Review of 2013-2014 Mobile Medical Applications: Regulatory Challenges and Precedents

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Abstract

The primary objective of this article is to offer a review of the regulation of mobile medical applications, and the most important changes that happened in this sector in 2013 and 2014. Furthermore, this project aims to provide the companies' point of view on these regulation guidelines.

For this report, we interchange "mobile medical apps" and "mHealth" (mobile health), which the World Health Organization defines as "the practice of medical and public health through the usage of mobile devices" (Stroux, 2012). In the context of this article, a mobile device may be a mobile phone, patient monitoring devices, personal digital assistant or other wireless devices.

We start with a review of the regulation of these devices in the United States, and look to European Union regulations as a parallel system. 2013 was a significant year in this area due to the publication of important guidelines about regulation and classification of mobile apps as medical devices. We further discuss how developers look at requirements of safety and efficiency, and how they assess these outcomes. Next, we explore the value proposition of mobile medical applications. Finally, we examine three case studies of mobile medical applications; one intended for imaging diagnostics, called ResolutionMD[TM], by Calgary Scientific Inc.; another, MyVisonTrack[TM], by Virtual Art and Science, Inc.; and a third, currently unregulated application from GN ReSound called ReSound Smart[TM].

The information for this project was mainly gathered using secondary research. We used databases, medical, business and mobile health reports, medical journals, and medical and mobile health websites to conduct this research. The time frame for data was mainly between 2010 and 2014, with only one reference each from 2002, 2004, and 2008.

As the world becomes increasingly mobile and moves to a value-based healthcare system, mobile medical applications offer a huge opportunity to provide cost-effectiveness, patient empowerment, and good health outcomes. 2013 and 2014 were significant years for the first steps of the regulatory agencies towards more structured guidance on this matter, but health application developers seemingly have yet to fully understand

the importance of providing safer, more efficient apps to patients and providers with respect to FDA guidelines.

Regulation

A. Regulation by FDA

As the use of mobile platforms in the United States has proliferated in recent years, there has been a concomitant boom in mobile health and wellness applications. With these applications growing in number and complexity, the FDA's regulatory authority has had to keep pace with technological innovation in order to mitigate risks to public and individual health. While the FDA does not have an overarching software policy, the agency has nevertheless issued a series of regulatory policies to address the burgeoning mHealth space. These policies are formally listed in the FDA's 2013 final guidance document, titled "Mobile Medical Applications: Guidance for Industry and Food and Drug Administration Staff" ("Mobile medical," 2013).

A November 2013 MobiHealthNews report puts the number of mHealth apps registered with or cleared by the FDA at 103 ("Analysis: 103," 2011). The report further observes that roughly 24 mHealth apps either registered as Class I devices or were cleared as Class II devices with the FDA in 2013 ("Analysis: 103," 2011). The only mHealth app to date to receive pre-market approval as a Class III device is Micromedical's PocketView ECG software, which was cleared in 2002. Although PocketView ECG's regulatory history is outside the scope of this review, the limited number of Class III mobile medical apps in general is somewhat unsurprising given the "onerous" process of seeking a pre-market approval for a Class III mobile medical app ("In-Depth: Digital," 2014).

Moreover, the barriers to receiving FDA listings as Class I or Class II devices partially explain the relatively few (103) mobile apps with FDA approval, compared to the roughly 100,000 existing mobile apps targeting health and wellness. Of course, the majority of mHealth apps are unregulated simply because they do not meet the definition of a medical device, not because developers are averse to regulation. These unregulated apps are discussed later in section A.3.

A.1 Guidelines for FDA Regulation

The FDA final guidance document states that the FDA aims only to extend its regulatory authority to mobile apps that meet the definition of a medical device under section 201(h) of the Federal Food, Drug, and Cosmetic Act and whose intended use is either:

-To be used as an accessory to a regulated mobile medical device; or
-To transform a mobile platform into a regulated device.

Consistent with FDA regulation for traditional medical devices, a mobile medical app's intended use governs its classification as a device. For example, a mobile app intended to use a mobile platform's built-in camera to communicate visual diagnostic information to a care provider would be considered a medical device, whereas a similar camera app intended for non-medical purposes, such as Instagram, would not. Also consistent with regulatory precedent, FDA targets mobile medical apps "whose functionality could pose a risk to a patient's safety if the mobile app were to not function as intended" ("Mobile medical," 2013).

The final guidance document organizes mobile medical apps into three buckets: apps the FDA will regulate, apps the FDA will not regulate, and apps the FDA will not regulate now but may exercise its enforcement discretion in the future ("Mobile medical," 2013).

A.2 Apps FDA will regulate

In its final guidance document (2013), the FDA describes three pathways for a mobile app to fall under its regulatory oversight:

i. "Mobile apps that are an extension of one or more medical devices by connecting to such devices for purposes of controlling the devices or displaying, storing, analyzing, or transmitting patient-specific medical device data."

Mobile apps in this category are regulated because they "control the operation or function" of a medical device and are thus medical devices themselves ("Mobile medical," 2013). Examples of such apps are those that control the settings of implantable neuromuscular stimulators, the calibration of cochlear implants, the inflation and deflation of blood-pressure cuffs, or that serve as remote controls for CT or X-ray machines ("Mobile medical," 2013).

Mobile apps in this category can also be those that deal with information taken from the parent medical device. Importantly, while the storage and display of medical device data are classified as Class I functions, analysis of that data—i.e. presenting the data in any form other than the original—constitutes a greater risk in the FDA's view (Thompson, 2013). Examples of these mobile apps are those that serve as medical device data systems (MDDS), connecting patient data from a central nursing station to a physician's mobile device, as well as those that transfer data from a bedside monitor to allow active monitoring ("Mobile medical," 2013).

ii. "Mobile apps that transform the mobile platform into a regulated device by using attachments, display screens, or sensors or by including functionalities similar to those of currently regulated medical devices." ("Mobile medical," 2013)

Mobile apps in this category are regulated as medical devices because they allow the mobile platform to function as its own standalone medical device. First, these apps may use attachments to the mobile platform. For example, an app that uses an attachable blood glucose strip reader transforms the platform into a regulated blood glucose meter. Second, these apps may take advantage of the platform's built-in functionalities. For example, an app can use a mobile platform's internal microphone to monitor a patient's heartbeat and would therefore fall under regulation as an electronic stethoscope (Thompson, 2013).

iii. "Mobile apps that become a regulated medical device (software) by performing patient-specific analyses and providing patient-specific diagnosis, or treatment recommendations." ("Mobile medical," 2013)

Mobile apps in this category fall into the broader realm of clinical decision support because they primarily assist in the analysis and interpretation of patient data taken from another medical device. The FDA provides, as an example, mobile apps "that use patient-specific parameters and calculate dosage or create a dosage plan for radiation therapy; Computer Aided Detection software; and radiation therapy treatment planning software" ("Mobile medical," 2013). These apps are regulated as medical devices because of the particular risk they pose to the patient undergoing treatment. Nevertheless, the FDA has left out more rigorous definitions of CDS regulation, which it addresses separately from the final guidance document on mobile medical applications (Thompson, 2013).

