



**INSTITUTE OF  
HEALTH ECONOMICS**  
ALBERTA CANADA

**GAME CHANGING OR DISRUPTIVE INNOVATION**  
**Analytical Framework and Background Study**

February 2011

## GAME CHANGING OR DISRUPTIVE INNOVATION – THIS PAPER

The purpose of this paper is to provide background information on "game changing innovations" in support of the February 24, 2011 conference *Becoming the Best: Building a Sustainable Health System – Game Changing Health Innovations*. It was developed by the Institute of Health Economics and funded by Alberta Health Services (AHS) as part of a future focused analysis of the health system examining drivers for health improvement and sustainability over the next 20 years. The initial target audience for this paper is the managers, policy makers and planners who are attending the conference, but it is of potential interest to others interested in the AHS initiative.

The paper is based on a limited search of the published and gray literature regarding disruptive innovations in health care. Rather than a comprehensive assessment, it is a selective review of material that will be most useful to managers in considering likely changes affecting health care over the next 20 years. A more extensive review of the literature will be developed as part of the project report later this year.

### PREPARED BY

This paper was prepared by:

John Rapoport, MA, PhD

Paul Chaulk, MSc

Robyn Kuropatwa BScN, MPA, MSc

Mary-Doug Wright BSc, MLS

**TABLE OF CONTENTS**

<b>PREPARED BY .....</b>	<b>i</b>
<b>GAME CHANGING OR DISRUPTIVE INNOVATION .....</b>	<b>1</b>
INTRODUCTION .....	1
DISRUPTIVE INNOVATION – THE FOUR BASIC ELEMENTS.....	1
TYPE OF MEDICAL CARE - CONTINUUM .....	2
TYPES OF BUSINESS MODELS.....	4
OTHER VIEWS OF DISRUPTIVE INNOVATION .....	5
LITERATURE REVIEW - OVERVIEW.....	6
DISRUPTIVE INNOVATION – SELECTED EXAMPLES FROM THE LITERATURE .....	9
<i>Disruption of Primary Care and Outpatient Physician Practice .....</i>	<i>9</i>
<i>Disruption of Hospital Care and Surgery.....</i>	<i>10</i>
<i>Imaging Innovations .....</i>	<i>11</i>
<i>Remote Patient Monitoring .....</i>	<i>12</i>
<i>Genomics, Personalized Medicine and Pharmacogenomics.....</i>	<i>12</i>
USING THE DISRUPTIVE INNOVATION FRAMEWORK WHEN ASSESSING INNOVATIONS .....	14
CONCLUSION.....	14
<b>REFERENCE LIST .....</b>	<b>15</b>

## GAME CHANGING OR DISRUPTIVE INNOVATION

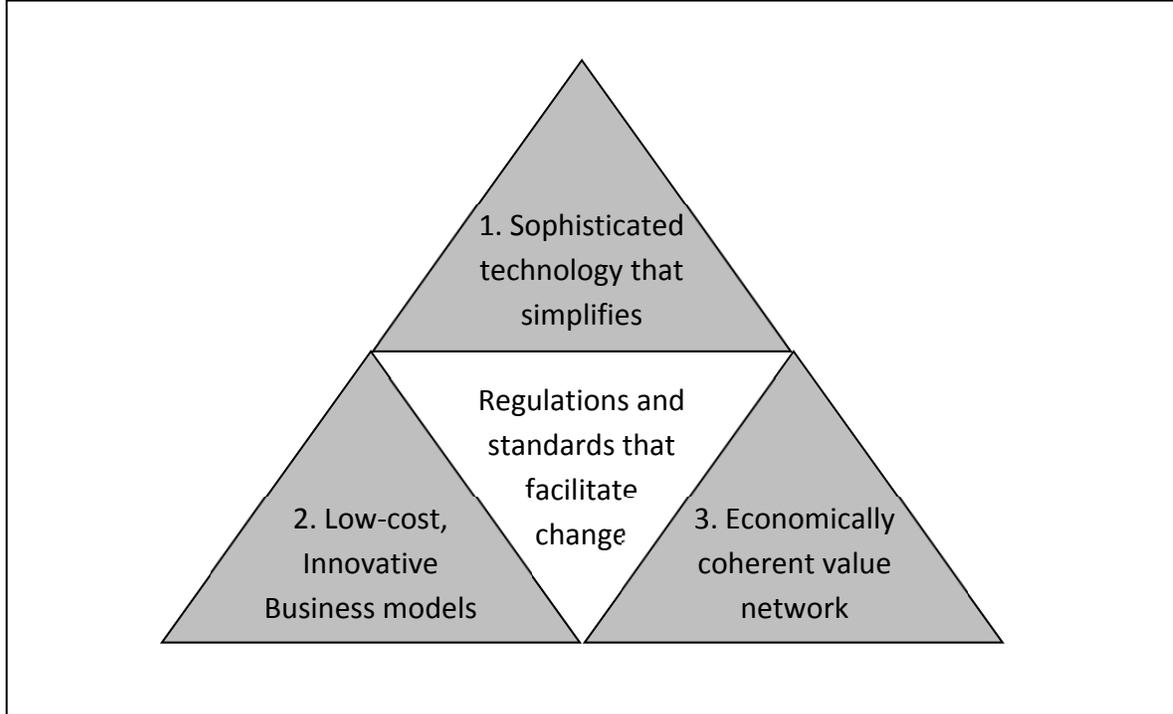
### INTRODUCTION

Disruptive innovation (the term generally used in the academic literature) or game changing innovation (the more informal term) has been the subject of much discussion in the recent literature on health care reform. Clayton Christensen of the Harvard Business School notes that disruptive innovation is an "agent of transformation" which transforms industries in a way that their product and services are more affordable and accessible and that people with less training and skill can make or use them.<sup>15</sup> Of course disruptive innovation is not the only type of innovation which can occur. Geoffrey Moore lists disruptive innovation as one of eight innovation types including also application innovation, product innovation, process innovation, experiential innovation, marketing innovation and business model innovation.<sup>49</sup> However, this review is limited to disruptive innovation and its applications to health care.

### DISRUPTIVE INNOVATION – THE FOUR BASIC ELEMENTS

The Christensen framework for disruptive innovation includes four basic elements, summarized in the following figure reproduced from his book. First, a change in technology occurs which is an enabler for a change in business model. Technology here is defined broadly, including not just machines or devices but methodology, scientific knowledge and anything else affecting the way production is carried out. Second, the emergence of the new business model disrupts the existing arrangements for providing a specific type of health care service. Business model in this context refers to the service delivery model but also the organization, financing and management of the unit delivering the service. The disruption may mean that existing providers carry out their functions in an entirely new way, e.g. by using personnel with different skill sets, new capital equipment and new forms of organization and management. Alternatively, entirely new types of providers may come into existence which disrupt and replace the previously existing organizations. Third, supporting networks such as equipment suppliers, providers of services, new types of funding mechanism or trainers of personnel must be put in place. Often it is not possible to disrupt just one part of the existing system but rather a whole series of inter-linked changes are needed. Finally, the exact way in which all this plays out is importantly dependent on the government regulations and policy environment relevant to health services.

