Rebecca Richards-Kortum returned from a 2005 trip to Malawi with a transformed view on the interplay between technology and cultural, economic, and social realities. While in a newborn intensive care unit, Kortum, now a mother of six children, witnessed premature infants struggling to breathe because the unit lacked technologies widely available elsewhere. She found an “equipment graveyard” full of assorted donated machines designed for high-resource hospitals. Richards-Kortum also met African children with AIDS who received antiretroviral drugs that required refrigeration, yet the children lived in villages without electricity.

Impelled by such adversity, Richards-Kortum decided to go beyond geographic and disciplinary boundaries to solve challenges in global health. She and her team integrate advances in nanotechnology and molecular imaging with microfabrication technologies to develop inexpensive, portable medical devices that can be used in a variety of settings. In 2005 Richards-Kortum established the educational initiative Beyond Traditional Borders and two years later founded the Rice 360° Institute for Global Health. The efforts have resulted in student-designed technologies that solve healthcare problems in the developing world. Elected to the National Academy of Sciences in 2015, Richards-Kortum recently led the development of a new form of fiber optic endoscopy, described in her Inaugural Article (1).

Low-Cost Sensors for Infectious Diseases
Richards-Kortum’s research group has integrated advances in nanotechnology and microfabrication to develop low-cost sensors to detect pathogens and infectious diseases, such as HIV (2), cryptosporidium (3), malaria (4), and tuberculosis (5). Exemplifying her group’s use of readily available materials, the HIV...
device is made of paper and plastic, and enables diagnosis of the viruses in infants in low-resource settings.

Richards-Kortum’s team also developed a low-cost sensor to detect hemoglobin concentration (6) in patients with anemia, which affects a quarter of the world’s population. The researchers impregnated paper with chemicals to break open red blood cells, and then created an inexpensive, handheld reader to analyze hemoglobin on the paper. The device reduced per-test cost more than 100-fold, compared with standard care.

Educational Programs in Global Health Technologies

Richards-Kortum’s interest in addressing global health issues, both through her teaching and her research, began in 2004 when she was preparing an engineering course for non-science majors. She suspected that global health would pique the interest of her students, and she became immersed in such issues. A year later Mark Kline, who is now the physician-in-chief at Texas Children’s Hospital, invited her to visit one of his clinics in Malawi: Queen Elizabeth Central Hospital, where approximately one in five infants is born prematurely. Years later, when Richards-Kortum and colleague Maria Oden won the 2013 $100,000 Lemelson-MIT Award for Global Innovation in honor of their inventions and teaching efforts, they donated the prize money toward the construction of a new neonatal ward at the Queen Elizabeth Central Hospital.

The life-changing trip, after which Richards-Kortum was named a Howard Hughes Medical Institute Professor in 2006, contributed to her founding the undergraduate education program Beyond Traditional Borders and Rice 360°: Institute for Global Health, which is a research and education institute that promotes the design and dissemination of low-cost solutions to global healthcare needs. Richards-Kortum has outlined how engineering education can help meet such needs in several articles (7–9). She and Oden mention that current funding mechanisms often favor technological innovation over simplicity, resulting in technologies that are too costly and difficult to maintain at scale. Instead, Richards-Kortum and her team advocate for “frugal design” that reflects the unique needs and constraints of low-resource settings. Examples of the many technologies created by her students include a “lab-in-a-backpack” full of diagnostic tools, a small clip that pharmacists can attach to a syringe to enable proper dosage of medicine, a hand-powered centrifuge constructed for $35 using a salad spinner, and a portable, battery-operated microscope that costs $240 to manufacture.

Cancer-Detection Innovations

Richards-Kortum’s research has led to 31 patents so far, including several for technologies that improve the early detection of cancer, especially in impoverished settings. In 2012, for example, she and her colleagues created a multimodal optical imaging system to noninvasively identify oral cancers and premalignant lesions (10). Three years later her group developed a low-cost, high-resolution microendoscope, and showed that it improves early detection of cancer and precancerous lesions in a variety of organ systems (10). In some cases, however, the microendoscope did not yield images with sufficient contrast to enable diagnosis of precancerous lesions.

The researchers solved the problem through a new form of fiber-optic endoscopy called differential structured illumination microendoscopy (DSIMe), which is described in Richards-Kortum’s Inaugural Article (1). The system, without any bulky optical components attached to the distal tip of the fiber bundle, can perform structured illumination in real time for optical sectioning, while eliminating out-of-focus light and maintaining imaging speed. When tested on patients undergoing surgery for cervical cancer, images acquired using DSIMe showed greater contrast than standard microendoscopy, thereby improving the ability to detect atypical cells.

Nursery of the Future

Working closely with partners in sub-Saharan Africa, Richards-Kortum’s team is currently developing the “Nursery of the Future.” She says, “The Nursery of the Future is a comprehensive set of affordable, highly effective technologies designed to support the well-known principles of newborn care.” It is directed toward preventing Africa’s close to one million annual neonatal deaths, many of which are a result of breathing problems associated with premature birth and infections. In the developed world, infants who struggle to breathe are treated using bubble CPAP (continuous positive airway pressure) machines that cost thousands of dollars, making them too expensive for district hospitals in Africa.

In 2013, while at the American Institute for Medical and Biomedical Engineering’s highest honor, the 2016 Pierre Galletti Award. Her family of three sons and three daughters includes two adopted children from Ethiopia. Using the Pumani CPAP and other low-cost technologies, she aims to deploy the project at key medical facilities across Africa. “Our goal is to fully equip the Nursery of the Future at a district hospital for a total cost of $10,000, less than the cost of one Western-style ventilator,” she says.