A.3 Apps FDA Will Not Regulate

Although they may be intended for use in health or medical settings, not all mHealth apps fall under FDA regulation because they do not meet the definition of a medical device. The FDA's final guidance document provides a set of examples of mHealth apps that it does not intend to regulate, but also notes that the list is not exhaustive. The operating assumption for an app not to be subject to regulation is simply one that is not defined as a medical device. There are five categories of unregulated mHealth apps listed in the final guidance document.

i. *Mobile apps serving as electronic medical reference materials*. Apps that serve as medical dictionaries, copies of medical textbooks or manuals, or translators for medical terminology are not considered medical devices insofar as they "are not intended for use in the diagnosis of a disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease by facilitating a health professional's assessment of a specific patient, replacing the judgment of clinical personnel, or performing any clinical assessment" ("Mobile medical," 2013).

ii. *Mobile apps serving as educational tools for medical training or reinforcement of training.* For example, apps providing access to medical

flash cards, interactive anatomy diagrams, or surgical training videos are not medical devices even though their function provides more than simply electronic presentations of information (as in the first case) ("Mobile medical," 2013).

iii. *Mobile apps aimed at "general patient education"* ("Mobile medical," 2013). Although the FDA notes that such apps are patient-specific, they are free from regulation because they are not intended to function as a device, but are instead meant to empower patients through awareness and education. Apps in this category include interfaces between healthcare providers and patients that are meant to provide information on upcoming treatments or disease diagnoses, information guides for finding gluten-free foods or restaurants, and databases allowing users to determine the names of pills given various descriptors ("Mobile medical," 2013).

iv. *Mobile apps that automate general office operations in a health care setting*, for example by generating appointment reminds, analyzing insurance claims for fraud or abuse, or managing shifts for doctors.

v. *Mobile apps "that are generic aids of general purpose products"* ("Mobile medical," 2013). This category captures apps whose intended uses are not medical in any way. Apps using the flashlight as a flashlight, without a medical purpose – or apps providing access to emails between doctors and patients – are unregulated because their intended use is not specifically medical.

A.4 Apps Subject to FDA Enforcement Discretion

While some mHealth apps will be regulated and some will not, there is a third class of apps that are not currently regulated but may be regulated in the future. The FDA explains that it intends to exercise enforcement discretion over apps that:

- "Help patients self-manage their disease or conditions without providing specific treatment suggestions;
- Provide patients with simple tools to organize and track their health information;
- Provide easy access to information related to patients' health conditions or treatments;
- Help patients document, show, or communicate potential medical conditions to health care providers;
- Automate simple tasks for health care providers; or
- Enable patients or providers to interact with Personal Health Record (PHR) or Electronic Health Record (EHR) systems." ("Mobile medical," 2013)

These can be categorized into six groups: patient self-management, patient tracking, access to contextually relevant information, patient communication and telemedicine, professional calculators, and connections to EHR (Thompson, 2010). These apps are currently

unregulated because they do not clearly qualify as medical devices, but the FDA may enforce regulation in the future if such an app could pose a risk to patient safety. Basically, these apps are those the FDA cannot clearly classify as a device, but that may eventually require regulation as a result of new technological developments.

This middle ground between regulation and deregulation allows the FDA substantial flexibility in addressing the challenge of keeping pace with the rapid innovation in mHealth. Also, since most apps in this category deal with patient empowerment, the FDA makes clear that it supports efforts to facilitate empowerment and does not want to stymie progress with regulation. Simultaneously, enforcement discretion maintains the FDA's commitment to its charge of protecting public health and patient safety in the burgeoning mHealth space.

B. Regulation in the EU

As in the United States, mobile devices are proliferating across Europe, with approximately 456 million Europeans having access to a mobile platform (GSMA mHealth, 2012). The market for mHealth in the European Union (EU) is estimated to take a 30% share of global mHealth revenue by 2017 (Figure 1).
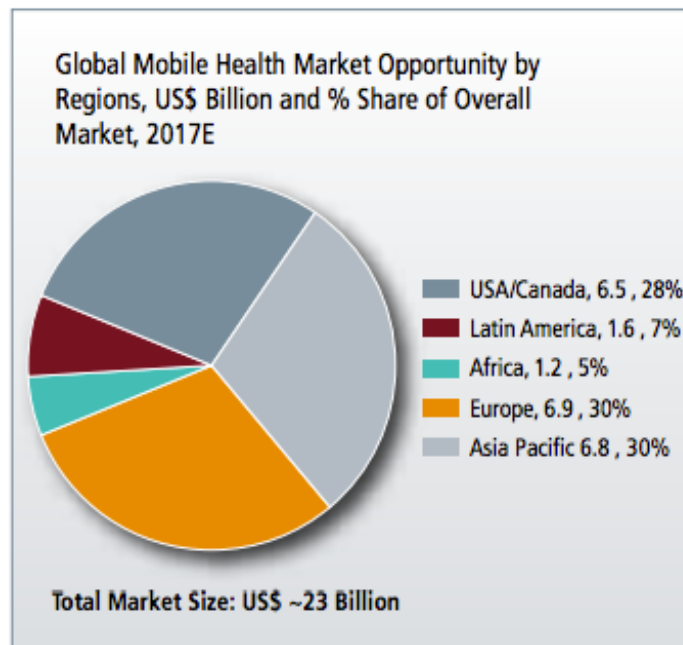

FIGURE 1. Global mobile health market opportunity by regions (adapted from "Touching lives: Assessment of the global mobile health market." *PriceWaterhouseCoopers and GSMA*, 2012).

The potential value of mHealth in Europe is substantial in real terms. Trials in Nordic countries predict a 50-60% reduction in hospital nights

and re-hospitalization for patients with COPD ("Socio-economic Impact," 2012). Similarly, remote patient monitoring in the UK is expected to have a 20% reduction in emergency admissions, 14% reduction in hospital nights, and a 45% reduction in mortality rates ("Socio-economic Impact," 2012).

The European Union is somewhat behind the United States in terms of specific mHealth regulation. The two regulatory frameworks currently governing mHealth, though not explicitly, are the Radio Equipment and Telecommunications Terminal Equipment Directive and the Medical Devices Directive. On April 10, 2014, the European Commission released a green paper on mHealth, describing its motivations for mHealth regulation, but the comment period for that document remains open at this time.

An important difference between FDA regulation and EU regulation is that there are not yet clear definitions of what distinguishes a mobile wellness app and a mobile medical device (app) in the EU. Moreover, the EU green paper does not free mHealth apps of regulation simply because they do not meet the definition of a device. Although questions remain as to how non-device (wellness) apps are to be regulated, the green paper states that such apps can nevertheless face regulation of some kind. Under FDA regulation, non-device wellness apps are simply not regulated ("Mobile medical," 2013).