Figure I.1 Model of Disruptive Innovation



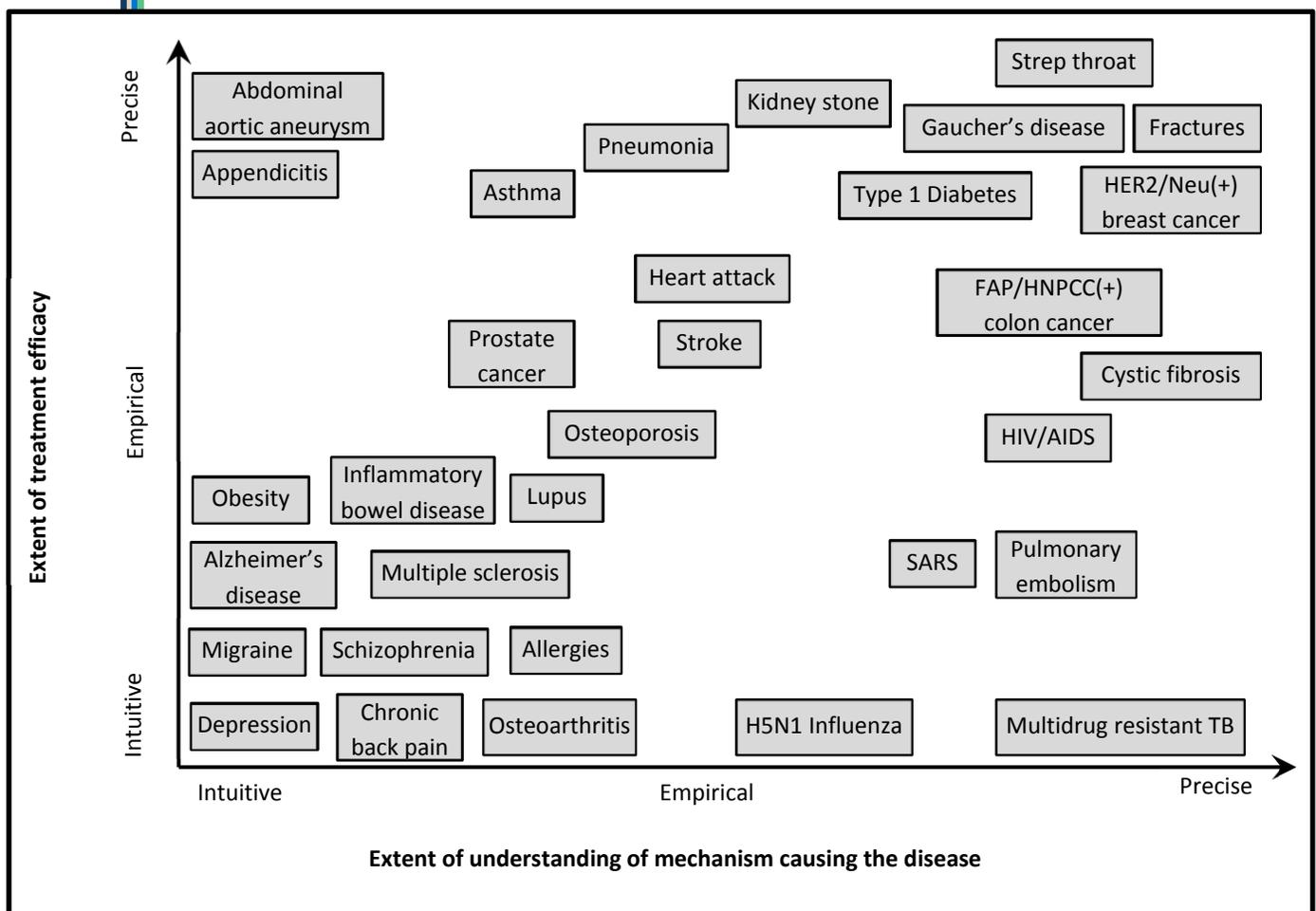
It is important to note that what makes an innovation disruptive is not just the magnitude of the advance. An innovation could represent a major scientific accomplishment but if it works to sustain the existing business model it is not considered to be disruptive. It is the change in business model from the existing one to a new one which is more efficient and/or better addresses the demands of consumers that is the key characteristic of disruptive innovation. Often it creates, as Pauly puts it, "new products of moderately lower quality and much lower cost". Pauly's view is that the legal system and the accepted type of public policy discussion have limited discussion of such alternatives.<sup>54</sup> Since these disruptions threaten the existing business model, those leading or profiting from the existing model are likely to oppose the innovation. Thus it is not surprising that established health care institutions such as hospitals, medical schools, and insurance companies and managed care organizations tend to fight the spread of disruptive innovations.<sup>14</sup>

### TYPE OF MEDICAL CARE - CONTINUUM

Changes in technology which are disruptive often change the way we understand and treat specific diseases. A clear example of this was the discovery that stomach ulcers are in fact caused by a bacterial infection. Before this discovery ulcers were treated with recommendations for lifestyle change, dietary changes and occasionally hospital care and surgery. After the disease was understood as a bacterial infection, drug treatment was clearly the treatment of choice. This is typical of the type of technological change which Christensen sees as an enabler for disruption. As he writes, such technology "routinizes the solution to problems that previously required unstructured processes of intuitive experimentation to resolve."<sup>15</sup>

Christensen sees type of medical care as falling along a continuum with “precision medicine” at one end and “intuitive medicine” at the other end. At the precision medicine end of the spectrum it is well known that a specific treatment works well and clear rules can be written to specify appropriate care. In intuitive medicine diseases are poorly understood and treatments are often trial and error. Empirical medicine which is in between is where evidence based medicine is appropriate; guidelines here can be developed based on existing knowledge about what works. The continuum idea can be applied to both diagnosis and treatment. The position of a particular disease need not be the same for each. The following diagram is used by Christensen to illustrate this. Abdominal aortic aneurysm is an example where the disease mechanism is poorly understood, but once diagnosis is made treatment is straightforward. Alternatively a diagnosis might be made with precision, but treatment efficacy is uncertain and choice of treatment has a significant intuitive component. The diagram indicates that SARS or HIV falls in this area. Fractures are in the precision medicine area for both diagnosis and treatment, while depression diagnosis and treatment are both intuitive medicine.

