Accelerating Digital Health Innovation

Analyzing opportunities in the healthcare innovation ecosystem

By

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SUBMITTED TO THE MIT SLOAN SCHOOL OF MANAGEMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF BUSINESS ADMINISTRATION
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2013

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ABSTRACT

There has recently been a dramatic increase in demand for healthcare innovation. In this thesis we present a framework for analyzing a digital health innovation ecosystem in the US. Our framework consists of four key activities: innovation generation, entrepreneurial team formation, early company incubation, and validation of the core innovation. Throughout the paper we analyze the existing literature around innovation in order to motivate the design of the framework.

The framework is applied to three key innovation ecosystems in the US; Silicon Valley, Boston, and New York as a way to illustrate how this tool can be used to analyze digital health ecosystems in order to understand what key areas exist for improvement. We end the thesis with a discussion of the various programmatic ideas that might be used to bolster each category as well as a discussion of adapting this type of ecosystem development to the natural capacity of a region.

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Introduction:

Over the past 5 years there has been a surge in healthcare innovation activity. In this paper we present an overview of these activities to better understand the landscape of digital health innovation in the US. Much of our analysis here may apply to other domains, however, for the purposes of this paper we remain oriented to activities in the US related to digital health. We focus specifically on innovation driven entrepreneurship. While, innovation does happen in larger firms, it has been shown that most new innovative products and technologies come from entrepreneurial firms (Schumpeter 1934, Tushman & Anderson 1986, and Henderson & Clark 1990) and therefore we believe this focus is the most productive way to understand the innovation ecosystem and the opportunities to further encourage innovation.

In this paper we have three goals:

1. Understand what is currently happening in key digital health innovation ecosystems in the US.
2. Understand the role that each of these organizations plays within the larger context of digital health innovation.
3. Understand what opportunities exist to improve these ecosystems and accelerate the pace of innovation in healthcare.

To achieve these goals we present a framework for understanding innovation driven entrepreneurship in digital health. We then review a number of key innovation organizations and how they relate to this framework both as a way to better understand the framework as well as to understand the individual roles of each of these organizations. Subsequently, we apply this framework to several key regional digital health innovation ecosystems in order to understand if opportunities for improvement exist. Additionally, we hope that in presenting this framework and analyzing several key ecosystems we can empower members of those and other ecosystems with a new methodology to perform this type of analysis in the future. We end the paper with a discussion of these results as well as a discussion of a number of different programmatic options to enhance these ecosystems.

Background

Why should we care about digital health innovation ecosystems?

The last five years has seen a rapid growth in the type and number of organizations supporting innovation in healthcare, both at the level of the Federal Government as well as through a number of regional grass roots organizations. New Federal efforts to encourage innovation and technology adoption include: the HITECH Act, which helped double rates of EMR adoption (US Department of Health and Human Services 2013), The Medicare and Medicaid Innovation, and the recent Open Data initiatives at The Department of Human and Health. Outside of Washington DC we have seen an equally historic focus on supporting healthcare innovation through the rapid growth of healthcare accelerators like Rock Health, community organizations like Health 2.0, and new hospital innovation centers like

the Garfield Center at Kaiser Permanente. As we continue to commit substantial resources toward innovation in healthcare it is important to understand what role they play in the ecosystem and what opportunities exist for improvement.

Why do we care about innovation in healthcare in the first place? The core challenge to society is the rise in healthcare costs in the last several decades – far outpacing the growth in GDP (Figure 4). In the US we spend more (as measured by either percent of GDP or per capita) than virtually any other industrialized nation. Yet for all of these resources our population level health outcomes are near the bottom of any industrialized country (Global Health Expenditure Database 2013). Additionally, by some measures medical errors are the leading cause of death in the US (Herzlinger 2006). Not surprisingly it was shown that the pace of innovation in healthcare has been slow (Cutler 2011), thus many in the country are looking to better understand how to support a more innovative healthcare environment as a step to solving some of the larger questions about the effectiveness of our healthcare system in the US. We hope that this paper can provide a framework for understanding what is currently being done to encourage digital health innovation in the US as well as being a framework to further enhance our current innovation ecosystems.

