, fell off the table, and cracked his head open," Erickson recounted. "After we came back from the emergency room, I noticed him playing with the phone, looking through some pictures. He's not smart enough to know that he shouldn't stand on a table and reach for electrical cords, but he's already smart enough to use the iPhone."

Over the past few years, these intuitive devices have deeply penetrated our daily lives not only in the United States but also around the globe. According to the Pew Research Center's Internet and American Life Project, 91 percent of American adults own a cellphone, and within that group, 60 percent own smartphones. A study by the United Nations shows more people have cellphones than toilets worldwide, and the networking equipment manufacturer Cisco estimates that ten billion mobile Internet devices—more than the projected population of the earth—will be circulating by 2016. Even now, people in developing nations account for 73 percent of the world's six billion mobile phone subscriptions.

Not surprisingly, developers are trying to harness the power and reach of the smartphone through hundreds of thousands of apps that promise information, entertainment, and solutions to everyday problems.

College of Human Ecology academics are tapping this potential as well, with two cross-disciplinary projects that tackle pressing issues of malnutrition and food access and distribution with the help of smartphones, demonstrating new ways for researchers in a wide range of disciplines to deploy and conduct their studies via these omnipresent devices.

Power in the palm of our hands

When David Erickson first heard about personal nutrition testing devices at a conference, he was not impressed. "At the time, I thought it was the stupidest idea ever," he said of the expensive equipment. "Who would ever buy something like that?"

Three years later, Erickson, who specializes in integrated micro- and nanofluidic systems, Saurabh Mehta and Julia Finkelstein in the Division of Nutritional Sciences, and Joe Francis, director of the Program in Applied Demographics, are developing just that: a smartphone accessory called Cornell NutriPhone that's intended to measure biochemical markers in bodily fluids such as saliva, sweat, blood, or urine.

What changed? Smartphone ownership has exploded, putting portable, easy-to-use, highly connected devices with great computational power into the hands of more than half the American adult population. Specialized, costly, and rarely used equipment is suddenly no longer necessary for at-home biochemical testing. Instead, NutriPhone is being developed to flexibly measure a variety of micronutrients right on gadgets most people already own.

Users simply slide an accessory over their phone and insert a test strip into a slot. "And then it's as easy as pressing 'analyze' in the app, which uses the camera to take a picture," said Matthew Mancuso, a graduate student in biomedical



The Cornell NutriPhone prototype. A test strip containing a saliva or sweat sample is loaded into the slot, photographed, and then analyzed for health purposes. Image provided.

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engineering who is licensing the technology from the Cornell Center for Technology Enterprise and Commercialization to bring it to market with his startup company, vitaMe Technologies.

The first prototype spits out pH measurements from sweat or saliva samples. Users can track and compare them over time and, for example, adjust what they eat to prevent too much acidity in their mouths from attacking tooth enamel.

But in the long run, the NutriPhone collaborators are thinking much bigger.

“For those of us in global health, the application of smartphones is very, very exciting,” said Mehta, assistant professor of global health, epidemiology, and nutrition. “We often talk about how in some of the areas where we work in Africa or India, we skipped the generation of landlines. When we started working in Tanzania, we were still using satellite phones. Now everyone has a cellphone, just within the last few years.”

Their vision: Even in remote parts of the developing world, individuals will use NutriPhone to determine their nutrition status, whether on their own phone with a community health worker or centrally at a health care clinic. Centers that currently rely on faraway laboratories or, worse, have no diagnostic capability at all, will be able to provide quick results along with treatments and nutrition education, creating a personalized feedback loop.

“This technology provides an incredible opportunity to elucidate the causes and consequences of malnutrition and inform interventions and public health approaches to advance human health.”

—Julia Finkelstein

“Part of the excitement for us is that most people aren’t even aware that they have these deficiencies,” Mehta explained. “Most clinicians don’t test for them unless they’re very advanced. Take, for example, vitamin A deficiency. Night blindness is one of the first clinical signs of vitamin A deficiency in a person and the penultimate step before corneal ulceration and blindness. So if tests were available, they could catch it earlier, when it’s much more reversible with lower risk of permanent damage in the long run.”

The NutriPhone team plans to use a \$100,000 seed grant they recently received from Cornell’s Atkinson Center for a Sustainable Future to expand their testing to nutrients including vitamin D and other biomarkers, such as cholesterol. In addition, they hope to develop tests for multiple nutrients simultaneously, which opens up even more possibilities for research and broader applications.

“Everywhere in the world people are doing finger sticks for hemoglobin, for example, as part of surveillance,” said Finkelstein, a nutritional epidemiologist at Cornell as well as a faculty fellow at the Center for Geographic Analysis at Harvard. “But hemoglobin doesn’t tell you why the person is anemic. In these settings, multiple micronutrient deficiencies are pervasive, and hemoglobin only tells you part of the story. If you shift from just thinking about hemoglobin to iron, B12 and folate, vitamin D, and inflammation results all in one test, then you start being able to, in just minutes, understand what nutritional problems a person faces and act in that moment to design an intervention to improve that person’s health.”

Paired with geospatial tagging by smartphones and tablets, this information can then be mapped using GIS methods to reveal nutritional deficiencies, at-risk populations, and health disparities in remote settings.

“When we first talked about this, after even just a few minutes you could see my eyes light up” said Finkelstein. “This technology provides an incredible opportunity to elucidate the causes and consequences of malnutrition and inform interventions and public health approaches to advance human health.”