Figure 2.4 Current Map of Common Medical Conditions



## TYPES OF BUSINESS MODELS

The type of medical care is important because it largely determines the business model. Generic types of business models include the Solution Shop, the Value Added Process and the Facilitated Network.

A Solution Shop business model involves the application of expertise by intuitive methods to fairly unstructured problems. Each unit produced is essentially unique. The work of multiple specialists in an academic medical center diagnosing a rare disease would be an example.

A Value Added Process business model involves production of a specifically defined service in a structured way. After diagnosis, many surgical treatments are suitable for a value added process approach. Christensen argues that significant cost reductions are achieved by moving these treatments out of the general hospital to a separate organization. He cites as an example the Shouldice Hospital in Ontario which does only particular types of hernia operations and has lower costs and better results than other providers of this surgery.

The Facilitated Network business model is suggested to be most appropriate for dealing with some chronic diseases. Where lifestyle modification and self-care are important a network connecting patients with others with similar conditions can help them learn from each other and provide support. Alcoholics Anonymous is a long standing example but advances in communications technology enables creation of other such groups where members are geographically dispersed.

The three different types of business model are likely to have different funding mechanisms. For a Solution Shop there is great uncertainty at the outset about the production process and the outcome of the service. In this setting payment is likely to be based on inputs used. The traditional fee-for-service compensation of doctors and hospitals is this type of funding model. At the start of treatment, e.g. hospital admission or initial physician visit for a given complaint, the total cost is not known.

In a Value Added Process the production method and the outcome are well known in advance, sometimes to the extent that the provider can offer a guarantee of a specific outcome. Payment is likely to be a flat fee for a specific service. Prices can be posted and known in advance by both buyer and provider.

The provider in a Facilitated Network is offering to the member access to other members of the network. Payment for such access is likely to be in the form of a membership fee, i.e. a fee which entitles one to such access during a specified time period.

## OTHER VIEWS OF DISRUPTIVE INNOVATION

Several of the articles reviewed added a broader context of innovation. Omachonu and Einspruch agree with Christensen that disruptive innovations are those innovations that disorder old systems, create new players and markets while marginalizing old ones, and deliver dramatic value to those that successfully implement the innovation. They view the catalyst for innovation as an important question. Do new or existing problems require new technologies to solve them? Or is it the case that new and emerging technologies need to be assessed to determine which needs they can address? They categorized innovations as falling in one of four quadrants of the combination of new and existing services with new and existing technologies. For example, the application of a new technology to an existing service is one quadrant. They also propose two dimensions of health care innovation including the environmental dimension composed of organizational leadership, organizational culture, physician acceptance, partnerships, etc. and an operational dimension including patient satisfaction, effectiveness, safety, cost containment, etc. They also propose a list of questions to address when examining innovations.

Moore<sup>48</sup> places innovations within the life cycle of technology adoption. Disruptive innovation, application innovation (taking existing products to new markets) and product innovation (taking established innovations to a higher level) come earlier in the cycle whereas business model innovation (reframing an existing value proposition to the customer or reframing a company's existing role in the value chain) and structural innovation (capitalizing on disruption to restructure industry relationships) come at the end of the life cycle. Unfortunately, the deeper the organization is in the life cycle, the greater the tendency to return to its former course. To overcome this inertia, he concludes management must deconstruct old processes and organizations. However, the challenge is that the legacy work still needs to be done during this process.

Finally, Lindqvist and Ghazi characterize innovations by where they take place, the degree of novelty and the degree to which they create uncertainty among existing companies:

- Innovations can affect the component level as opposed to the whole system, the latter innovations creating greater difficulty for the existing companies or organizations to adapt.
- The degree of novelty distinguishes incremental innovations from more radical innovations though this could be different depending on whether it looks at the degree of change in the product versus the degree of change in the benefit derived from the product.
- Radical (as opposed to incremental) innovations tend to cause the most uncertainty among existing companies and customers as to whether to stay with the existing technology or adopt the new one.

As in Christensen, disruptive innovations are described as new market innovations or low-end innovations. However, they review other literature that suggest that top-down innovations can also be more expensive but deliver superior performance, gradually taking root through economies of scale. They review two criticisms leveled at the Christensen work, while noting its important contributions. One criticism is the vagueness of the definition. The second criticism is that the

Christensen model oversimplifies reality in that customers often taken into account many dimensions of a product when making their decision. They emphasize the importance of the perceived value by the consumer in addition to the actual performance level of the technology. Finally, they raise the question as to whether an innovation is disruptive if it does not take over the market or displace the incumbent firm.

In conclusion, while these articles offer additional insight and ways of assessing innovation, they are generally consistent with the Christensen model and all emphasize the importance of changes in the business model.

### **LITERATURE REVIEW - OVERVIEW**

The literature search was conducted during December 2010 and January 2011 and covered only English language sources. PubMed was searched first to develop and test search strategy for identifying peer-reviewed journal literature. Key databases were subsequently searched for additional academic literature.

Key concepts were searched in PubMed using MeSH (Medical Subject Headings) and text words. Other resources were searched using terminology appropriate to each resource, but based on terminology used for the PubMed search. It should be noted that the concept of game changing innovations is not well-indexed in any of the databases searched. Few subject headings were found for the specific concepts (game changers, disruptive technologies) and they were not uniformly applied; the search therefore relied heavily on text word searching of titles and abstracts.

The grey literature such as books, reports, and unpublished material was identified by searching a selection of relevant government, organization/association, think tank, and research institute websites, as well as library catalogues, grey literature repositories, and free Internet-accessible databases.

The literature review carried out by the IHE was limited to sources which dealt with disruptive innovation. That is, if the title or abstract specified disruptive innovation as a focus we included it. We also included sources which discussed disruptive innovation even if that specific terminology was not used by the authors. However, sources which were about technological innovations and had only a technical or clinical focus without any consideration of implications for health services organization were excluded.

The review included 113 published articles. The summary tabulations presented here rely just on the articles and the percentages may add up to more than 100% because an article may be categorized in more than one group. The articles classified as conceptual (about 20%) attempted to extend, modify, supplement or replace the Christensen analytical framework. They also included a few which critiqued the concept of disruptive innovation, either as a useful analytical construct, an accurate representation of trends in health care or a desirable path to follow. More than half of the articles (about 60%) described an innovation and argued that it was, or was likely to become, disruptive. Another large group of articles (about 40%) offered the author's thoughts in the form of

a general commentary and/or advice to particular groups on how to work in a world of disruptive innovation. Conspicuous by their relative absence were articles which relied on data to perform evaluations or assessment of innovations or to test hypotheses.