Framework for Understanding the Innovation Ecosystem

There are many models of innovation covered in the literature. We will not attempt to do this literature justice here[1]. For the purposes of this paper it is important, simply to reference several key ideas common in the literature. The first is that a simple linear model of innovation in which all innovation is pushed onto society from science (ie science push model of innovation) is not accurate (Martin & Tang 2007). Secondly, we assume in this paper that some innovations are primarily inspired by new technological discoveries while others are motivated primarily by a market demand. Third we assume that the vast majority of innovations require input from the market throughout the various stages of the innovation process.

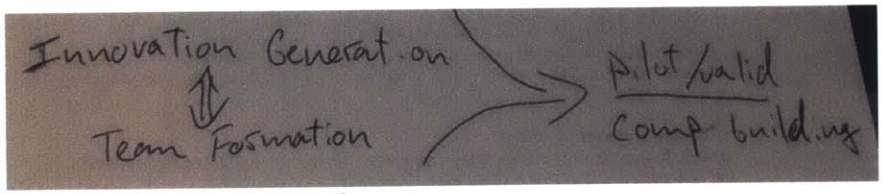

Figure 1: Innovation Framework

Figure 1 above gives an overview of the framework we will use to analyze the various actors in the innovation ecosystem. Our framework has four key activities:

1. Innovation (or "idea") generation
2. Entrepreneurial Team Formation
3. Early Company Building

[1] If you are interested in reviewing several different systems of innovation, consider Martin & Tang 2007.

4. Early Validation (usually in the form of a pilot or test that establishes that the product solves a critical problem and meets a key market need).

It is important to note that these activities do not happen in a strict linear order, in fact they most likely follow a non-linear path. There are many models that describe this non-linear process, two prominent ones are Spiral Innovation (described in a forthcoming paper from the Center for Biomedical Engineering at John's Hopkins) and Design Thinking (Brown 2008). Broadly, the generation of new innovation and the formation of a team happen at interchangeable moments. Sometimes the innovation (especially in a formal R&D setting) precedes all other stages, however, frequently teams form to tackle a specific problem and the innovation is discovered by that team as they begin to better understand the problem. Similarly, while the validation and early company incubation generally happen after the innovation generation and team formation these steps often feedback on each other. A team may learn something during the testing and validation that causes them to repeat the innovation generation or in some cases even reconfigure a team based on a new understanding of the problem and the opportunity. The purpose of this framework is not to advocate for a specific order of these activities but rather to suggest that these activities are somewhat distinct and therefore this framework is a useful construct for understanding how the different programs within an ecosystem support each of the activities in the innovation lifecycle.

In addition to the iterative nature of innovation, its location is also important. There is a substantial literature which shows that region / industry based clusters of activity predict the level of entrepreneurial activity better than a solely region based or industry based analysis (Delgado 2010). There are likely several reasons why location matters for innovation. The clustering of firms (both entrepreneurial and established) around an industry will attract specialty knowledge and resources to the region (Porter 2000). Furthermore, some resources are specific to entrepreneurial firms such as risk capital and legal resources (eg IP, company formation). Additionally, it is expensive to move information and people across geographic boundaries (Ellison 2007, Audretsch 1998). Even more important is the fact that information about innovation itself is especially "sticky" (Von Hippel 1994). The farther apart those who understand the problem are from those who understand the solution, the more resources it will take to communicate it, which will slow or prevent innovation from happening. With this backdrop we will discuss the nuances of each activity within the framework.

Idea / Innovation Generation:

Innovations can originate from a variety of contexts; however, these sources can generally be grouped into one of two categories:

1. Formal R&D
2. Autonomous Innovations

Formal R&D:

Formal R&D includes:

1. Commercial R&D Labs (ie Pfizer)
2. Research University Labs (ie MIT)
3. Hospital Innovation Centers (ie Mayo Clinic Center for Innovation)

Historically, it was believed that large research laboratories drove virtually all innovation. Increasingly, we are beginning to understand that different forms of innovation come from different places. Formal R&D certainly provides a strong foundation for many innovative activities and it is the source of many innovations, but innovation is complex and it is reductionist to simplify its sources to a single type of activity such as research in a laboratory.

A newer form of formal R&D is the innovation centers at hospitals. Many of these were founded within the last 10 years. Relative to most university based R&D labs, these centers of innovation focus on applied research, in particular they are often places for clinicians to explore new clinical protocols[2].

