We are familiar with the fact that the cost and power of computing has dramatically improved over time. We are also all too familiar with the fact that the cost of healthcare seems out of control in the opposite direction. Computing power that once cost a fortune and took up a large air-conditioned room now resides in your smartphone, laptop, or key chain.

Numerous challenges currently face the healthcare system. These include unchecked expansion of costs, lack of preventive care, massive increases in chronic disease conditions and age-related illnesses, widespread obesity, poor adherence to medical regimens, and shortages of healthcare professionals in certain areas. Individuals, companies, and governments all continue to struggle with the rising cost of health care. Everyone will benefit from each step that we can take in bringing cost-effective solutions to bear.

We believe that the increased availability of low-cost sensors and computation can be leveraged to address major elements of the healthcare problem. Researchers in the Department of Computer Science and Engineering at the University of Notre Dame are working together to provide innovative solutions to these problems. In this report, we look at a “big data” approach to predicting disease, at improvement in the delivery of radiation therapy, at improved doctor training through medical robots, a concussion detection app that runs on your smartphone or pad, a stroke rehab therapy that runs on your computer gaming system, and a smartphone drug test-strip. Some of these ideas are in the early stages of development, while others are still making their way to market. As we work toward the goal of computing cost-effective healthcare, we welcome your support.

Kevin Bowyer
Schubmehl-Prein Professor
Chair of the Department of Computer Science and Engineering

INTRODUCTION TO NOTRE DAME’S OPEN ENROLLMENT GUIDE

As the healthcare landscape continues to shift, we must further evolve our benefits plans for 2014 as part of our ongoing commitment to provide quality, affordable health and wellness plans to our Notre Dame Community. While we are fortunate to provide insurance to faculty and staff, the reality is our costs are growing at a rate the University cannot sustain.
Knocking Concussions

His name is Preston Plevretes. As a 19-year-old LaSalle University college student, he looked forward to a bright future. Tall, handsome, and athletic, Preston played football in high school, and continued playing for LaSalle. One day at football practice, Preston knocked heads with another football player and suffered a concussion. Within a few days, a campus nurse and trainer cleared him to return to play. Like many teenagers, Preston thought he was invincible so he ignored his headache and returned to the field. A couple of days later, in a game against Duquesne University, Preston suffered another hit, but this time the consequences were catastrophic: traumatic brain injury. The term does not adequately describe the devastation – tunnel vision, a halting gait, difficulty speaking, permanent debilitation. The kid with the bright future now cannot drive a car or live on his own.

So why was Preston playing football with a concussion? Two reasons. First, kids (and sometimes coaches, trainers, and nurses) ignore warning signs so the athlete can get back in the game. Second because the technology to diagnose concussions costs a lot and resides a hospital visit away. Think MRI.

Enter Chris Poellabauer and Patrick Flynn, researchers in the University of Notre Dame’s Computer Science and Engineering department. They realized a hand-held, mobile app to detect concussions could overcome these roadblocks and possibly prevent injuries like Preston’s from happening to other kids. Such a computer app would not be swayed by emotion during a game, or require a trip to a hospital for further testing. The Notre Dame research team developed an IPad app that looks for detectable changes in speech that occur after an athlete suffers a concussion. Before an athletic event, the athlete uses a computer tablet to take a test that establishes a baseline reading. After the event, the athlete takes the test again, this time looking for traumatic brain injury indicators like distorted vowels, hyper nasality and imprecise consonants. Athletes cannot fake their responses to get back in the game, and a conclusive argument can be made as to whether or not he or she has suffered a concussion.

The researchers tested the technology on University of Notre Dame students who participate in the University’s club boxing tournaments – Bengal (men) and Baraka (women) Bouts. In 2012, 9 concussions were detected out of the 125 participants in the Bengal Bouts. The data matched favorably with standard concussion tests given by medical personnel at the same time.

Computerized concussion tests are slowly being adopted by schools and sports teams across the country. As this happens, future work focuses on apps that take advantage of the gyroscopes, cameras, and microphones found on mobile devices. With mobile app concussion detection, the University of Notre Dame hopes to prevent Preston Plevretes-like injuries. He and other young athletes deserve our best as we fight for cost-effective healthcare.
In 2011, the Computerworld Honors Program selected Dr. Chen as a laureate. The citation reads, “the program, founded in 1988, cancer research recognizes organizations and individuals who have used information technology to promote and advance public welfare, benefit society, and change the world for the better.” Changing the world for the better, Dr. Chen leads the way in cost-effective healthcare in the area of cancer research and treatment.

We need more Danny Chens. Dr. Chen pursues cutting-edge research in the area of computational medicine, while at the same time excels at teaching -- winning an undergraduate teaching award in the Department of Computer Science and Engineering.

Dr. Chen developed a cancer treatment, which delivers a targeted dose of radiation to tumors. You know how difficult it is to take a picture of a moving person? Think of taking an x-ray as taking a picture, and a moving heart as a moving person, and you begin to see the difficulty of hitting the right spot with a dose of radiation. His new technique provides effective treatment with much less potential damage to healthy tissue in about half of the time of older methods. “Medical imaging is a physician’s eye into the body,” says Chen. “Even when you know the disease, you have to know exactly where it is located to avoid damaging healthy tissue and vital organs.”

Another major problem in medical imaging is that scans of the same area in the same body do not always match, meaning it is difficult for the doctor to pinpoint one location from scan to scan. Dr. Chen works with Dr. X. Sharon Hu. Together they developed a hardware based medical imaging system that solves the “moving person” issue. Dr. Chen and Dr. Hu’s approach to targeted radiation therapy allows shorter time to deliver radiation therapy, which enables hospitals to treat more cancer patients, reduces the treatment costs for both cancer patients and hospitals, allows cancer patients to receive earlier treatment, and decreases the risk of uncertainty in the treatment process.