About one quarter) of the authors who considered specific innovations thought they would disrupt hospitals (and of course the doctors who work in them). About half of articles were about innovations that would disrupt outpatient physician practice. Smaller numbers of articles focused on disruption of pharmaceutical or medical/nursing education.

In terms of the type of clinical activity affected, about 15% of articles reviewed were relevant to diagnosis and about 25% related to treatment. Prevention and chronic disease management accounted for smaller groups of articles. Of course many articles were about technologies, e.g. electronic and communications innovations, which affected multiple areas since their initial effect was on health system integration and coordination.

The broad service categories and specific services various articles discussed as being disruptive innovation included:

#### **Patient Self Care**

- Health care Tourism<sup>67</sup>
- Social Media<sup>40</sup>

#### **Primary Care/Community Care**

- Retail clinics<sup>53, 8, 33, 61, 42</sup>
- Workplace clinics<sup>66</sup>
- E-Clinic for Drugs<sup>25</sup>
- Extension for Community Health Care Outcomes<sup>3</sup>
- Community Health Networks<sup>62</sup>
- Community Nursing Center<sup>2</sup>

#### **Diagnostic Imaging**

- MR guided focused ultrasound<sup>7</sup>
- Computing in radiology<sup>43</sup>
- Mobile computing platform in radiology<sup>51</sup>
- Picture Archiving and Communication<sup>13</sup>
- Imaging<sup>49</sup>
- Molecular Imaging<sup>37</sup>

### Personalized Medicine/Genomics

- Personalized medicine – genomics<sup>22, 10, 16, 5, 23</sup>
- Gene based vaccines<sup>41</sup>
- Genomics<sup>10, 65</sup>

### Hospital Based Care

- Single specialty hospital<sup>8</sup>
- Ambulatory surgery center<sup>8</sup>
- Operating room organization<sup>27</sup>
- Operating room of the future<sup>60</sup>
- Orthopedics (several technologies)<sup>32</sup>
- Pediatric Surgery<sup>74</sup>
- Surgery Type<sup>50</sup>
- Specific Procedures
  - Carotid artery stenting<sup>68</sup>
  - Drug eluting stents<sup>46</sup>

### Clinician/Providers – Scope of Practice

- Doctor of Nursing Practice degree<sup>34, 11</sup>
- Nurse practitioners<sup>35</sup>
- General Practice Physician with Special Clinical Interest<sup>6, 47</sup>
- Paramedic Expanded Scope<sup>63</sup>

### Telehealth/Telemedicine

- Remote Patient Monitoring<sup>17</sup>
- Telemedicine<sup>21, 1, 31</sup>

### ICT – Enabling Technologies

- Web based physician order entry<sup>72</sup>
- Informatics/communications technology<sup>71, 70, 28, 30, 73, 52, 36, 12, 58, 64, 39, 9, 44</sup>
- Instructional Technology<sup>26</sup>
- Wireless Technologies<sup>65</sup>
- Tracking Technology<sup>29, 4</sup>

## DISRUPTIVE INNOVATION – SELECTED EXAMPLES FROM THE LITERATURE

### Disruption of Primary Care and Outpatient Physician Practice

Several sources in the literature<sup>53, 8, 33, 42, 20, 56, 57</sup> identified retail clinics as an innovation disruptive of primary care physician practice. Such a clinic may be located at a mall, a drug store or retail store and is generally staffed by nurse practitioners. It offers to treat a specific list of common ailments with a flat price for each one. Conditions on such a list might include things like ear infections, wart removal, athlete's foot, allergies, seasonal flu vaccine, sinus infections and minor burns. It likely is open from early morning until late evening and takes patients as walk-ins without appointments.

The conditions treated by retail clinics are clearly toward the precision medicine end of the spectrum, i.e. can be effectively dealt with by a rule-based approach. This is the right condition for a value added process business model and the retail clinic is based on that. Patients who go to retail clinics typically know what they have and how to treat it. They are looking for a confirmation of their self-diagnosis and access to treatment in a way that is quicker and more convenient than making an appointment with a primary care physician. Many users of retail clinics in the United States do not have insurance coverage, lack a relationship with a primary care physician or for other reasons have restricted access to health care.<sup>53, 33</sup> A certain regulatory environment is necessary for this model to work. A jurisdiction that did not permit nurse practitioners to practice without close on-site physician supervision or payers who were not willing to pay for care from independent non-physician providers would constitute an environment hostile to retail clinics.

Retail clinics have been found to have lower cost than comparable treatment in physician offices<sup>45</sup> and it has been suggested that many visits that now take place in emergency departments could be managed at retail clinics<sup>69</sup>. While retail clinics are in most cases an alternative business model which has been instituted by entirely new provider organizations, typically a venture-backed for-profit company, there have been some moves by hospitals to affiliate closely with established retail clinics or to start their own.<sup>38, 24</sup> A variant of the retail clinic, the workplace clinic, has some of the same potential to disrupt physician primary care. Clinics in the workplace have been started by employers in an attempt to contain health care costs and have met with some acceptance although not widespread adoption.<sup>66</sup>

Another innovation frequently mentioned as disruptive to primary care physician practice was the medical home. There are many different variants of the medical home model but a typical definition would be the following: "In a medical home model primary care clinicians and allied professionals provide conventional diagnostic and therapeutic services as well as coordination of care for patients that require services not available in primary care settings. The primary care clinicians serve as advocates for patients and are paid to coordinate their care thus averting unnecessary tests and procedures, hospital admissions, and avoidable complications."<sup>18</sup> Another aspect of the medical home often emphasized is that care is continuous and provided to a person at all stages of life.<sup>75</sup>

The retail clinic and the medical home both share a goal of improving access to care and both include non-physician providers as part of team based care. The retail clinic is a disruptive innovation which is mostly external to existing organizations while the medical home is a change in the business model within the existing structure of a physician practice. Both claim to be "patient-centered", although as Pollack et al. note they mean different things by this term: "In the medical home patient-centeredness focuses on shared decision making and addressing the multifaceted needs of patients. For retail clinics, patient-centeredness relies on convenience, where care is provided in consumer friendly locations, with extended hours and no appointments."<sup>55</sup>

### **Disruption of Hospital Care and Surgery**

Various surgical technologies were mentioned as disruptive by articles reviewed. Often computer guided imaging or surgical devices were associated with these innovations. Laser eye surgery (LASIK laser-assisted in situ keratomileusis) is perhaps the best known example. It clearly disrupted hospitals by moving many eye operations to the Value Added Process model of the outpatient eye surgery center from the Solution Shop model of the hospital surgery department. Not only did the physical location change however. The resources needed in terms of equipment, the skill sets of the surgeons and support staff, the costs and outcomes, the time required of patients all are different. Much less surgical skill is needed for LASIK than for the procedure it replaced. As Christensen puts it surgical skills are in effect "embedded in the machine". One implication is that profits flow more to the machine makers than to the physicians.