Autonomous Innovations:

An often-overlooked form of innovation is autonomous innovation. These are innovations that originate outside of formal R&D environments. Some research has suggested that these even makeup the vast majority of new products and services (Von Hippel 2005). These innovations generally result from the intersection of problem rich and solution rich environments. In the literature these people are referred to as "lead users" because they are the people who directly experience the problem on a daily basis and thus understand that problem best. In healthcare, these are likely to be clinicians or patients suffering from a specific problem and motivated to find solutions to it. One of the challenges for this style of innovation in healthcare is the fact that the people who understand the problem best (clinicians) are also very unlikely to have the engineering skills to develop a new technology-based solution[3]. Therefore, these solutions will likely result from collaborations with engineers and others that have an understanding of how to build these solutions. An important element of the lead-user literature is the idea that the information required to develop new innovations is "sticky" (Von Hippel 1994). Namely, with each link in a chain that the information has to travel it requires an exponential increase in resources to effectively transport that information to the new party. Thus we can expect that to encourage this kind of autonomous innovations we need to encourage clinicians and patients to interact with engineers in order to overcome this natural barrier in healthcare. This further suggests that location matters and that these innovation ecosystems must be regional in nature because they benefit from frequent interaction between these different parties.

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[2] See http://kpnet.kp.org/innovationcenter/what-we-do.html and http://www.mayo.edu/center-for-innovation/what-we-do for a more detailed description of the services and activities they provide (primarily to clinicians at these institutions).

[3] For a review of medical school acceptances by undergraduate field of study see: https://www.aamc.org/download/321496/data/2012factstable18.pdf. As shown in that chart, very few medical school entrants have an engineering background.

Programs to Encourage Innovation Generation:

There are an infinite number of ways in which to encourage more innovation generation. Traditional funding from government programs like the NIH for formal R&D laboratories has been proven to be effective (Martin & Tang 2007). In addition to these traditional activities it is also important to focus on programs that encourage autonomous innovation. Several examples that exist in various ecosystems include conferences / meetups[4], hackathons, and prizes.

Conferences and meetups provide a critical activity in educating engineers (ie solution rich environments) to critical needs worth solving. A good example of these types of conferences are the Pain Points in Healthcare meetup in Boston, as well as larger conferences such as Health 2.0's Matchpoint Conference. Because location matters, it is critical that these activities take place frequently and in all ecosystems; a conference in San Francisco is unlikely to impact the autonomous innovation of Boston. Furthermore, it is important that conferences be part of a larger ecosystem in order to have impact.

Hackathons are another example of an event type that encourages autonomous innovation. A hackathon can have any number of formats, but a very common format is a weekend long event in which a diverse audience of clinicians, engineers, entrepreneurs, and designers collaborate to develop new ideas that they think would help to solve a need in the world. While this format fills several different needs in the innovation ecosystem, one of those needs is to generate new ideas (or innovations) – which is to be expected given the theoretical framework about sticky information and lead-user innovation. A good example of these events is the Hacking Medicine events in Boston (http://hackingmedicine.mit.edu).

A final program type that encourages both autonomous innovation as well as formal R&D are prizes. Prizes, such as the XPrize Tricorder (http://www.qualcommtricorderxprize.org/) can be very effective at focusing and driving innovation toward a specific goal (Murray 2012).

As showcased above there are a number of ways to encourage innovation both in formal R&D environments as well as in autonomous environments. We will see later how these efforts fit into specific ecosystems throughout the country.

Team Formation:

A dynamic innovation ecosystem needs to have both innovation capacity and entrepreneurial capacity. Regardless of the source of the actual innovation, most new innovative products come from entrepreneurial entrants, and therefore require an entrepreneurial team. In order for the innovations to have impact in the world a firm needs to attract the necessary resources to create a viable innovation. We know that the ideal co-founding teams have diverse backgrounds and some history working together (Wasserman

[4] A list of frequent meetups in Silicon Valley, Boston, or New York can be found by searching for "digital health", "quantified self", "Health 2.0", etc.