The EU green paper also makes clear what the European Commission (EC) sees as priorities in regulating mHealth. While patient safety certainly ranks among the EC's main objectives, the green paper also emphasizes patient data security and interoperability between mHealth apps and existing medical devices. Under Article 8 of the Charter of Fundamental Rights of the European Union, European citizens are guaranteed the right of personal data protection, and mHealth developers are generally directed to the European Commission's guidance for data protection in apps. Interoperability is another focus for EU regulation because of the EU's aim to promote widely scalable health solutions across Europe, consistent with an emphasis on EU-wide equality of access.

Companies' perspective on regulation

A. Safety and efficiency requirements

A.1 A few developers are seeking the regulation path
Among the almost 100,000 mobile medical devices, there are a few medical applications companies that are seeking to prove the effectiveness and safety of their products (Research2Guidance, 2014). Most of these clinical trials are originated in the United States (Figure 2).
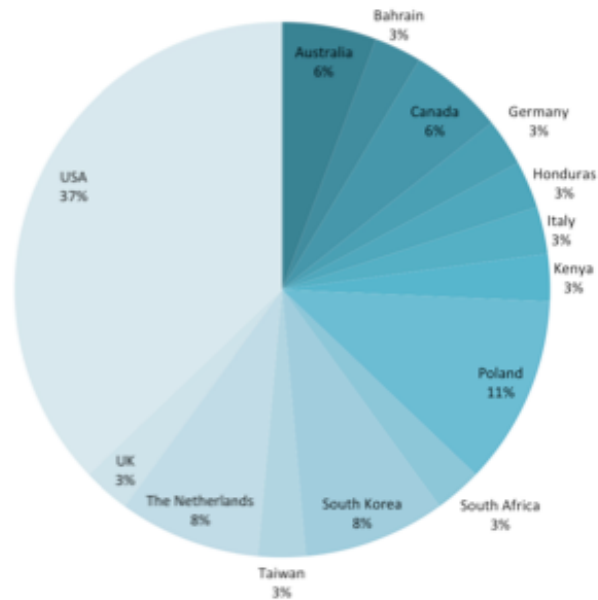
FIGURE 2. Chart showing the percentage of clinical trials with mobile medical devices by country: 37% are conducted in the US (adapted from "Evidence for mHealth Report." Stroux, L., 2012, *A Market Research Project conducted in collaboration with GSMA*).

The website www.ClinicalTrials.gov provides a relatively low number of search results for terms related to mobile health studies with effectiveness and safety as key outcomes when compared to the available quantity in app stores. The majority of the studies in this database are related to diabetes mellitus, depression, mental disorders, HIV and vascular diseases.

Most of the key outcomes in the database are focused on the efficiency of the mobile medical device. For instance, the research "Improving Medication Adherence through SMS in Adult Stroke Patients: a Randomized Controlled Behavior Intervention Trial" conducted by Aga Khan University also set safety as one of the secondary outcome measures through a self-designed toll which would measure the acceptability of mHealth intervention, as well as SMS reception, quality issues, and safety. But setting safety as an outcome of these studies is still rare.

Notably, the studies that considered safety outcome measures were conducted mainly from 2013 and 2014. This statement can lead to a few different conclusions: the first possibility is that the regulation guidelines are indeed very recent; therefore, developers are only just discovering what has to be done to go through the entire regulation process. Second, a better understanding of the value attached to the compliance with safety and effectiveness requirements should be established. Third, there could also be a need for a set of guidelines determining what companies need to consider in order to develop high quality health apps.

A.2 Most developers take another way

Even though the FDA regulation guidelines are now released and public, to avoid regulatory issues, developers often use old and proprietary solutions that have been approved or cleared by regulations already. Otherwise, they even reduce the number of features offered in order to avoid classification as a medical device. One of the reasons for those decisions is the difficulty of balancing continuous upgrades in mHealth with the need of an up-to-date patient protection rights approval (Research2Guidance, 2014).

Another reason for this incongruity with the regulation process may arise due to the very nature of traditional IT companies. This business environment is ruled by the competition without artificial constraints, wherein bad products end up with a bad reputation, and the companies that produce them go out of business (Thompson, 2010).

When it comes to healthcare, bad products can injure patients and even cause death. Thus, when a company decides to make business in the mobile health industry, the whole process of development is extended by:

- Added cost;
- Longer times in product development;
- Added complexity;
- More discipline and rigor;
- More paperwork. (Research2Guidance, 2014)

Those aspects of healthcare are reason enough for a company to avoid the regulatory system. On the other hand, according to Thompson, companies that thrive through the whole process may gain important competitive advantages and weaken the potential of other unregulated apps (2010).

According to a research performed by Research2Guidance in 2014, the low number of clinical trials made for mobile health applications is highly surprising, as traditional payers in the medical and health sectors consistently require better clinical studies to valuate their investments. 47% of mHealth app publishers do not yet have a clear view on the FDA's guideline that was published last year, calling into question if this guideline actually constitutes a comprehensive framework for the mHealth sector (Figure 3).

Guidance from FDA

The FDA recently published guidelines for mHealth apps. Do you think that these guidelines now give the mHealth app market a comprehensive regulatory framework?
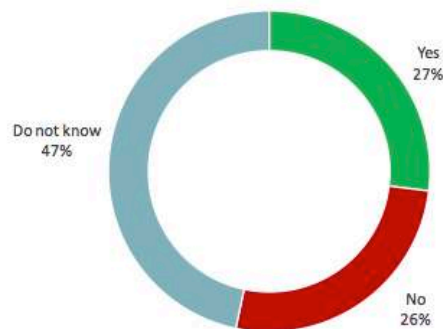

Yes
27%

No
26%

Do not know
47%

FIGURE 3. Chart showing developers' point of view about FDA guidelines for mHealth Apps (adapted from "MHealth app developer economics 2014," *Research2Guidance*, 2014)._

To demystify the FDA requirements for app developers and incentivize good practices, the Consumer Electronics Association (CEA) is promoting a nationwide educational program series called "Mobile Medical Apps (MMA) Roadshow: Managing App development under FDA Regulation." With workshops held in different universities across the US, the project aims to answer some app developers' questions concerning the FDA and quality systems to show that regulation and innovation can be compatible (CEA, 2013).

A.3 How is society reacting?

While the regulation over mobile medical devices is only starting to improve, the marketplace is performing its own review process, although most of these reviews are largely focused on personal impressions rather than on evidence-based facts and unbiased assessments. Some organizations are trying to provide certifications to mHealth apps, but they are still encountering challenges with consistency, security, and even conflicts of interest (Powell, Landman & Bates, 2014).

For the developers who are willing to go through the regulation process, a mobile health application has to meet the safety and effectiveness requirements to get clearance or to be approved by the FDA as a medical device. On the other hand, there have been some independent studies that investigated the safety and efficacy of some apps focused both on healthcare professionals and on the general population. They concluded that the results were not satisfactory for a great number of published apps (Maged, 2014).