Of course one of the most disruptive changes to surgery is when the need for surgery itself is eliminated. Christensen points out that at one time much surgery was exploratory surgery, done for purposes of diagnosis.<sup>15</sup> Advances in imaging technology have largely eliminated the need for exploratory surgery. Also noninvasive technologies can substitute for surgery in treatment. For example, Bradley identifies magnetic guided resonance focused ultrasound as a substitute for surgery in treatment of many types of tumors.<sup>7</sup>

Hansen and Bozic identify several innovations in which they argue are disruptive because they address the lower quality end of the field and reduce cost considerably. Mobile fluoroscopic imaging systems do not provide as good an image as some other systems but can be used easily in emergency departments and physicians' offices for less complicated procedures. For appropriate procedures this does enable a change in the location of care. It also changes the mix of providers used in that the surgeon can take and interpret the images without the aid of a radiologist or radiologic technician. It is interesting that in this case the innovation was in imaging but it served as an enabler for the disruption of orthopedic surgery practice. (Disruptive aspects of mobile imaging are further discussed below in the section on imaging innovation). They also mention increased use of ambulatory surgery centers and nurse practitioners or physician assistants as disruptive to orthopedic practice.<sup>32</sup>

Some sources which mentioned innovations disruptive for surgery emphasized the coming needs for changes in the skill sets of surgeons. If this is the only change, however, it might be questioned

whether the innovation is actually disruptive in the sense of a change in the business model. Satava argues that as robotic surgery and image guided therapy come into wider use, it will be important for surgeons to be grounded in the science of systems integration.<sup>50</sup> Also organizational changes in the way surgery is organized can have important impacts. Girotto et al.<sup>27</sup> report on a change in the hierarchical organization to reduce costs and increase patient through-put. Since this did not change the basic business model or create any new organization, it might more properly be characterized as an innovation which sustains the existing model of hospital-based surgery.

### **Imaging Innovations**

As noted above, advances in imaging technology have largely eliminated the need for exploratory surgery and have disrupted the skill set required and location where surgery is performed. Christensen et al also note that advances in imaging technology can also disrupt existing centralized imaging practices. Advances in hand-held or portable imaging can disrupt centralized diagnostic imaging units in hospitals that require sophisticated expertise and where patients must be taken to the centralized location. New imaging diagnostics can allow the point of care to shift to clinics, offices, and ultimately homes. These advances were seen to hold the potential to greatly improve the throughput of emergency departments, where waits for diagnostic imaging comprise much of the time spent by patients.

One example of a disruptive imaging innovation is mini-fluoroscans or mini-C-arms, which are mobile fluoroscopic imaging systems designed for point of service, real-time imaging for orthopedic care. They do not offer the same image quality as full scale fluoroscopy or digital radiography but are lower in cost and easier to use<sup>32</sup>, while not appropriate for many complex procedures; they are adequate for less complicated interventions. This illustrates one of the common mechanisms of disruptive innovation, an innovation that initially disrupts the lower end of the existing spectrum of care by offering a lower cost, more convenient alternative. By doing so they also cut down on time and money spent on the wait for traditional centralized imaging. They also increase the autonomy of the orthopedic surgeon while reducing the need for radiology technicians.

Looking forward, molecular imaging is a complex of technologies that is predicted to diffuse into clinical practice over the next 10 to 20 years.<sup>37</sup> One current example is FDG-PET ([<sup>18</sup>F]-fluorodeoxyglucose (FDG) positron emission tomography) scanning that scans for increased metabolic activity accompanying malignancy. Molecular imaging is seen to be disruptive to current models of radiologic practice in regards to who performs imaging. This technology could disrupt individual or group radiology practice in favors of a multidisciplinary model requiring radiologists to collaborate with teams of chemists, physicists and non-radiologist physicians. Molecular imaging is not a lower cost, lower quality disruptive innovation. Rather, it is an example of a top-down innovation that is more expensive but delivers superior performance, gradually taking root through economies of scale.

## Remote Patient Monitoring

Remote patient management was identified as an innovation disrupting the current management of chronic diseases.<sup>17</sup> Developments in enabling technology for physiologic monitoring and telecommunications have made it possible to provide information about a patient's current status to care providers who are at a different location than the patient and at a time different from when the measurement was taken, disrupting real time, in-person clinician-patient interactions in hospitals, home care, etc. It further disrupts the usual business model for care of chronic disease in hospitals and primary care by shifting some responsibilities to the patient and non-clinical providers. Savings from decreased use of emergency departments, inpatient hospital care, skilled nursing facilities, and reduced home care staff travel can result.

## Genomics, Personalized Medicine and Pharmacogenomics

Genomics, personalized medicine and pharmacogenomics, although early in development, were identified as being disruptive.<sup>16, 10, 23, 5</sup> With the possibility of sequencing a person's entire genome for \$1000,<sup>22</sup> genome data is available to all people within and outside of the health system.

Downing states it is now feasible to consider strategic application of genomic information to guide patient management by being predictive, pre-emptive and preventive and enabling patient participation in medical decisions.<sup>22</sup>

Personalized medicine within the context of genomics is defined by different authors as focused on diagnoses and interventions<sup>22</sup>, tailored interventions to individual variation in risk and treatment response<sup>16</sup>, stratified or segmenting the population into sub-groups based on hereditary risk of a disease occurrence recurrence and likelihood of treatment response or somatic changes in tissue, most often a tumor.<sup>16</sup> Willard had the most specific definition of "the delivery of health care in a manner that is informed by each person's unique clinical information; genetic, genomic and other molecular biological characteristics and environmental influences."<sup>22</sup>

The goals of personalized medicine are to take advantage of molecular understanding of disease, combined with other individual factors, to optimize preventive health care strategies while people are still well or at the earliest stages of disease.<sup>22</sup> Carlson writes that over the next 10 to 20 years genomics in health care practice should take primarily three forms<sup>10</sup>:

- Personalization: Earlier intervention with potent effective drugs, devices and treatments targeted by more actionable diagnostics.
- Prediction: Disease and clinical risk management programs focused on lifestyle calibrations and based on increasingly granular and individualized risk data
- Prevention: Public health and preventive clinical initiatives informed by epigenetic environment/behavior/gene interactions for example to address the causes rather than the symptoms of diabetes and obesity.