2012). This is a particular challenge in healthcare because it is also the case that large hierarchical firms (exactly like the ones that dominate healthcare) are the least likely to generate new entrepreneurial teams (Burton 2001). To overcome this challenge we need to take extra steps in healthcare to encourage new diverse teams to form. This is a second, and important, role that conferences and meetups play in the innovation process.

It is also where hackathons excel. One reason why they are likely to be more successful than a standard meeting or conference is the fact that they time compress the experience of working together as a team. This is no replacement for time – ultimately it takes longer to identify if a team truly works well together, however, it can help to short circuit the process by acting as a useful first filter to show teams what it might be like to work together.

Interdisciplinary classes are another good example of encouraging this type of team formation. The audience for these is limited (as they only take place at Universities to our knowledge) however they have the same general effect as hackathons in that they encourage diversely skilled student teams to form around an idea for the length of a semester. A number of universities have good examples of these programs however one of the best is Biodesign at Stanford. It was originally focused on medical devices but has recently expanded its focus to include healthcare.

The ideal entrepreneurial team has a good culture fit that is hard to predict ahead of time in addition to the right set of skills and knowledge necessary to turn the core innovation into a new product or service while simultaneously building a new company to take the product or service to market, therefore the best ecosystems are those that have a number of different networking events, workshops (ie hackathons) and other activities (such as classes) to encourage diverse teams of potential entrepreneurs to work together as a test of whether they would make a good long term entrepreneurial team. This is at the core of why ecosystems with porous boundaries frequently perform best at generating new innovations.

Early Company Incubation:

There is a period directly after the entrepreneurial team has formed when the firm knows approximately the innovation it wants to create and it now needs time to build the company. This requires validating that the core idea can be built – ie turned from a technology into a product. It requires validating that the market has a need that is solved by this innovation in a manner that potential customers are willing to pay for. It also requires a number of logistical yet important steps such as incorporating, protecting IP, raising seed capital, and recruiting additional team members. Informal networks support all these. Networking events, open office hours from serial entrepreneurs, and community organizations (ie Health 2.0) support this process, which is yet another reason why these are important elements of an ecosystem. Accelerators are the most direct type of support for this activity. There has been a recent surge of new healthcare accelerators in the last five years driven initially by Rock Health. For a great review of these and other accelerators see: http://www.chcf.org/publications/2013/02/seeding-digital-health.

These accelerators focus on providing new firms access key mentorship resources that each of the elements of company development above. These organizations play a particularly key role in healthcare because they can help provide new teams with key skillsets through mentors and new team members that they would not otherwise have. As we've already noted in this paper the structure of current healthcare firms does not support or encourage the ideal team makeup and therefore it stands to reason that these accelerators can help serve a critical role by helping to support an early team that might be missing a particular skill or expertise. It should be noted however, that through their acceleration activities these organizations do not specifically encourage team formation or makeup for teams lacking a core skillset. In fact, most of these accelerators use team makeup as a core element of whether to accept a team into their accelerator so these are not a replacement for encouraging the right kind of team. However, they can be a useful support structure for a team that has most but not all of the skills and expertise necessary to be successful. Another important element of accelerators is to help entrepreneurs connect with industry partners. This can be the foundation of new pilot projects. In the next section we will discuss the need for testing and validation of new innovations and the unique challenges in digital health.

Testing and Validating a New Innovation:

As an innovation is developed and brought to scale, it must be tested and validated. For a new firm they frequently need to validate the market – validate that there is a customer willing to pay for what they are building. Market validation can be done with largely the same methods as with any innovation – through market research (surveys, customer interviews, letter of intent to pilot once it is built, etc). In addition to market validation, a young firm must also validate the clinical value of the innovation[5]. Generally, this process happens through a formal research pilot (similar to a clinical trial for a drug or device) or through an ad-hoc pilot with a specific physician or group of physicians. Formal research pilots can take months (or years) to setup and require a substantial amount of buy-in from everyone in the clinical organization. This process can easily take 6 months to a year. Many innovations simply find a physician who is excited to help pilot the given innovation with a group of willing patients. This latter approach, while often faster and more flexible relies on the personal and professional networks of the entrepreneurs involved, and subsequently limit the likelihood of autonomous innovations.