Maged *et al*. (2014) cites work by Visvanathan *et al*. (2012), in which that the accuracy and reliability of researched apps used for diagnosis and

patient management were called into question. According to Visvanathan, only 34% of the researched apps had the participation of health professionals in development. Therefore, the lack of medical professional involvement in the development of the medical apps has the potential to undermine the content quality.

One example broadcasted on the news concerns the Dutch "SkinScan" app. This application focused on identification and management of skin cancer. When compared to 93 clinical images from the National Cancer Institute and Fitzpatrick's dermatology in General Medicine, the app gave positive results for high-risk melanomas to only 10.8% of the images, which clearly shows the potential risks of unregulated apps caused by the lack of rigorous medical orientation. Since then, the company has changed the name of the app to "SkinVision" and made an announcement that they are seeking clinical trials in Europe to prove the effectiveness of their app when compared to traditional diagnostic tools (Maged, 2014). This example of a company conducting clinical trials to prove the efficacy and safety of their mobile medical device is one among only a few.

Given the high number of mobile health applications, Powell, Landman & Bates suggest that guidelines should be established for app developers, which would serve as a basis for safety, accuracy and security (2014). Besides, the shift to an efficiency-based approach where the outcomes are a reference for reviewers and, therefore, potential users, can bring the attention of the developers to populations with the greatest medical needs.

B. *Value proposition of mobile medical devices*

The success of outcomes for medical devices is becoming even more important as the healthcare sector shifts towards value-based healthcare. For payers and investors in medical devices, it is important to demonstrate not only efficacy and safety, but also cost-effectiveness and sustainability. On the other side, patients value ease of use, personalization, portability, and patient empowerment (Giovannetti, 2014). All these aspects are embedded in the value proposition of the mobile medical device market.

B.1 *Value for patients*

As the number of physicians relative to patients decreases across the world, mHealth apps offer the possibility of easier access to medical information for patients. They can use social networks to discuss health-related issues online, such as PatientsLikeMe.com. 23% of US Internet users with chronic conditions have searched for social networks online to find others who are experiencing similar things (Ernst & Young, 2012). One of the greatest uses of this smart mobility is patients' engagement. It works to manage chronic diseases through behavioral tools, gamification, text messaging, and data tracking, as well as to enhance wellness and fitness. Many mobile medical apps are add-ons to existing devices, used to

enhance their value proposition beyond the product (Ernst & Young, 2012) (Price Waterhouse Cooper, 2013).

B.2 Value for health professionals

These advances are enabling the empowerment of patients over their own health. With the development of sensors and other devices, patients have the possibility of tracking data and sending them to their physician through a mobile application. Furthermore, physicians also have:
- Access and share of patient information, EHRs and EMRs;
- Access to medical information databases, such as pharmaceutical inventories, medical literature and calculators, for instance, BMI or APGAR;
- Remote diagnosis and monitoring through better awareness of the condition of patients with chronic conditions;
- Potential of reaching remote locations, such as rural areas;
- Better efficiency with higher revenue potential, due to more patients being taken care of in the same timeframe with lower costs (Coursaris, 2004) (Figueredo, 2013) (Price Waterhouse Cooper, 2013).

B.3 Value for payers and for society

By improving the healthcare system efficiency, society benefits with more cost savings and enhanced quality of life and productivity for the general population. A report from Price Waterhouse Coopers on the socio-economic impact of mobile health estimates that 265 billion EUR can be saved in healthcare costs between 2013 and 2017 due to mHealth (2013) (Figure 4).
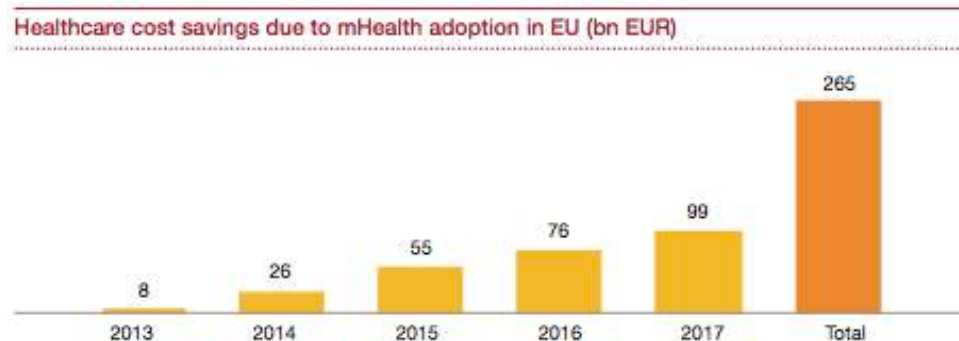

FIGURE 4. Chart showing Healthcare savings due to mHealth adoption in European Union. Adapted from "Socio-economic impact of mHealth: an assessment report for the European Union". *Price Waterhouse Cooper*, 2013.

B.4 Challenges

Despite the added value that the mobile medical health sector can offer, there are a few barriers that need to be taken into account. Regulation uncertainty, lack of interoperability standards, and lack of data protection legislation are mechanisms that, if improved, could ensure users safety and

trust. However, they are currently delaying adoption and limiting the scale of effectiveness of these technologies. Also, the lack of reimbursement mechanisms and sustainable business models available for these technologies limits their affordability and makes devices commercially unviable. On the other hand, the lack of clinical trials with safety and efficiency outcomes prevents investments from being well-utilized (Price Waterhouse Cooper, 2013).

To demonstrate the value a mobile health app can bring, the following are two examples of health apps for diabetics that are highly rated in the market. Glooko offers glucose, calories and medicine data tracking, a FDA approved cable to facilitate use and transmission of glucose data, various platforms usage (glucometers and Smartphones), data analytics and graphing, data sharing with clinicians, predictive analytics, optimization of hospital and insurers service, and partnerships with research organizations to enhance credibility (ValueChainGeneration, 2014).

WellDoc focuses on value for patients. Improved aspects of the diabetic patient experience include an easier approach to chronic disease management, better quality of life, adaptation to diabetics' unique lifestyle, real-time support, and patient empowerment. According to MarketIntelNow, "for physicians, the value proposition is three-fold:

i)   improved patient outcomes through expert diabetes consulting,
ii)   increased efficiency through time saving tools, and
iii)   new and future potential reimbursement and pay-for-performance models which incentivize better care for patients" (2008).

Case Studies

The following cases were prepared to survey a broad variety of the mobile medical applications currently available on the market. In particular, the cases cover the three types of medical applications that the FDA regulates and are some of the most developed products on the market in each of those areas. Examining each product as a case allows for a better understanding of how the FDA's regulatory processes apply to real situations.

A. ResolutionMD

A.1 Abstract

ResolutionMD (K123186) is a diagnostic medical image viewer from Calgary Scientific, Inc. The mobile interface is an extension of similar interfaces in the clinical and web settings for the same product. The goal of the device is to ease diagnosis through accessibility and convenience of relevant images. ResolutionMD prides itself on its mobility and security, particularly in rendering medical information from a remote source rather

than downloading sensitive files. The FDA most recently approved the product on March 14, 2013.