Mobile food markets

At Cornell Cooperative Extension of New York City, executive director Donald Tobias* and Khin Mar Cho, a specialist for international agriculture, food, and nutrition education, are employing new technologies to solve the healthy food and nutrition puzzle.

Since 2007, the online database tool MarketMaker has been linking more than 2,000 producers and processors of fresh, local foods with markets such as stores, restaurants, distributors, and schools across New York state. Attracting more than one million hits per year, the map-based system shows farmers and potential buyers where certain products are needed or available in real time.

Tobias and Cho, along with Ronnie Coffman, director of international programs in the College of Agriculture and Life Sciences, recognized the tool’s promise for developing countries, where farmers are often isolated from markets and lack control over prices and data on buyer demands. They are exploring MarketMaker’s potential in parts of Africa and Asia through a multi-year, USAID-funded project called MEAS (Modernizing Extension and Advisory Services).

Similar to those of the NutriPhone team, their efforts are possible thanks to the pervasive reach of cellphones. With government support, these devices have penetrated so deeply into rural areas—in Rwanda, for example, growing from 2.5 million subscribers in 2009 to more than 6 million presently—that farmers are already holding part of the solution in their hands, said Tobias, who has seen the technology’s reach on his travels to these regions.

“It was not uncommon to meet with farmers in their field who would be carrying two cellphones because they liked features of different cellphone services,” Tobias noted.

Cho and Tobias traveled to Ethiopia, Rwanda, and Bangladesh—all three are targets of the U.S. government’s Feed the Future food security initiative—to bring together government officials, processors, farmers, and marketers. With the help of translators, Tobias and Cho led them through concept-mapping exercises, a method developed by policy analysis and management professor Bill Trochim, that offers visual representation of trends after brainstorming sessions.

They found that farmers have difficulty negotiating fair prices for agricultural inputs, such as high-quality seeds and fertilizer, and are at the mercy of brokers for the compensation they get for their products at market.

In Bangladesh, for instance, growers might bring pineapples to the market. “The broker arrives and tells them what the price is going to be, period,” Tobias reported. “The farmers aren’t in a position to negotiate; they don’t know the prices until they show up with their pineapples. It’s not like they can go anywhere else with them.”

Up the distribution chain, supermarket managers in cities in Ethiopia, for example, are equally frustrated because they have no way of communicating to farmers what they would like to see on their shelves during the next season. Given the changing tastes of the emerging middle classes in



Khin Mar Cho (holding fruit) meets with farmers and middlemen at a major pineapple market in Bangladesh. Photo provided.

these countries, growers could be using their land for more profitable crops if only they knew what those were.

MarketMaker may be the missing link, but Tobias and Cho are thinking beyond loading the app onto every producer's phone. Rather, their explorations have brought different strategies and leading players to the forefront in each setting. At Bangladesh Agricultural University, for instance, leaders are developing a marketing system from scratch, while Rwanda's government will fund a second-generation app that builds on an existing, private market information system.

"What they can learn from our research is strategies and lessons that are relevant to their countries' needs so they can advance features in their system," said Cho, adding that other nations such as the Philippines, India, and Thailand are beginning to use variations on MarketMaker, as well.

Among the system's best practices, the idea of "food hubs" appeared to be particularly intriguing. In New York City, in particular, numerous faith-based organizations combine biweekly orders to bring fresh produce to the community.

On the other end, farmers deal with only one order and can rest assured that everything that goes out on the delivery truck is already sold. The most entrepreneurially-minded among them may even use MarketMaker's map to figure out what other products they can pick up along the way to the city, an idea that appealed to farmers whom Cho and Tobias approached at Africa's largest open-air market in Ethiopia.

Distribution of the food at its destination can then be paired with educational measures. "When we first start food hubs, people receiving the food often say, 'these carrots have dirt on them,' and they'll be kind of offended. And we'll explain that they were in the ground a few hours ago," Tobias said. "In terms of our international work, we found that combining nutrition education with agricultural programs in this way was a new concept."

Transformative tech

Back in New York, even sixth graders are using MarketMaker to order fruits and vegetables for their schools—proof that the tool is as easy to use as the smartphones and tablets on which it runs.

The children show that a new tech-savvy generation is primed to reap even greater benefits that technologies such as NutriPhone, MarketMaker, and many others will provide.

"[In developing countries] we've seen children taught to use iPads," Tobias said. "They go out into the rice fields, take a picture of the plants, and send that to an extension center where an agent can tell farmers the optimal time to plant. To me, that's fascinating. You have a very cost-effective way of transferring information to make important farming decisions, and you have children involved in technology. For people like ourselves in extension, members of a land-grant university that's responsible for the dissemination of innovation and education, this technology is going to change what we do in the world in a big way." • • •

**Editor's note: Donald Tobias, executive director of CCE-NYC, passed away November 22, 2013 in New York City.*

Olivia M. Hall, PhD '12, is a freelance writer and anthropologist.

For more information:

New York MarketMaker
nyc.cce.cornell.edu/programs/marketmaker/

David Erickson
de54@cornell.edu

Julia Finkelstein
jlf288@cornell.edu

Joe Francis
jdf2@cornell.edu

Saurabh Mehta
sm939@cornell.edu

Khin Mar Cho
kc458@cornell.edu