While any medical innovation can likely be approached (and should be) in an iterative fashion, digital health presents a unique opportunity to approach innovation in an especially iterative fashion. This is due to the fact that the product development life cycle of software is very short and iterative. It is also the result of the fact that the original core

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[5] It should be noted that some digital health innovations are focused on providing backend tools for healthcare organizations, either as tools for the organizations (such as EMRs) or as tools for individual physicians (such as applications to help physicians text each other). We are focused here on describing the validation process for digital health innovations that are focused on meeting a clinical need.

innovation and the resulting product are more decoupled than they might be in drug development.

To better understand several of the unique components of testing and validating digital health innovation, consider The Diabetes Prevention Program (DPP) (Orchard 2005). The DPP is a lifestyle intervention that slows the progression of Type II Diabetes. Omada Health (http://omadahealth.com/), a startup in San Francisco, is trying to bring this innovation to scale by delivering the intervention through a web and mobile experience. The original innovation was the actual design of the lifestyle intervention. It is reasonable to expect that the intervention will have the same effect through a website as through paper based interventions. However, because the delivery mechanism is different it needs to be re-validated, though it is less a question of whether it will work and more a question of exactly how to construct the software to achieve the original results. Thus it is critical to enable a validation environment that matches this iterative process.

In drug development this does not happen because the core compound does not changed. Once the drug itself has been developed it is then validated. The development of the software itself is so flexible that it enables a test and iterate cycle that is not possible with drug development. In an ideal development environment, the process of validating this innovation would be iterative. For example, a group of users who have volunteered to help test a product would be able to rapidly give feedback on each new iteration of the product (which might be as often as daily or weekly). This iterative process would continue until the product began to show the clinical impact expected by the original core innovation.

There are very few formal organizations or programs to reduce the barriers to an entrepreneurial firm finding a pilot site. Generally these include:

1. Networking events: as mentioned earlier these help build informal networks, and thus they can be a source of encouraging more pilots to happen.
2. Accelerators: attempt to connect their participant entrepreneurs with the right people at healthcare organizations who can help them establish a pilot at their organization. In particular the New York eHealth Accelerator actually accepts companies with the guarantee of a pilot.

Summary

We have presented a framework here for understanding the key activities that the different organizations in the digital health ecosystem support. Those activities include the generation of new innovations, the formation of a team around those innovations that can drive them forward as new firms, support them, and incubate them, as well as help with the process of validating these new innovations as they attempt to reach scale.

Data Collection and Methods:

In order to collect data about the state of each of these ecosystems we did a cursory review of a larger number of ecosystems (shown in Figure 2 below), before doing a deeper

analysis of our three core ecosystems. We collected data by searching the web for innovation organizations and programs by location as well as visiting frequent organizing sites like meetup.com. Finally, we interviewed a number of entrepreneurial experts in each ecosystem in order to double check that we discovered the majority of organizations driving the innovation ecosystems. It is impossible to know if we have captured every single group and organization supporting innovation, however, our primary goal is to get a sense of the types of activities happening in each ecosystem and therefore our analysis does not rely on capturing 100% of the activities that are ongoing in each location.

In addition to researching the activities in each ecosystem we wanted to assess the inputs and outputs of each ecosystem as well. Therefore, we captured the "entrepreneurial capacity" of each region in a 1 – 5 score representing the degree to which our interviews uncovered a cultural bias for innovation as well as the degree to which we found specific organizations supporting every stage of the innovation framework presented in this paper. We then specifically assessed the formal R&D capacity of each region by totaling the amount of NIH funding in each region, the total VC funding in each region (not only digital health), the number of early stage digital health investment deals, and the number of meetups on meetup.com that pertain to healthcare innovation.