FIGURE 5. Image showing ResolutionMD interface. Adapted from Calgary Scientific, Inc.

A.2 Categorization

ResolutionMD was approved as a mobile medical device in the category of applications that "display, transfer, store, or convert patient-specific medical device data from a connected device" ("Mobile medical," 2013). In this case, the product displays diagnostic images and scans that are normally available only at a central clinical computer and allows medical professionals more convenient access to patient information. Other devices in this category connect to and collect data from central nursing stations, bedside monitors, or perinatal monitoring systems. Most devices in this category are found to be substantially equivalent to the original systems from which they receive their data.

A.3 Background

Medical professionals lack a mobile interface for diagnostics to allow them to conveniently access patient data. Currently, diagnostic errors constitute the largest portion of medical errors at 28.6%, costing the healthcare system $38.8 billion in malpractice lawsuits (Sifferlin, 2013) (Lowes, 2013) (ResolutionMD®, 2014). Mobile devices offer a solution that is not only more convenient, but also potentially faster, due to the ability to buffer large image files remotely. This speed is crucial in treating for time-sensitive diseases like stroke, in which 2 million neurons are lost per minute ("Infographic: ResolutionMD", 2014).

One implication of providing patient data to a remote, mobile interface is an increased need for privacy with respect to confidential patient information. A healthcare breach can cost between $50,000 and $1.5 million for a serious HIPAA breach ("Image-Viewer is Fully Secure," 2014). Many hospitals are cautious about allowing employees to obtain such information on laptops, tablets, and phones, requiring a thorough security screening of the device before allowing it to be used for work purposes. A 2012 study from the Healthcare Information and Management Systems Society (HIMSS) revealed that 34% of surveyed organizations had security as their chief concern, and 23% had experienced a breach in the past year ("Practice Management," 2014). As such, the market for data display applications demands a safe interface for patient data that includes a secure login and responsible image storage (if images are stored at all).

A.4 Technical Assessment

The mobile medical device associated with ResolutionMD is the extension from its web platform to tablets and smartphones ("Image-Viewer Works," 2014). The current version is compatible with iOS and Android platforms and provides the same diagnostic repertoire as the web version, including CT and MR imaging. Some features including the scalpel tool and image rotation tool are available only on web versions. Others, such as split-screen and the lens tool that allows a user to see anatomical features behind a bone, are available only on the iPad ("Product Features," 2014). Currently, ResolutionMD supports Non-DICOM images and videos for iOS, which includes JPG, PNG, MPG, and MP4 formats. Overall, these discrepancies between the web version, tablet version, and mobile phone versions of ResolutionMD are minimal and do not detract from the usefulness of the product across platforms ("Access to Non-DICOM," 2014). This application succeeds in its goal of providing a seamless transition from stationary to mobile interfaces.

Recent studies of the latest ResolutionMD app have demonstrated that the system loads images in 2.7 minutes, as compared to 12.3 minutes for commercial desktop picture archiving and communication systems (PACS) or 17.5 minutes for in-house viewing systems. The mobile system is 4 to 6 times faster than its computer-based alternatives ("Infographic: ResolutionMD," 2014). With a 92-100% physician satisfaction rating, ResolutionMD fills the market's need for a more convenient and rapid diagnostic image display system.

ResolutionMD takes several measures to ensure that its content is not only readily available, but is also private. All medical data is deleted from the phone memory when the phone logs out or the application times out. Clients are required to log in before viewing any images, and SSL encryption is implemented to secure the client's device. Administrators also have choices such as the option to install a VPN as the secured network for accessing ResolutionMD application information, preventing

outside users from entering the client's network altogether. ResolutionMD answers the expensive nature of healthcare data breaches with these security provisions, making it a more attractive product in the market ("Image-Viewer is Fully Secure," 2014).

A.5 Regulation

On March 14, 2013, the most recent version of ResolutionMD was FDA approved on all modalities except mammography. The clearance was granted based on the standard equivalence of ResolutionMD with PACS and in-house designated diagnostic workstations, meaning that medical professionals should feel comfortable diagnosing patients with the web or mobile versions of ResolutionMD as they would with any other standard diagnostic imaging tool ("Practice Management," 2014).

Calgary Scientific, Inc. has also secured regulation approvals outside of the United States. ResolutionMD was the first device of its kind to receive approval from the China Food and Drug Administration (CFDA) in April 2014. The CFDA conducted its own set of trials in China before approving the device. In addition to the CFDA certification, ResolutionMD is Health Canada approved and CE marked (the equivalents of FDA approval in Canada and the EU, respectively). Securing international regulation approvals has allowed this product to expand beyond its Canadian origins to cross borders and serve users from a variety of countries.

A.6 Conclusion

Calgary Scientific's ResolutionMD fills a distinct niche in a market that required a more convenient, quick, and secure means of diagnosing patients remotely. The program's compatibility over many interfaces serves as a distinct asset to medical professionals, in particular to those who frequently deal with emergency conditions. Its security also puts hospitals at ease when evaluating their liability for patient medical information. While ResolutionMD certainly makes strides in the medical device industry, its clear extension from PACS and designated diagnostic workstations allowed it to pass through FDA regulation as an obvious substantial equivalent. The ability of this data display application to obtain quick approval in an international scale with an in-demand product ensured its economic viability. It also offers 20-40% cost savings to its main clients, whom tend to be larger hospital systems. ResolutionMD succeeds as a medically useful and economically rewarding product.

B. myVisionTrack
B.1 Abstract

The myVisionTrack device by Virtual Art and Science, Inc. is an application that allows retinal degenerative disease patients to monitor their vision function from home. The application's tests were proven to have a strong correlation with comparable eye function readings from

patient clinical visits to ophthalmologists (Duffy, 2013). myVisionTrack also informs a specialist if the patient experiences a significant decline in optical function so that the readings can be discussed as a part of standard care. The product values convenience and accuracy and was approved by the FDA on February 22, 2013.

FIGURE 6. Image showing myVisionTrack interface. Adapted from Kera News.

B.2 Categorization

*My*VisionTrack is considered an application that turns a mobile platform into its own regulated medical device by making the phone or tablet a standalone tool. The applications classified in this category also include those that measure and display the heart's electrical pulses; amplify the sound of an organ; employ an accelerometer to measure physiology during CPR, sleep, or tremor; create sounds to test for hearing disability; analyze skin lesions with fractal regression; use lasers to remove acne or hair; and that have attachments to measure blood to ascertain blood oxygen levels or blood glucose levels. Specifically, myVisionTrack fits this category because it is an independent diagnostic test that allows patients to determine their medical status based on a digital vision exam.

