

W Hitting home with technology development for asthma

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For Moore's law see

Proc IEEE Inst Electr Electron Eng

1998; **86**: 82–85.

For more on the Home-BASE

Center see <http://Ubhomebase.org/>

Technology solutions for asthma self care are particularly timely and imperative as asthma poses a substantial public health problem. Asthma is associated with approximately 2 million annual emergency department visits and costs an estimated US\$56 billion annually in lost productivity and healthcare. As the prevalence and negative impacts of asthma increases, an estimated 13% of those with asthma have symptoms every day, 37% had active symptoms in the past 30 days, 24% had symptoms with difficulty staying asleep, and 25% missed work or their usual activities because of their asthma. Self management of asthma is not simple. Care of this chronic disease at home is a complex, multistep, decision-making process that involves identifying and avoiding triggers, altering the environment, remembering both routine and rescue medications, recognising symptoms indicative of changes in underlying physiology, adjusting medical therapy, and determining appropriate times to contact a health-care provider. Additionally, many individuals do not properly execute the steps in taking medication or measuring lung function without errors. Asthma self-management, which can be error-prone, is a worsening public health problem ripe for novel approaches that engage multiple perspectives.

Technological innovations are revolutionising healthcare. According to Moore's law, computer processing speed and power will double roughly every 18 months, rendering more efficient and cost-effective technology systems every year. It is conceivable that innovations in the next 20 years will fundamentally change every process in health-care delivery. For example, sensors and microprocessors might become so affordable

and ubiquitous that health monitoring will become a passive process, requiring minimum effort on the part of the individual, and integrated into smart homes that have more computing capacity than modern day hospitals. One example of innovation is occurring at the University of Buffalo's Home-BASE Center (Center for Excellence in Home Health and Well-Being through Adaptive Smart Environments). The centre uses both transdisciplinary and transcommunity (including lay and industry team members) approaches to ensure relevant and meaningful designs in these potentially groundbreaking technologies.

Home-BASE researchers are engaged in research and educational activities dedicated to home health and wellness. The Breathe Smart Team in Home-BASE started as a collaboration between Nursing and Biomedical Engineering and has since expanded to include efforts from disciplines of geography, mechanical engineering, business, industrial and systems engineering, computer science, epidemiology, biostatistics, architecture and planning, rehabilitation science, and medicine.

Affiliated researchers have produced innovations such as smart shirts (for wearable breathing measures), smart radios (for non-contact breathing detection), smart necklaces (for breathing sound sensing), and others that promise to change the manner in which respiratory disease is prevented, monitored, and managed in the future. By tapping into the ubiquity of smart devices, we can develop new devices for patients to monitor and control their asthma. For example, the MobiSpiro is a microphone-based spirometry device for an unmodified smartphone. With a set of built-in sensor calibration models and machine learning algorithms, we are exploring the possibility of using the smartphone for the analysis of common lung function tests (figure 1). Another device uses a smartphone coupled with a custom 3D printed "smart" spirometer that enables an asthma patient to monitor and record their conditions as needed (figure 2). A smartphone rehabilitation game application is also in development that trains and guides breathing exercises for those with asthma. The goal for this application (figure 3) is to motivate the user and promote exercise compliance through gamification and effective, timely feedback.

It is important to engage researchers, clinicians, and the public in technology innovations, and Home-BASE works closely with the local Asthma Coalition, affiliated with the American Lung Association and the New York State Department of Health to ensure their approach moves beyond the walls of academia and traditional clinical settings. Specific activities in which health-care providers and health discipline researchers engaged in

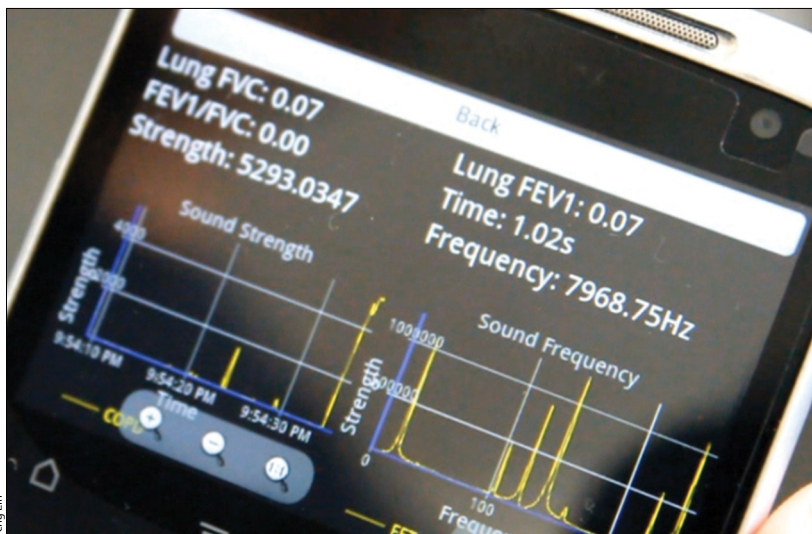


Figure 1: The MobiSpiro applications to estimate lung function using smartphone built-in sensors