Downing goes even further to argue that it is personalized medicine (diagnoses and treatment) in combination with personalized health care which includes greater public awareness, involvement of the public in policy development, growing use of information and communication technology and social networking that will result in wide-ranging and disruptive change for the community.

Conti's<sup>16</sup> description of how pharmacogenomics have changed the use of Warfarin, a common blood thinner used to prevent the formation and migration of blood clots, is a clear example of personalized medicine where drugs and/or drug combinations are optimized for each individual's unique genetic make-up.

Warfarin is number two among drugs associated with emergency room visits in the United States. The probability of major bleeding is approximately 2.5 percent per year or higher and minor bleeding event rates have been as high as 36 percent per year. The majority of all patients who have experienced bleeding events during the first 28 days on Warfarin have been discovered to have a specific gene variant. These gene variants account for more variability in dosing than do age, gender and weight taken together. These findings have resulted in the approach to determining the patient specific use and dosage of Warfarin, a move along the continuum from intuitive toward precision medicine.

Oncology has achieved a number of genomic advances in stratified therapeutics and diagnostic tests. Insights into tumor biology have led to new clinical strategies to be used in combination with traditional chemotherapy.<sup>16</sup> Across clinical neurosciences, many advances are being made toward understanding the biological underpinning of diseases such as neurodegenerative disorders, neuropsychiatric conditions, addiction and developmental disorders.<sup>22</sup> Drews states that although sensationally rapid developments in the fields of population genomics and pharmacogenomics are not likely, there can be little doubt that these will have deep influence on medicine and drug therapy.<sup>23</sup>

The discussion of who will be disrupted varies across the authors. Carlson<sup>10</sup> argues that due to personalization, the increasing capacity to identify differences in individuals and the need to target their specific treatment, there would be no need for generalists, only proliferating categories of specialists. The ability to understand the causes of current diseases such as heart disease, Alzheimer's and schizophrenia would move from intuitive to precision based clinical diagnoses and targeted treatments represent moves toward precision therapy.

Personalization, prediction and prevention could each result in shifts across the business models. Prediction and prevention strategies to identify risk factors and address the cause rather than the symptoms of diabetes or obesity would foster targeted, personalized, risk reduction programs. In these cases, the clinical service business model may move from solution shops to value added processes or to a combination of value added and facilitated network business model.

It is interesting to note that all authors identified and discussed challenges and enablers that need to be in place for the benefits identified from genomics in health care practice to be achieved. These included key infrastructure to support clinicians using detailed clinical data, public policy which supports the development of more personalized medicine, improved clinical knowledge from research which involves recovering useful information from medical practice, education and training of health care providers in many disciplines to understand the patient care objectives of personalized medicine and robust information technology to support data capture, interoperability and information exchange.

### **USING THE DISRUPTIVE INNOVATION FRAMEWORK WHEN ASSESSING INNOVATIONS**

The application of the disruptive innovation conceptual framework by health system managers might be aided by an attempt to answer the following series of questions when a new technological or delivery model innovation is being considered:

- Does it change the position of diagnosis or treatment of disease on the continuum from precision medicine to intuitive medicine?
- What is the current business model for provision of the service (Solution Shop, Value Added Process or Facilitated Network)?
- What is the business model likely to arise after the innovation is adopted?
- How are the skill sets needed by providers changed by the innovation? Are changes in training needed to provide a suitable labor supply?
- Is the legal, social and cultural environment consistent with, and supportive of, the new business model?
- How well do the existing business model and the likely new business model address specific consumer demands? Is "moderately lower quality and much lower cost" an attractive option?
- Is the new business model likely to be introduced within existing organizations or within new organizations?
- Are there suppliers of equipment, supporting or complementary services, needed by the new business model which do not now exist?
- Is the existing funding mechanism consistent with the new business model?

### **CONCLUSION**

The answers to these questions should make it easier to figure out the likely sources of support or opposition to the adoption of the new innovation. They should also, when combined with other information, help guide the policy discussions of what posture the health system should have toward the new innovation e.g. adopt it system wide, adopt it on a limited or trial basis, resist its adoption, take a neutral stance and let actors outside the existing system guide its development.

## REFERENCE LIST

1. Aas IH. The future of telemedicine--take the organizational challenge! *Journal of Telemedicine and Telecare*. 2007; 13(8):379-81.
2. Anderko L, Lundeen S, Bartz C. The Midwest Nursing Centers Consortium Research Network: translating research into practice. *Policy Politics & Nursing Practice*. 2006 May; 7(2):101-9.
3. Arora S. Kalishman S. Thornton K. Dion D. Murata G. Deming P. Parish B. Brown J. Komaromy M. Colleran K. Bankhurst A. Katzman J. Harkins M. Curet L. Cosgrove E. Pak W. *Expanding access to hepatitis C virus treatment--Extension for Community Healthcare Outcomes (ECHO) project: disruptive innovation in specialty care*. *Hepatology*. 52(3):1124-33, 2010 Sep.
4. Baldwin LP, Low PH, Picton C, Young T. The use of mobile devices for information sharing in a technology-supported model of care in A&E. *International Journal of Electronic Healthcare*. 2007; 3(1):90-106.
5. Benner M. Catching up in pharmaceuticals: Government policies and the rise of genomics. *Australian Health Review*. 2004 Nov 8; 28(2):161-70.
6. Boggis AR, Cornford CS. General Practitioners with special clinical interests: a qualitative study of the views of doctors, health managers and patients. *Health Policy*. 2007 Jan; 80(1):172-8.
7. Bradley WG Jr., MR-guided focused ultrasound: a potentially disruptive technology. [Review] [12 refs]. *Journal of the American College of Radiology*. 6(7):510-3, 2009 Jul.
8. Burns LR, David G, Helmchen LA. Strategic response by providers to specialty hospitals, ambulatory surgery centers, and retail clinics. *Population Health Management*. 2010 Nov 23.
9. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. *Journal of American Medical Association*. 2006 Sep; 13(5):547-56.
10. Carlson RJ. The disruptive nature of personalized medicine technologies: implications for the health care system. *Public Health Genomics*. 12(3):180-4, 2009.
11. Chase SK, Pruitt RH. The practice doctorate: innovation or disruption? *Journal of Nursing Education*. 2006 May; 45(5):155-61.
12. Cheek P, Nikpour L, Nowlin HD. Aging well with smart technology. *Nursing Administration Quarterly*. 2005 Oct; 29(4):329-38.
13. Chen J, Bradshaw J, Nagy P. Has the Picture Archiving and Communication System (PACS) Become a Commodity? *Journal of Digital Imaging*. 2010 Apr 24.
14. Christensen CM, Bohmer R, Kenagy J. Will disruptive innovations cure health care? *Harvard Business Review*. 2000 Sep; 78(5):102-12, 199.