B.3 Background

There are more than 40 million degenerative retinal disease patients worldwide (Bartlett, 2013). Common degenerative retinal diseases included macular degeneration and diabetic retinopathy. Macular degeneration is an eye condition that involves the decay of the macula in the posterior lining of the eye. Its symptoms include blurred vision, vision loss, and swelling of abnormal subretinal blood vessels in neovascular forms of the disease ("Facts About Age-Related," n.d.). Diabetic retinopathy, a disease distinctly related to diabetes, is a result of increased blood sugar levels and their degeneration of the eye's lining. Symptoms include seeing "floaters," blurred vision, dark or empty spots in the middle of the field of vision, and difficulty seeing at night ("Diabetic

Retinopathy," n.d.). These diseases are often diagnosed and assessed with the help of vision examinations. Timely treatment of age-related macular edema and diabetic retinopathy is important to halt disease progression. Since both symptoms become progressively more severe (macular edema with age, diabetic retinopathy with proliferation) and continue to erode the retina, a remote monitoring system could significantly improve disease management ("Research | Vital Art," n.d.). Currently, patients have their vision analyzed when their disease progresses and they experience symptoms of deterioration. Consistent vision examination in a remote setting could improve convenience of this testing system and alert patients and physicians to developing symptoms before they become significant enough to warrant the scheduling of a clinical visit.

B.4 Technical Assessment

The myVisionTrack application presents patients with remote option diagnostic vision examinations. The tests present the patient with three similar shapes side-by-side, one of which has modified edges (wavy or jagged), and asks patients to identify which shape is unlike the others ("FDA Approves myVisionTrack," 2013). Patients cover one eye before seeing the test questions to focus the assessment on one retina individually rather than allowing both eyes to collaborate on comprehending the visual information. Each answered question leads to another, with increasingly varying edge types, until the patient has consistently identified the correct answer. After the test, the patient's data is stored to a self-assessment database. Research with age-related macular degeneration in particular proves that patients have significant difficulty determining differences in the shape discrepancy test. This is thus an accurate method for determining the state of the photoreceptor mosaic for age-related macular degeneration patients (Wang, Woodson, Locke, & Edwards, 2002). If the device detects any significant change in the patient's vision function, it automatically alerts the patient's eye specialist with updates. Research studies have confirmed high compliance by users and high satisfaction of them (Duffy, 2013).

Software considerations for the device include the optimization of the shape discrepancy test for vision function assessment and the physician alert system. In particular, the application was designed with clear graphics to assist its users in obtaining accurate test results. Another priority was application simplicity, to facilitate the acclimation of new users of mobile technology and to improve the application aesthetically. Lastly, myVisionTrack's designers included a storage database on the mobile platform, as well as an export function to provide relevant information to pre-approved medical professionals who have prescribed the device ("Research | Vital Art," n.d.).

B.5 Regulation

The myVisionTrack was approved by the FDA as a medical device due to its substantial equivalence when compared to other vision function tests used by medical professionals. The FDA approval process required over two years of clinical trial research. One trial in particular involved 40 diabetic retinopathy patients who were prescribed myVisionTrack. These patients compared their self-assessments with readings taken by their ophthalmologists at beginning, midpoint, and ending appointments to show a strong correlation between the readings (Duffy, 2013). The FDA approval of myVisionTrack also stipulates that this application be prescription-only (Bartlett, 2013).

Visual Art and Science, Inc. also obtained a proprietary patent on its shape discrimination hyperacuity (SDH) test (Bartlett, 2013).

B.6 Conclusion

The myVisionTrack application is regulated due to its replacement of an already approved medical process: the diagnosis of degenerative retinal diseases through visual examination. In order to make this testing regimen more convenient and consistent for patients, Visual Art and Science, Inc. has transferred what was normally a medical exam to accessible remote platforms. The change meets a distinct market and medical need for earlier diagnosis of age-based disease. One potential hurdle in the development of this product was its approval as a prescription-only solution. As such, myVisionTrack raised $550,000 and began soliciting pharmaceutical partnerships after obtaining FDA approval as a means of maintaining its business.

C. ReSound Smart

C.1 Abstract

ReSound Smart is a mobile application from GN ReSound, one of the world's largest hearing aid companies, that controls the ReSound LiNX™ hearing aid. The application allows users to send audio straight from an iPhone, iPad, or iPod touch to the hearing aid. They can also modify the settings (bass, treble, overall volume) on their hearing aids and set location-based profiles through their mobile device's GPS. This allows the patient increased control on sound balance and an increased ability to adjust the hearing aid. The ReSound Smart application has not obtained FDA approval, but is currently on the market.
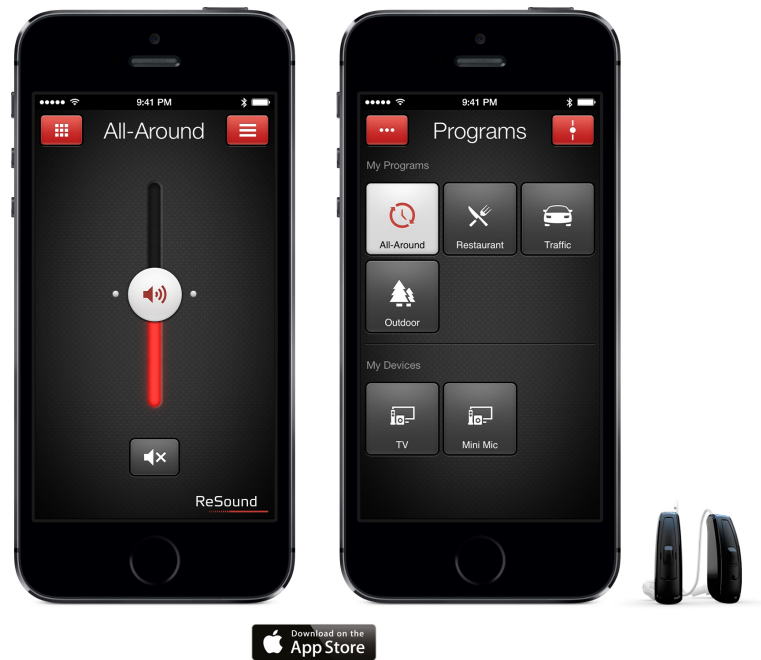
FIGURE 7. Image showing ReSound Smart interface. Adapted from Carolina Hearing Doctors, 2014.

C.2 Categorization

This application would at first appear be classified as one which controls the "operation, function, or energy source" of an existing medical device and thus, by extension, is itself a medical device. Other devices in this category include applications that: control the flow of blood transfusion pumps, operate computed tomography (CT) and X-Ray machines; change the settings of an implanted neuromuscular stimulator; calibrate or control a cochlear implant; or change the inflation/deflation of a blood cuff. The ReSound Smart application does control the function of hearing aids and, as such, would most likely be considered a device in this category. However, the FDA specifically mentions that it intends to regulate "apps that are used to calibrate hearing aids and assess the electroacoustic frequency and sound intensity characteristics emanating from a hearing aid, master hearing aid, group hearing aid or group auditory trainer" ("Mobile medical," 2013). The ReSound Smart app neither calibrates the LiNX hearing aid nor assesses the sound intensity characteristics that it produces. Rather, the ReSound Smart application changes the sound intensity of the LiNX by increasing or decreasing the volume and sound elements. ReSound Smart, therefore, is not officially categorized as a device.