We assess the NIH funding using the online tool to download all funding data from the NIH by institution and city (see http://report.nih.gov/award/index.cfm). We then grouped the cities according to each ecosystem's region and summed up the total funding. We used a Price Waterhouse Coopers report to assess the total VC funding in each ecosystem in 2012 (see https://www.pwcmoneytree.com/MTPublic/ns/index.jsp). The number of digital health investment deals was computed in an investment report from Rock Health (see http://www.slideshare.net/RockHealth/2012-year-end-funding-report). Finally we computed the number of meetups by searching that site's repository of activities. The results are presented in the table below:

	Eship Cap	NIH	Total VC Funding	Digital Health Deal Count	Num. of Meetups
Boston	5	$1,770,846,123	$3,296,474,700	20	4
Silicon Valley	5	$1,264,047,030	$10,968,046,700	27	9
Baltimore	1	$1,254,961,675	$735,402,000	2	3
Seattle	2	$868,378,028	$1,052,501,000	5	1
NYC	4	$823,040,093	$2,360,490,700	2	15
Chicago	3	$710,112,866	$1,391,918,800	7	2
Cleveland	2	$303,296,477	$285,750,500	2	0

Figure 2: Quick overview of key metrics for various ecosystems

Additionally, the following table presents an overview of the organizations that we investigated and considered as part of this process across each of the ecosystems that we reviewed.

	Stage				
	Innovation Generation		Team Formation	Initial Incubation	Test / Validate
Region / Organization	Formal R&D	Autonomous			
Boston					
Center for Connected Health @ MGH	X				X
Stoeckle Center @ MGH	X				
CIMIT @ MGH	X			X	X
Innovation Fund @ Boston Childrens	X				
Hacking Medicine		X	X		
Rock Health				X	
Healthbox				X	
Oreilly's Health Foo		X	X		
Strata Rx		X	X		
Health 2.0 Conferences		X	X		
Silicon Valley					
Garfield Center @ Kaiser	X				
Biodesign		X	X		
Rock Health				X	
StartX Med				X	X
Oreilly's Health Foo		X	X		
Health 2.0 Conferences		X	X		
Strata Rx		X	X		
Health Hatch (https://www.healthtechhatch.com/)					X
Prebacked (http://www.prebacked.com/ignition/bcbs#schedule)			X		
Baltimore					
TEDMED		X	X		
Center for Bionengineering Innovation and Design	X		X		X
Seattle					

MacColl Center for Healthcare Innovation	X				
NYC					
NY Digital Health Accelerator				X	X
Blueprint				X	
Wired Health Conference		X	X		
Strata Rx		X	X		
Chicago					
NUvention		X	X		
Healthbox				X	
Health 2.0 Conferences		X	X		
Cleveland					
Cleveland Clinic Innovation Alliance	X		X	X	X
Minnesota					
Mayo Clinic Innovation Center	X				
All Regions					
Data Design Diabetes Competition	X	X			
XPrize Tricorder	X	X			
Health 2.0 Dev Challenges		X	X		
Startup Health				X	

Key Regions of Innovation

In order to get an overview of the relationship between innovation capacity in each region and level of entrepreneurial activity, we charted the level of NIH funding in each region against the entrepreneurial capacity of that region. This can be seen below:

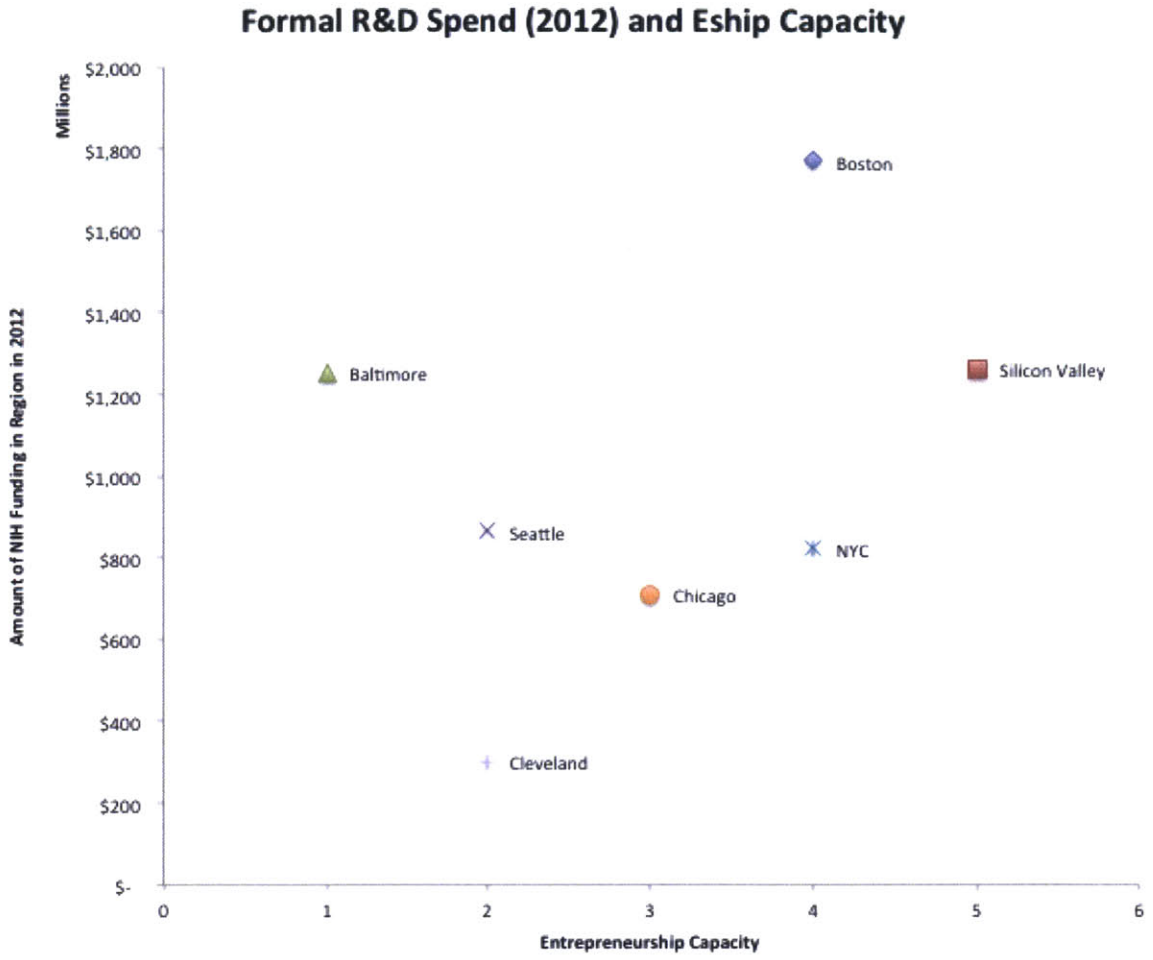


Figure 3: Formal R&D spending measured by NIH funding, and entrepreneurial capacity as measured by evidence of entrepreneurial ecosystem.

We then did a deeper analysis using our framework and the data presented above of three key innovation ecosystems: Boston, SF / Silicon Valley, and New York City.

We chose Boston because it is one of the major innovation ecosystems, independent of industry, and because it is particularly known for healthcare innovation driven both by its innovative policy environment and the number of research universities per capita. San Francisco and the Silicon Valley innovation ecosystem is still the premier ecosystem in the world and thus it is critical for us to analyze it through the lens we have been developing in this paper. We chose New York as our third ecosystem because the New York eHealth Collaborative and its associated Digital Accelerator are very unique features that we have not seen replicated elsewhere.

Ecosystem #1: Boston

Boston is arguably the best innovation ecosystem for healthcare in the world. Certainly, at the level formal R&D activity it is home to a number of the world's top research universities and it is consistently the largest recipient as a region of NIH funding (Weisman 2013). Probably the single weakest point regarding Boston (especially compared to Silicon Valley) is its culture (Saxenian 1996). It is home to a great entrepreneurial culture, however, that culture is not as open and collaborative as its counter part in Silicon Valley. This was one of Saxenian's key findings and we also noticed it in interviews of the two ecosystems.

There are a couple of groups in Boston that specifically try to encourage autonomous innovation as well as diverse team formation. These are, however, areas that are ripe for more activity. Especially given the level formal R&D activity our framework suggests that substantially more innovation would be generated and scaled by focusing on encouraging autonomous innovation and team formation. It is also important to note that there is a very active Venture Capital and Angel Investing community in the Boston area. This makes it easier to get seed funding than in other ecosystems. It also can be a source of team formation as VCs act as the center of networks. Several of the teams that we interviewed for this paper mentioned finding key talent through local Venture Capitalists.