15. Christensen C, Grossman J, Hwang J. *The innovator's prescription: a disruptive solution for health care*. McGraw Hill 2009.
16. Conti R, Veenstra DL, Armstrong K, Lesko LJ, Grosse SD. Personalized medicine and genomics: Challenges and opportunities in assessing effectiveness, cost-effectiveness, and future research priorities. *Medical Decision Making*. 2010 May; 30(3):328-40.
17. Coye MJ, Haselkorn A, DeMello S. Remote patient management: technology-enabled innovation and evolving business models for chronic disease care. *Health Affairs (Millwood)*. 2009 Jan; 28(1):126-35.
18. Deloitte Center for Health Solutions. The medical home: disruptive innovation for a new primary care model 2008. Available from: [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us\\_chs\\_MedicalHome\\_w.pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_chs_MedicalHome_w.pdf)
19. Deloitte Center for Health Solutions. Social networks in health care: communication, collaboration and insights 2010. Available from: [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/US\\_CHS\\_2010SocialNetworks\\_070710.pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/US_CHS_2010SocialNetworks_070710.pdf)
20. Deloitte Development disruptive innovations in health care. Available from: [http://www.deloitte.com/view/en\\_US/us/Industries/health-plans/Center-for-Health-Solutions-Health-Plans/disruptive-innovations/index.htm](http://www.deloitte.com/view/en_US/us/Industries/health-plans/Center-for-Health-Solutions-Health-Plans/disruptive-innovations/index.htm)
21. Doarn CR. Telemedicine in tomorrow's operating room: a natural fit. *Seminars in Laparoscopic Surgery*. 2003 Sep; 10(3):121-6.
22. Downing GJ. Policy perspectives on the emerging pathways of personalized medicine. *Dialogues in Clinical Neurosciences*. 2009; 11(4):377-87.
23. Drews J. Strategic trends in the drug industry. *Drug Discovery Today*. 2003 May 1; 8(9): 411-20.
24. Ferris AH, McAndrew TM, Shearer D, Donnelly GF, Miller HA. Embracing the convenient care concept. *Postgraduate Medicine*. 2010 Jan; 122(1):7-9.
25. Fox N, Ward K, O'Rourke A. The birth of the e-clinic. Continuity or transformation in the UK governance of pharmaceutical consumption? *Social Science & Medicine*. 2005 Oct; 61(7):1474-84.
26. Gibson CC. When disruptive approaches meet disruptive technologies: learning at a distance. *Journal of Continuing Education in the Health Professions*. 2000; 20(2):69-75.
27. Girotto JA, Koltz PF, Drugas G. Optimizing your operating room: Or, why large, traditional hospitals don't work. *International Journal of Surgery*. 2010; 8(5):359-67.
28. Goldstein MM, Rothstein MA. Information technology is considered a potentially transformative element in the field of health care by purchasers, regulators, providers, vendors, and consumers alike. Introduction. *Journal of Law, Medicine & Ethics*. 38(1):6, 2010.

29. Gorsha N, Stogoski J. Transforming emergency care through an innovative tracking technology: an emergency department's extreme makeover. *Journal of Emergency Nursing*. 32(3):254-7, 2006 Jun.
30. Goth G. A game changer? As Google and Microsoft put their PHR plays into action, CIOs formulate their next moves. *Healthcare Informatics*. 2008 Jul; 25(7):52-4.
31. Halamandaris VJ. Telemedicine revolution makes the home the center of health care. *Caring*. 2004 Jul; 23(7):52-5.
32. Hansen E, Bozic KJ. The impact of disruptive innovations in orthopaedics. *Clinical Orthopaedics and Related Research*. 2009 Oct [cited 2010 Dec 27]; 467(10):2512-20. Available from: [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2745460/pdf/11999\\_2009\\_Article\\_865.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2745460/pdf/11999_2009_Article_865.pdf)
33. Hansen-Turton T, Ryan S, Miller K, Counts M, Nash DB. Convenient care clinics: The future of accessible health care. *Disease Management*. 2007 Apr; 10(2):61-73.
34. Hathaway D, Jacob S, Stegbauer C, Thompson C, Graff C. The practice doctorate: perspectives of early adopters. *Journal of Nursing Education*. 2006 Dec; 45(12):487-96.
35. Heidesch T. Disruptive innovation. NPs are true health care reformers. *Journal of Advanced Nursing Practice*. 2008 Dec; 16(12):94.
36. Hillestad R, Bigelow J, Bower A, Girosi F, Meili R, Scoville R, et al. Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Affairs (Millwood)*. 2005 Sep; 24(5):1103-17.
37. Hillman BJ. The diffusion of new imaging technologies: a molecular imaging prospective. *Journal of the American College of Radiology*. 2006 Jan; 3(1):33-7.
38. Kaissi A. Hospital-affiliated and hospital-owned retail clinics: Strategic opportunities and operational challenges. *Journal of Healthcare Management*. 2010 Sep;55(5):324-37
39. Kamel Boulos MN, Wheeler S. The emerging Web 2.0 social software: an enabling suite of sociable technologies in health and health care education. *Health Information Library Journal*. 2007 Mar; 24(1):2-23.
40. Kane GC, Fichman RG, Gallagher J, Glaser J. Community relations 2.0. *Harvard Business Rev*. 2009 Nov; 87(11):45-50, 132.
41. Kaslow DC. A potential disruptive technology in vaccine development: gene-based vaccines and their application to infectious diseases. [Review] [15 refs]. *Transactions of the Royal Society of Tropical Medicine; Hygiene*. 98(10):593-601, 2004 Oct.
42. Kissinger M. Retail health clinics drive innovation into primary care practices. *Journal of Medical Practice Management*. 2008 Mar; 23(5):314-9.
43. Levy F. Computers and the supply of radiology services: anatomy of a disruptive technology. *Journal of the American College of Radiology*. 5(10):1067-72, 2008 Oct.