C.3 Background

Hearing loss is a common condition that affects 10% of the world population (Oishi & Schacht, 2011). Hearing aids, while effective solutions to the problem of hearing loss, often require manual adjustment. Adjustment of hearing aids is not only inconvenient and slow, but can be socially ostracizing. Other problems with pre-existing hearing aids include the required proximity to hear a conversation partner and the need to switch between hearing aid and headsets when using a mobile device ("ReSound LiNX," n.d.).

C.4 Technical Assessment

The ReSound Smart application has several technical advantages over pre-existing hearing aids in that it supplements the LiNX to meet the largest challenges currently facing the hearing disabled community. The ReSound Smart application is available on iOS, and allows users to not only modify their hearing aid volume and bass/treble balance, but also can form specific profiles that are linked geographically to locations that the user frequents ("ReSound Smart," n.d.). When the user arrives in a frequented location, the hearing aid automatically shifts its settings to the user's predefined preference. In addition to changing profiles, the ReSound Smart application links directly to the mobile device platform to receive incoming calls, music, or microphone input. With this addition, users no longer need to switch between hearing aids and headphones. ReSound Smart can also be set to pick up noise through the mobile device's microphone, which it transports directly to the LiNX hearing aid. This eliminates the need for close-proximity conversations, as a user can place the mobile device in any strategic location that allows for the required transmission (Manjoo, 2014). Lastly, the devices were given a sleek design and 10 color options to improve patient comfort aesthetically ("ReSound LiNX," n.d.).

C.5 Regulation

The ReSound Smart application is currently not regulated by the FDA because it does not fall under the current FDA definition of a medical device.

C.6 Conclusion

While one might imagine that ReSound Smart would be regulated by the FDA, due to its direct control of the FDA-regulated LiNX hearing aid, ReSound Smart is one example of an application that lies narrowly outside of the regulation of the FDA. As such, the ReSound Smart application is available on the iOS application store as a free addition to the LiNX hearing aid ("ReSound Smart," n.d.). With so many mHealth applications commonly available, this product is a model of the questionable boundaries of regulation, and the tension between regulatory authority and

rapid innovation. Myriad applications fall into a grey zone similar to that of the ReSound Smart application and narrowly avoid FDA oversight, allowing them to come to market more quickly, empowering patients.

Conclusion

Our review of 2013-2014 mobile medical devices has demonstrated that this medical device sector is rapidly expanding and requires expanded regulation. The current regulation systems, whether they be in the US or abroad, regulate only a small fraction of the mHealth apps which they define to be devices. This organizational lag certainly poses challenges for increasingly mobile societies: it will become increasingly more difficult to determine which apps are trustworthy and effective. Simultaneously, developers will continue to create mHealth apps with the current surge of mobile technology, taking advantage of any holes in FDA regulation. The recent developments of 2013-2014 are, consequently, both promising and foreboding for the autonomy and convenience of healthcare.

References

Bartlett, M. (2013, March 24). Vital Art and Science Receives FDA Clearance for myVisionTrack Medical Device that Monitors Retinal Disease. . Retrieved May 30, 2014, from http://myvisiontrack.com/fda-clehttp://myvisiontrack.com/fda-clearance/arance/

Calgary Scientific. (2013, April 9) ResolutionMD^{TM} First to Receive FDA Clearance for Diagnostic Medical Image Viewing on Android Devices. Retrieved from http://www.calgaryscientific.com/news/fda-clearance-for-diagnostic-medical-image-viewing-on-android/.

Calgary Scientific Inc. Extends Access to Non-DICOM Data with ResolutionMD® 4.0 | Calgary Scientific. (n.d.). *Calgary Scientific Inc. Extends Access to Non-DICOM Data with ResolutionMD® 4.0 | Calgary Scientific*. Retrieved May 30, 2014, from http://www.calgaryscientific.com/news/calgary-scientific-inc-extends-access-to-non-dicom-data-with-resolutionmd-4-0/

Consumer Electronics Association. (2013) *Mobile Medical Apps (MMA) Roadshow: Managing App Development Under FDA Regulation.* Retrieved from http://www.ce.org/News/News-Releases/Press-Releases/2013-Press-Releases/CEA-Joins-Industry-Groups-in-Sponsoring-Educationa.aspx

Coursaris, C.K. (2004). MHealth: Exploring the impact of wireless technology in health care. *Quarterly Journal of Electronic Commerce (QJEC), Summer,* 51-68.

Diabetic Retinopathy. (n.d.). *Diabetic Retinopathy*. Retrieved May 30, 2014, from http://www.aoa.org/patients-and-public/eye-and vision-problems/glossary-of-eye-and-vision-conditions/diabetic retinopathy?sso=y

Duffy, M. (2013, April 11). VisionAware Blog. - *VisionAware*. Retrieved May 30, 2014, from http://www.visionaware.org/blog.aspx?BlogID=9&BlogEntryID=688

Elder, M. (2010, December). *The world market for mobile medical "apps": a Kalorama Information market intelligence report.* New York: Kalorama Information. ENSURING YOUR ENTERPRISE IMAGE-VIEWER IS FULLY SECURE . (n.d.). . Retrieved May 30, 2014, from http://www.calgaryscientific.com/wp-content/themes/calgaryscientific/assets/pdfs/Security-052014.pdf ENSURING YOUR ENTERPRISE IMAGE-VIEWER WORKS WITH CURRENT INFRASTRUCTURE. (n.d.). . Retrieved May 30, 2014, from http://www.calgaryscientific.com/wp-content/themes/calgaryscientific/assets/pdfs/Interoperability-052014.pdf

Ernst & Young. (2012). M*Health: Mobile technology poised to enable a new era in health care.* Retrieved from Ernst & Young:

http://www.ey.com/GL/en/Industries/Technology/mHealth---mobile-technology-poised-to-enable-a-new-era-in-health-care

European Commission. (2014, April 10). *GREEN PAPER on mobile Health ("mHealth").* Retrieved from http://ec.europa.eu/digital-agenda/en/news/green-paper-mobile-health-mhealth

European Commission. (n.d.) *Infographic: Medical apps, is certification required?*. Retrieved from http://ec.europa.eu/digital-agenda/en/news/infographic-medical-apps-certification-required-0

European Commission, DG health amd Consumer, Directorate B, Unit B2 "Health Technology and Cosmetics". (2012, January). *Medical devices: Guidance Document. Qualification and Classification of stand alone software. MEDDEV 2.1/6.* Retrieved from http://ec.europa.eu/health/medical-devices/files/meddev/2_1_6_ol_en.pdf