During 2010, the United States spent an estimated $125 billion on cancer care.

More than 1 million people a year get cancer.

2 out of every 3 people diagnosed with cancer today survive at least 5 years.
What if the person selling you your blood pressure pill replaced it with a sugar pill? What if it was a person’s diabetes medicine? Or HIV medicine? The World Health Organization estimates that 10-30% of medicine in developing countries is counterfeit. Counterfeit drugs are cheap to make using either inexpensive substitutes or simply eliminating ingredients. In the same way that drug dealers cook meth in the back of cars, counterfeiters “cook” fake medicines in huts under shade trees (WHO). This results in both a public health challenge, and an economic challenge to the pharmaceutical industry. Since the production costs of fakes are minimal, the profits to counterfeiters are high.

Researchers are fighting this problem using test strips (called PDAs) and smartphones. The test strips test whether or not the drug is a fake, and the smart phones read the test and track where fakes are found. The process is simple: a healthcare worker scrapes a suspect pill across a PAD, dips it in water, and then has a smartphone analyze and interpret the result. After test results are available, the smartphone transmits the geo-tagged image (the same way your car knows your location using GPS) to a remote computer for further processing. The remote computer captures a geographically indexed record of tests so that counterfeiting hotspots can be identified, allowing counterfeiters to be caught.

Smartphone geotagging insures people in developing countries receive the medicine they think they are getting.

Reducing these errors will save lives and save billions of dollars.

Dr. Laurel Riek is a researcher in the Dept. of Computer Science and Engineering at the University of Notre Dame, and works on social robotics and healthcare informatics. Her work in healthcare explores ways to use robotics technology to solve real-world problems in patient safety. One project focuses on improving existing patient simulator technology, making it more realistic and interactive. Patient simulators in widespread use today display few facial expressions or gestures, despite the importance of these cues in how doctors assess and treat patients. Dr. Riek is designing new, facially expressive robots based on real patient data: facial expression, head and body movements, and speech that reflect how real people with real disease move and sound. For example, a robot animated to have a stroke mimics the head, eye, and facial movements characteristic of an actual person with the disease. This technology will provide a more life-like simulation for clinical trainees, making them far less likely to make a costly (or deadly) mistake with real patients in the future.

The Air Force Academy uses 12 simulators to train pilots so that pilots can learn what it feels like to be in a cockpit before flying an actual airplane. Doctors, like pilots, train on simulators. Before doctors practice medicine on real people, they train on android robots – hopefully reducing future medical errors. In the United States, preventable medical errors that harm patients kill as many as 400,000 people per year and cost as much as $1 trillion dollars.
Moneyball for Improved Healthcare

In the 2011 movie Moneyball, Brad Pitt plays the Oakland A’s Manager Billy Beane. The real-life Billy Beane became a legend in baseball circles building a successful team by predicting which unlikely players working together would produce a winning line-up. He saw connections others missed using his computer to search the stats for skills his team needed – a technique we now call data analytics.

How does data analytics apply to healthcare? Today, the treatment of disease rather than the prevention of it drives the practice of medicine. Medicine tends to treat illnesses after they emerge, rather than proactively before disease has become firmly rooted and is more easily preventable. Doctors make educated guesses assessing future risks based on their experiences – putting younger or more inexperienced physicians at a definite disadvantage. One preventative strategy involves universal testing for potential illness, but this has obvious shortcomings; namely, it costs too much time and too much money.

So what if we used data analytics to compare a patient’s own medical history with similar patients health information across the population as a whole, to predict diseases a specific patient is most likely to develop next? Nitesh Chawla, a professor in the Computer Science and Engineering Department, created a data analytic program called CARE (Collaborative Assessment and Recommendation Engine). CARE filters a patient’s prior diagnostic codes against a database, and predicts the patient’s greatest disease risks. The goal is to determine and minimize an individual’s risk. “We want to provide every patient with a personalized answer to the question: What are my disease risks?” says Chawla. The potential for ‘personalizing’ health care from a disease prevention, disease management and therapeutics perspective is increasing with the implementation of data analytics in preventative medicine.

In its current state, CARE only uses diagnostic codes in its searches – physician’s notes and other medical history information are ignored. In future generations of the software, these features may be added for added accuracy. Some day a doctor’s “best guess” coupled with data analytics could make true inroads in preventative medicine, and that is a truly winning line-up in the fight for cost-effective health care.

Balancing Act for Better Health

Nintendo Wii, some specially modified games and a balance board. While regular games would be too difficult and too fast for a stroke patient to play, these games are customized to address the issues particular to stroke victims – balance and reaction time. The patient gets immediate feedback from the game – “you are leaning left and forward, not balanced”. “Unlike other games, WeHab can remember where a client is in their therapy sequence and capture progress that can be shared with their therapist,” says developer Aaron Striegel. The game aspect makes it more fun, and less sterile than therapy in a hospital. Instead of endless testing, the therapy itself is now an instrument tracking progress every second of every session. Stroke clients can get return of function months and years after their stroke, and often do not get the uninterrupted services they need during that time. The plan is for patients to take home a version of WeHab to continue therapy after their insurance-covered therapy time is exhausted. With reduced cost in-home therapy, patients may continue on the road to recovery. Simple, inexpensive, and patient-friendly WeHab is tipping the balance in favor of cost-effective healthcare.