

THE FUTURE OF HEALTHCARE IT'S HEALTH, THEN CARE



Fran Turisco
Research Principal,
Healthcare Emerging
Practices, CSC
fturisco@csc.com

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www.csc.com/lefreports

Ten technologies featured in “[The Future of Healthcare: It's Health, Then Care](#)” LEF report that demonstrate the power of technology and brilliant minds to improve health outcomes

Healthcare is broken globally. Fortunately, there are many smart minds from research, care delivery, the business world and education working on the problems ailing healthcare. These different perspectives help move the overall system forward and in the right direction, making healthcare better by preventing disease, identifying disease earlier, getting the patient back to a normal life, improving healthcare processes or lowering costs. Technology is a conduit for it all.

We all know about using smartphones for wellness and monitoring. This report plunges into the next phase or phases for wellness, diagnostics, treatments and better quality of life, supported by technology. The following examples demonstrate the breadth and depth of some of the work in progress.

Ten Technologies	Further Description and Developments
1. Intelligent pill can deliver targeted doses of medication to specific locations in the body	<p>Philips Research has an intelligent pill that can be programmed to deliver targeted doses of medication to patients with digestive disorders such as Crohn's disease, colitis and colon cancer. The pill determines its location via a pH sensor that measures acidity of the environment. The device releases medicine from its reservoir via a microprocessor-controlled pump either in bursts or a controlled release, and can target multiple locations.¹</p> <p>Further out, scientists are working on smart pills that dispense medicine when they recognize defects in nearby cells, such as DNA defects in cancer cells, enabling selective drug delivery to the damaged cells.</p>

<p>2. Sensor technology for tracking medication adherence</p>	<p>Proteus Biomedical is also working on technology that incorporates a tiny sensor into pills for tracking medication adherence; the company, which announced a sizeable investment by Novartis in January 2010, is targeting medication adherence for organ transplants, cardiovascular disease, infectious diseases, diabetes and psychiatric disorders.² Once the pill is swallowed, the sensor reports to a wearable receiver on the patient's skin (the Raisin technology discussed in E-Power to the Patient) that the medicine has been taken.</p>
<p>3. Brain implants using brain activity to improve health and outcomes – example of one that prevents seizures</p>	<p>The RNS System, a responsive neurostimulator from NeuroPace, detects abnormal electrical activity in the brain that signals the onset of a seizure, and delivers a specific pattern of mild electrical stimulation to block the seizure. The implant, about the size of a domino, offers a new option to severe epilepsy patients who do not respond to medication and cannot have surgery. The device has undergone clinical trials at a number of academic medical centers, yielding very positive results that demonstrate the implant can decrease seizures in epilepsy patients not respondent to medication. In July 2010 NeuroPace submitted its Premarket Approval (PMA) application to the FDA.³</p>
<p>4. Contact lens with microchip to detect glaucoma</p>	<p>Scientists at Sensimed have created a smart contact lens with an embedded microchip that is worn by the patient and monitors intraocular pressure over a 24-hour period. If a patient wears the contact lens for a day, glaucoma can be detected sooner and more reliably, and the efficacy of the treatment can be monitored over time, potentially averting blindness.⁴</p>
<p>5. Artificial pancreas – for diabetics</p>	<p>The ultimate goal is to provide a closed-loop device that monitors <i>and</i> corrects. That is the plan for researchers at Massachusetts General Hospital and Boston University, who have successfully completed a trial with 11 type-1 diabetic patients who used the researchers' new "artificial pancreas," which consists of insulin pumps, glucose sensors and regulatory software. This is the first artificial pancreas device that uses both insulin (to lower blood sugar) and glucagon (to raise). According to Dr. Steven Russell, one of the study leaders, "Insulin has one of the narrowest therapeutic ranges of any drug. There are also a number of variables that affect the amount of insulin needed for a given blood glucose level. All of these calculations needed to keep the blood glucose of someone with diabetes within normal range may be too much for a human but perfect for a computer."⁵</p>
<p>6. Bioprinting – Creating new skin using old technology</p>	<p>Scientists at Wake Forest University have discovered how to apply ink-jet printer technology to "print" proteins directly onto a burn victim's body for faster and more thorough healing. By using protein-based skin cells instead of ink, researchers can spray layers of skin that will be absorbed into a patient's body and eventually regenerate on their own. Such bioprinting is still in the lab testing stage, but results with mice show much faster healing compared to current methods.⁶</p>
<p>7. Artificial retina – a DOE project</p>	<p>The U.S. Department of Energy's (DOE) Artificial Retina Project, a collaboration of five DOE national laboratories, four universities and private industry, is working on developing the most advanced retinal prosthesis. To date, important progress has been made by enabling direct communication between the implant and the neural cells that carry visual information to the</p>