Facts About Age-Related Macular Degeneration. (n.d.). *[NEI Health Information]*. Retrieved May 30, 2014, from https://www.nei.nih.gov/health/maculardegen/armd_facts.asp

FDA Approves myVisionTrack for smart phones. (2013, April 26). *Macular Network macularnet*. Retrieved May 31, 2014, from http://macular.net/fda-approves-myvisiontrack-for-smart-phones/

Figueredo, K. (2013). Rethinking the mHealth value proposition. Retrieved from http://www.more-with-mobile.com/2013/08/rethinking-mhealth-value-proposition.html

Giovannetti, G. (2014, January 14) *Pulse of the industry: Medical technology report 2013*. Retrieved from: Ernst & Young website: http://www.ey.com/US/en/Industries/Life-Sciences/Pulse-of-the-industry---medical-technology-report-2013

GSMA mHealth. (2012). *mHealth and the EU regulatory framework for medical devices.* Retrieved from http://www.gsma.com/connectedliving/wp-content/uploads/2012/03/mHealth_Regulatory_medicaldevices_10_12.pdf

Infographic: ResolutionMD Accesses Images up to 6 Times Faster Than Other Image-Viewing Systems | Calgary Scientific. (n.d.). *Infographic: ResolutionMD Accesses Images up to 6 Times Faster Than Other Image-Viewing Systems | Calgary Scientific*. Retrieved May 30, 2014, from http://www.calgaryscientific.com/infographic-mayo-study/

International Medical Device Regulators Forum (IMDRF). (2014) *MDSAP: Medical Device Single Audit Program*. Retrieved from www.fda.gov/.../MedicalDevices/...Programs/MDSAPPilot/UCM372066....

Lowes, Robert. (2013). Diagnostic errors dominate malpractice payouts. Retrieved from: http://www.medscape.com/viewarticle/803026

Maged, N. et al. (2014). Mobile medical and health apps: state of the art, concerns, regulatory control and certification. *Online J Public Health Inform. 5(3):229*. doi: 105210/ojphi.v5i3.4814

Manjoo, F. (2014, April 23). Conjuring Images of a Bionic Future. *The New York Times*. Retrieved May 30, 2014, from http://www.nytimes.com/2014/04/24/technology/personaltech/app-controlled-hearing-aid-improves-even-normal-hearing.html?_r=0

MarketIntellNow (2008). Interview with WellDoc. Retrieved from http://marketintellnow.blogspot.com.br/2008/05/interview-with-welldoc.html.

Mobihealthnews. (2013). Analysis: 103 FDA regulated mobile medical apps. Retrieved from http://mobihealthnews.com/27645/analysis-103-fda-regulated-mobile-medical-apps/

Mobihealthnews. (2014). In-depth: Digital health trends in 2014. Retrieved from http://mobihealthnews.com/29442/in-depth-digital-health-trends-in-2014/

Oishi, N., & Schacht, J. (2011, June 1). Emerging treatments for noise induced hearing loss. . Retrieved May 31, 2014, from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3102156/

Powell, A. C., Landman, A. B., Bates, D. W.. (2014 March). In search of a few good apps. *The Journal of the American Medical Association*. Retrieved from https://jama.jamanetwork.com/article.aspx?articleid=1852662.

Practice Management: Your Patient Data Secure. (n.d.). . Retrieved May 30, 2014, from http://www.rheumatologynetwork.com/practice management/your-patient-data-secure

PriceWaterhouseCoopers and GSMA. (2012). *Touching lives: Assessment of the global mobile health market.* Retrieved from: http://www.pwc.in/assets/pdfs/telecom/gsmapwc_mhealth_report.pdf

Price Waterhouse Coopers. (2013) *Socio-economic impact of mHealth: an assessment report for the European Union*. Retrieved from http://www.gsma.com/connectedliving/wp-content/uploads/2013/06/Socio-economic_impact-of-mHealth_EU_14062013V2.pdf.

Product Features. (n.d.). . Retrieved May 30, 2014, from http://www.calgaryscientific.com/wp-content/themes/calgaryscientific/assets/pdfs/ResolutionMD_Feature_Sheet.pdf

Research | Vital Art and Science Inc.. (n.d.). *Vital Art and Science Inc*. Retrieved May 30, 2014, from http://myvisiontrack.com/research/

Research2Guidance. (2013) *Mobile health market report 2013-2017: The commercialization of mHealth applications (Preview). Volume 3.* Retrieved from website: http://www.research2guidance.com/shop/index.php/mhealth-report-2

Research2Guidance. (2014). *MHealth app developer economics 2014.* Retrieved from website:

http://www.research2guidance.com/r2g/mHealth-App-Developer-Economics-2014.pdf.

ResolutionMD® - Diagnostic Medical Imaging Software. (n.d.). Retrieved November 2, 2014.

ReSound LiNX. (n.d.). . Retrieved May 30, 2014, from http://www.gnresound.com/~/media/DownloadLibrary/ReSound/Products/LiNX/end-user-brochure.pdf

ReSound Smart. (n.d.). *App Store*. Retrieved May 30, 2014, from https://itunes.apple.com/us/app/resound-smart/id816203976?mt=8

Sifferlin, Alexandra. (2013, April 24). Diagnostic errors are the most common type of medical mistake. *Time magazine*. Retrieved from: http://healthland.time.com/2013/04/24/diagnostic-errors-are-more-common-and-harmful-for-patients/

Stroux, L. (2012). Evidence for mHealth. *A Market Research Project conducted in collaboration with GSMA*.

The Boston Consulting Group and the Telenor Group. (2012). *The Socio Economic Impact of Mobile Health*. Retrieved from: http://www.telenor.com/wp-content/uploads/2012/05/BCGTelenor-Mobile-Health-Report-May-20121.pdf

Thompson, B. M. (2010) *FDA Regulation of Mobile Health*. Chester Street Publishing.

Thompson, B. M. (2013) *FDA Regulation of Mobile Health*. (2nd ed.). Chester Street Publishing.

U.S. Department of Health and Human Services. Food and Drug Administration. CDRH. CBER. (2013 September) *Mobile medical applications. Guidance for Industry and Food and Drug Administration staff*. Retrieved from www.fda.gov/downloads/MedicalDevices/.../UCM263366.pdf

U.S. Food and Drug Administration. *Mobile medical applications*. Retrieved from http://www.fda.gov/medicaldevices/productsandmedicalprocedures/connectedhealth/mobilemedicalapplications/default.htm

ValueChainGeneration. (2014). Glooko. Retrieved from http://valuechaingeneration.wordpress.com/2014/04/.

Vollebregt, E. (2011 July 27). Regulation of medical Apps FDA and European Union. *JHW Editorial Info- Regulatory Affairs of Medical Apps*.

Wang, Y., Woodson, E., Locke, K., & Edwards, A. (2002, June 1). . . Retrieved May 30, 2014, from http://www.iovs.org/content/43/6/2055.full.pdf