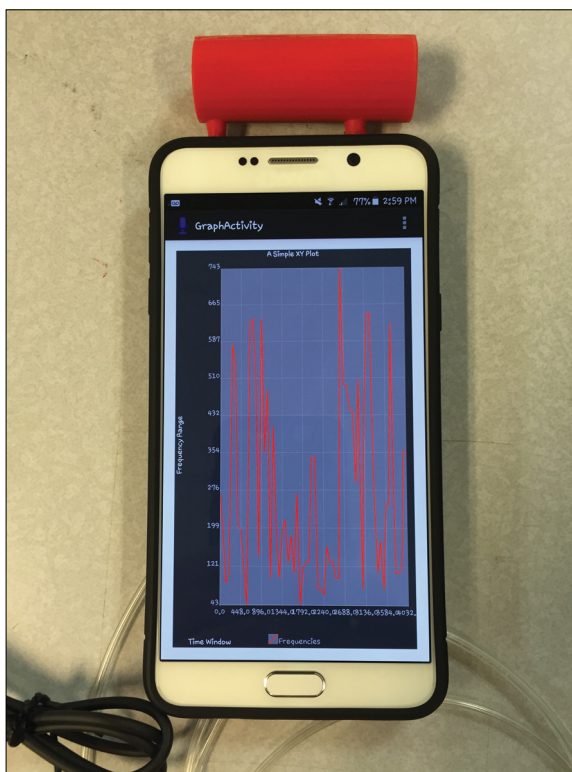


Figure 2: 3D printed airflow device (red tube) that is used to take peak expiratory flow measurements which are sent to the smartphone and processed using a custom application

the process included summarising epidemiological data, interviewing end-users and key informants, reviewing the scientific literature, engaging in brainstorming, inserting the gold-standard Asthma Action Plan algorithm into concept development, and designing laboratory and clinical trials.

The published work from the Multidisciplinary Assessment of Technology Centre for Healthcare (MATCH) affiliated in the United Kingdom, embodies this important collaborative approach through links to several universities, industry partners, and policy makers. With several university centres and groups using similar processes to develop health-care innovation, there are vast opportunities for collaboration and shared learning. The University of Missouri-Columbia's Tigerplace is an assisted living facility dedicated to enabling older adults to maintain maximum independence through nursing care facilitated by novel transdisciplinary sensor development and use. Also, the Center for Inclusive Design and Environmental Access and the Toronto Rehabilitation Institute are developing assistive devices and improving accessibility for an aging population.

Looking outside of the clinical field can also yield results. Following engineering and business partners and using the patent search as a way to analyse existing intellectual property and technology provides a wealth of knowledge

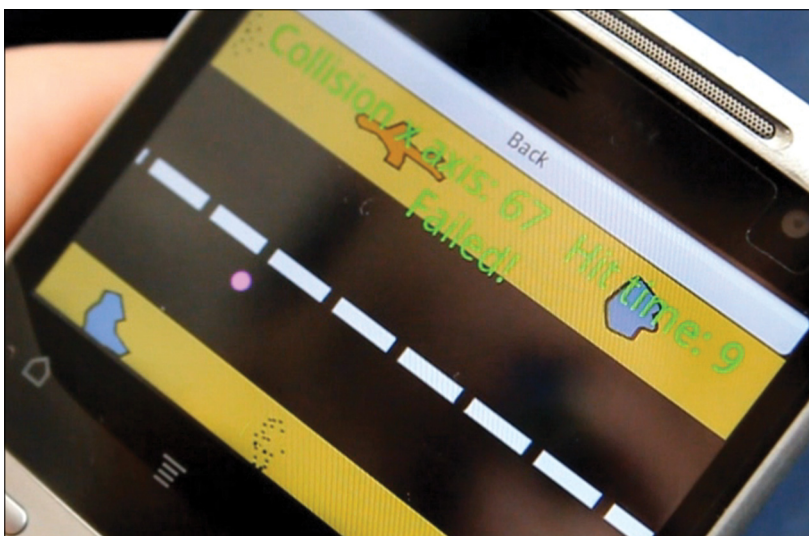


Figure 3: A smartphone exergame for in-home pulmonary rehabilitation

regarding technological advancements. A thorough, systematic search identified 14 inventions related to home asthma monitoring. By tracking activity of assignees (ie, owners) and inventors of those patents, we identified one commercially available product to consider for possible use, and contact information regarding four other possible technologies. A conventional scientific literature database search (such as PubMed) would not have uncovered these technologies because those interfaces do not draw upon intellectual property databases catalogued by the US Patent and Trademark Office, World Intellectual Property Organization, Google Patents, and approval documentation at the US Food and Drug Administration. We identified the Derwent Innovations Index database (Thompson Reuters) to be a user-friendly search engine that covers domestic and international patents for beginners.

Smart solutions need in depth knowledge of the problem to be solved and the science and technology that is available to solve the problem, with transdisciplinary and transcommunity research as essential to the development of smart solutions. By crossing borders between disciplines, and in our respected lay and health industry partners, smarter solutions will result in healthier people.

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JC has been a consultant for the American Lung Association's Erie County Asthma Coalition. WX holds patents relevant to the Home-BASE Center's work outside of the products mentioned here. All other authors declare no competing interests.

For more on MATCH see <http://www.match.ac.uk/index.php>