	<p>brain; however, considerable research remains. The challenge is to replace the lost light-gathering function of rods and cones with a video camera, and to use the camera-collected information to electronically stimulate the part of the retina not destroyed by disease. In addition, a software system called the Artificial Retinal Implant Vision Simulator (ARIVS) provides “real-time image processing to improve the vision afforded by the camera-driven device. The preservation and enhancement of contrast differences and transitions, such as edges, are particularly important compared to picture details like object texture.”⁷</p>
<p>8. Serious video games hone medical student decision-making skills</p>	<p>PULSE!! is a “serious” video game jointly developed by the University of Texas, Corpus Christi, and BreakAway Ltd., a developer of video games and simulations. PULSE!! offers professionals and students the opportunity to practice on 3D video patients using the same interactive techniques and decision-making processes they would use with real patients. The provider sees the patient’s chart, his or her physical presentation, and results from any recent tests. The patient responds to questions entered by the provider via a chat function. The provider can order tests and treatments, providing a level of interaction once available only via on-the-job training. And the 3D environment taps into the familiarity and ease-of-use of video games.</p>
<p>9. Robots as care assistants</p>	<p>Robots are care team members, too. The Huggable teddy bear robot being developed by MIT can serve as a medical communicator. Packed with electronic sensors and sensitive skin technologies, the robot can distinguish between cuddling for comfort or agitation by sensing the strength of the squeeze. When it is fitted with audio and video, nurses and patients can receive real-time information on a child’s status.⁸</p> <p>For older patients, French company Robosoft offers an at-home assistance robot called Kompaï R&D to minimize the need for a home care aide. The robot understands and executes simple orders and gives a certain level of response, has localization and navigation technologies for going from one place to another on demand or on its own initiative, provides communication with the patient, and is permanently connected to the Internet and all its services.⁹</p>
<p>10. Lab-on-a-chip</p>	<p>Other technology examples involve diagnostic tests that can be given by members of the care team other than the physician or nurse practitioner. Researchers at the University of California, Davis, have created a lab-on-a-chip for HIV testing that does not require expensive resources and is able to deliver results in seconds. Typically, diagnosing and monitoring HIV requires highly trained specialists and expensive medical machines. In contrast, the portable and less expensive lab-on-a-chip is a holographic, lens-free imaging mechanism that counts the number of cytokine molecules (inflammatory proteins) and captured T-cells (HIV-infected white blood cells) to determine if the blood is HIV positive.¹⁰ With alterations, this lab-on-a-chip could be used to accurately measure a wide variety of blood factors for patients at the point of care at an affordable cost.¹¹</p>

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- ³ "NeuroPace Submits PMA Application for FDA Approval of Novel Investigational Device for Epilepsy," NeuroPace press release, 8 July 2010, <http://www.neuropace.com/about/news/20100708.html>; and "Pivotal Trial Data Demonstrate NeuroPace RNS System Reduced Seizures in People with Epilepsy," NeuroPace press release, 7 December 2009, <http://www.neuropace.com/about/news/091207.html>
- ⁴ "Smart Contact Lens Detects Eye Disease," *Smarter Technology*, 21 April 2010. <http://www.smartertechnology.com/c/a/Technology-For-Change/Smart-Contact-Lens-Detects-Eye-Disease/>; and "Diagnostic Contacts – A contact lens that tracks ocular pressure may help treat glaucoma," *IEEE Spectrum*, June 2010, <http://spectrum.ieee.org/biomedical/diagnostics/diagnostic-contacts/0>
- ⁵ Interview with Steven Russell, MD, 11 May 2010. Also see <http://www.artificialpancreas.org/>
- ⁶ "Inkjet-like device 'prints' cells right over burns," Reuters, 7 April 2010, <http://www.reuters.com/article/idUSTRE63657520100407>; "Using Ink Jet Technology to 'Print' Organs and Tissues," <http://www.wfubmc.edu/Research/WFIRM/Bioprinting.htm> (see video); and "New Pics: Inkjet Printer Makes Instant Skin Grafts for Burn Victims," 2 November 2010, <http://www.fastcodesign.com/1662613/new-pics-inkjet-printer-makes-instant-skin-grafts-for-burn-victims> (see video).
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- ⁸ Huggable Overview, <http://robotic.media.mit.edu/projects/robots/huggable/overview/overview.html>
- ⁹ "robuBOX-Kompaï now available in Open Source," Robosoft press release, 3 May 2010. http://www.robosoft.com/img/tiny/CP/CP_OpSource_ICRA_EN.pdf
- ¹⁰ "New 'Lab on a Chip' Device Revolutionizes HIV Testing," DailyTech, 19 July 2010, <http://www.dailytech.com/New+Lab+on+a+Chip+Device+Revolutionizes+HIV+Testing/article19073.htm>. Also see journal article: Gulnaz Stybayeva et al, "Lensfree Holographic Imaging of Antibody Microarrays for High-Throughput Detection of Leukocyte Numbers and Function," *Analytical Chemistry*, 82:9, 1 April 2010, <http://pubs.acs.org/doi/abs/10.1021/ac100142a?prevSearch=%2528HIV%2529%2BAND%2B%255Bauthor%253A%2BBozcan%255D&searchHistoryKey=>
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