44. Lymberis A, Olsson S. Intelligent biomedical clothing for personal health and disease management: state of the art and future vision. *Telemedicine Journal and E-Health*. 2003; 9(4):379-86.
45. Mehrotra A, Liu H, Adams JL, Wang MC, Lave JR, Thygeson NM, et al. Comparing costs and quality of care at retail clinics with that of other medical settings for 3 common illnesses. *Annals of Internal Medicine*. 2009 Sep 1; 151(5):321-8.
46. Michaelis L, Vaul J, Chumer K, Faul M, Sheehan L, DeCerce J. Disruptive technology: new medical advances are troublesome for even the most successful health systems and innovator health companies. *Journal of Cardiovascular Management*. 15(2):9-12, 2004 Mar-Apr.
47. Moffat MA, Sheikh A, Price D, Peel A, Williams S, Cleland J, et al. Can a GP be a generalist and a specialist? Stakeholders views on a respiratory General Practitioner with a special interest service in the UK. *BMC Health Services Research*. 2006; 6:62.
48. Moore GA. Darwin and the demon: Innovating within established enterprises. *Harvard Business Review*. 2004 Jul; 82(7-8):86-92, 187.
49. Potchen EJ, Clarke B. Transformative technology: a conversation with E. James Potchen and Bill Clarke. Interview by John K. Inglehart. *Health Affairs*. 26(2):w227-35, 2007 Mar-Apr.
50. Satava RM. Disruptive visions: A robot is not a machine...Systems integration for surgeons. *Surgical Endoscopy*. 2004 Apr; 18(4):617-20.
51. Shih G, Lakhani P, Nagy P. Is android or iPhone the platform for innovation in imaging informatics? *J Digit Imaging [Internet]*. 2010 Feb [cited 2010 Dec 24]; 23(1):2-7. Available from: [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2809941/pdf/10278\\_2009\\_Article\\_9242.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2809941/pdf/10278_2009_Article_9242.pdf).
52. Smith SP, Barefield AC. Patients meet technology: the newest in patient-centered care initiatives. *Health Care Management (Frederick)*. 2007 Oct; 26(4):354-62.
53. Paterick ZR, Pradhan SR, Paterick TE, Waterhouse BE. Changing perspectives in medical practice: disruptive innovation. *Journal of Medical Practice Management*. 24(5):290-2, 2009 Mar-Apr.
54. Pauly MV. We aren't quite as good, but we sure are cheap': prospects for disruptive innovation in medical care and insurance markets. *Health Affairs*. 27(5):1349-52, 2008 Sep-Oct.
55. Pollack CE, Gidengil C, Mehrotra A. The growth of retail clinics and the medical home: Two trends in concert or in conflict? *Health Affairs (Millwood)*. 2010 May; 29(5):998-1003.
56. Practice for patients' Vol. 1 Iss. 3. Available from: [http://www.innosight.com/documents/Innosight\\_Practice\\_for\\_Patient.PDF](http://www.innosight.com/documents/Innosight_Practice_for_Patient.PDF)
57. Proceedings of the California HealthCare Foundation/Health Affairs Roundtable "Retail Clinics: Disruptive Innovation in Primary Care?" 2008 May Available from: <http://www.chcf.org/~media/Files/PDF/H/PDF%20HARoundtableRetailClinics.pdf>

58. Ralston JD, Martin DP, Anderson ML, Fishman PA, Conrad DA, Larson EB, et al. Group health cooperative's transformation toward patient-centered access. *Medical Care Research and Review*. 2009 Dec; 66(6):703-24.
59. Rohrer JE, Angstman KB, Bartel GA. Impact of retail medicine on standard costs in primary care: A semi-parametric analysis. *Population Health Management*. 2009 Dec;12(6):333-5
60. Satava RM. The operating room of the future: observations and commentary. *Seminars in Laparoscopic Surgery*. 2003 Sep; 10(3):99-105.
61. Schulman KA, Vidal AV, Ackerly DC. Personalized medicine and disruptive innovation: implications for technology assessment. *Genetics in Medicine* . 2009 Aug; 11(8):577-81.
62. Steiner BD, Denham AC, Ashkin E, Newton WP, Wroth T, Dobson LA, Jr. Community care of North Carolina: improving care through community health networks. *Annals of Family Medicine*. 2008 Jul; 6(4):361-7.
63. Stirling CM, O'Meara P, Pedler D, Tourle V, Walker J. Engaging rural communities in health care through a paramedic expanded scope of practice. *Rural Remote Health*. 2007 Oct; 7(4):839.
64. Swendeman D, Rotheram-Borus MJ. Innovation in sexually transmitted disease and HIV prevention: internet and mobile phone delivery vehicles for global diffusion. *Current Opinion in Psychiatry*. 2010 Mar; 23(2):139-44.
65. Topol EJ. Transforming medicine via digital innovation. *Science Translational Medicine*. 2(16):16cm4, 2010 Jan 27.
66. Tu HT, Boukus ER, Cohen GR. Workplace clinics: A sign of growing employer interest in wellness. *Research Briefs*. 2010 Dec (17):1-16.
67. Underwood HR, Makadon HJ. Medical tourism: game-changing innovation or passing fad? *Healthcare Financial Management Articles*. 2010 Sep; 64(9):112-4, 116, 118.
68. Veith FJ. Perspective: carotid stenting and the history of disruptive technology in vascular surgery. *Seminars in Vascular Surgery*. 2008 Jun; 21(2):115-6.
69. Weinick RM, Burns RM, Mehrotra A. Many emergency department visits could be managed at urgent care centers and retail clinics. *Health Affairs (Millwood)*. 2010 Sep;29(9):1630-6
70. Westbrook JI, Braithwaite J. Will information and communication technology disrupt the health system and deliver on its promise? *The Medical Journal of Australia*. 2010 Oct 4; 193(7):399-400.
71. Westbrook JI, Braithwaite J, Gibson K, Paoloni R, Callen J, Georgiou A, et al. Use of information and communication technologies to support effective work practice innovation in the health sector: A multi-site study. *BMC Health Services Research*. 2009 [cited 2010 Dec 27]; 9:201. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2776590/pdf/1472-6963-9-201.pdf>.

72. Windle J, Van-Milligan G, Duffy S, McClay J, Campbell J. Web-based physician order entry: an open source solution with broad physician involvement. *AMIA Annual Symposium Proceedings [Internet]*. 2003 [cited 2010 Dec 24]:724-7. Available from: [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1480193/pdf/amia2003\\_0724.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1480193/pdf/amia2003_0724.pdf).
73. White RE. Health information technology will shift the medical care paradigm. *Journal of General Internal Medicine*. 2008 Apr [cited 2010 Dec 27];23(4):495-9. Available from: [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2359518/pdf/11606\\_2007\\_Article\\_394.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2359518/pdf/11606_2007_Article_394.pdf).
74. Ziegler MM. The innovation of success: the pediatric surgery and APSA response to “disruptive technologies”. *Journal of Pediatric Surgery*. 2009 Jan; 44(1):1-12.
75. Academy Health Research Insights. Medical Homes and Accountable Care Organizations: If We Build It, Will they come? Genesis of This Brief: Academy Health’s 2009 Annual Research Meeting. 2009. Available from: <http://www.academyhealth.org/files/publications/RschInsightMedHomes.pdf>