Boston has great support for early company incubation. It has two accelerators focused on healthcare and a third very high quality accelerator that has mentored healthcare companies in the past. It has two formal entities that support early stage validation of innovations and startups; CIMIT and Center for Connected Health. Support for pilot projects would greatly benefit from an enhanced culture that was more encouraging of experimentation and openness. We did not find the same reception when interviewing members of the healthcare community in Boston as in San Francisco. Additionally, Rock Health was conceived of in Boston (at Harvard Business School) yet it was founded in San Francisco because they could not find receptive partners in the Boston medical community to collaborate with.

Ecosystem #2: San Francisco / Silicon Valley

In this paper we treat San Francisco and the Silicon Valley as a single ecosystem. As one ecosystem it is the most dynamic engine of innovation in the world. While it does have a wealth of programs for supporting entrepreneurship and innovation, as we will see in a moment it is not clear that it has more than the Boston community. However, what it does have is an advantage on culture. Its culture supports an openness that supports grass roots level cross-pollination. While this impacts a number of different areas across the innovation ecosystem, it particularly impacts autonomous innovation as well as validating new ideas.

Several programs that the Silicon Valley ecosystem has that are unique are the StartX Med community and the Biodesign program. The biodesign program is primarily focused on medical devices, however, recently it expanded its focus to encompass digital health. The program is particularly good at encouraging diverse groups of people to collaborate on new innovations. StartX Med is an accelerator run by a young group of Stanford students (though it is a separate non-profit). It is notable because it has encouraged collaboration

and innovation between the Stanford Hospital and innovators who need help establishing a pilot project or an opportunity to test and validate.

Ecosystem #3: New York City

New York City has been making a serious commitment to innovation generally in recent years. With the introduction of General Assembly, the Mayor's initiative to bring in an applied sciences technology campus, and the New York eHealth Collaborative, there are a number of new programs and efforts to encourage autonomous innovation and team formation. However, many of these efforts are not specifically focused on healthcare. As can be seen in the chart below, there is significantly less support for generating innovation as well as for team formation.

Notably, however, New York's eHealth Collaborative recently established a Digital Health Accelerator. This accelerator gives portfolio companies up to $300,000 and a guaranteed clinical pilot partner to help validate the idea. This is the first example of an accelerator (that we know of) taking an explicit role in ensuring seed stage funding, early company mentorship, as well as an environment to validate against. The primary challenge for New York is culture. They don't have a culture of innovation. This is beginning to change outside of healthcare through organizations like General Assembly. We found significant cultural challenges, however, in the interviews we did relating to the academic medical centers. There was a significant stigma about participating in commercial activities. This resulted in hesitation about spinning companies out of academic centers of innovation as well as for participating in the early stage validation or development of a company.

Discussion:

One overarching theme is the degree to which an ecosystem as innovation capacity versus entrepreneurial capacity. As seen in Figure 3, some ecosystems have substantial innovation capacity, however they lack the entrepreneurial activities necessary to encourage the rest of the innovation life cycle in our framework. These ecosystems could likely extract substantial value by focusing on adding events and activities that support team formation, company incubation, and validation support. A good example of this is actually Cleveland Clinic. The innovation center is one of the few organizations in the country that focuses on this entire life cycle. More needs to be done in Cleveland, but the innovation center is a significant step toward adding entrepreneurial capacity.

For some ecosystems, the challenge is creating innovation capacity. This is often particularly daunting for policy makers because they naturally default to assuming that they must build a world-class research institute in order to increase their innovation capacity. This is certainly an admirable aim – and likely worth the investment – however, it is not required. As we have seen in Boulder, CO, a dynamic innovation ecosystem can be built without significant participation from the local university. As described in our framework, ecosystems that need to generate more innovation capacity should focus on autonomous innovation (mixing problem rich and solution rich environments) as a method

for generating more innovation. This does not require significant public resources to achieve.

Another critical element that most ecosystems overlook is culture. As we saw above Silicon Valley is not (as measured by the number of programs) the obvious center of innovation and entrepreneurship – however it clearly is. There is a long background literature establishing the importance of culture in encouraging innovation. The key elements of an entrepreneurial culture include encouraging openness to new ideas and a high tolerance of failure. This is a culture that is often at odds with the other needs and requirements of healthcare. For example, it has been shown that different companies generate radically different rates of entrepreneurial activity (Burton 2001). One of the key reasons for this appears to be the culture of an organization. Hierarchical organizations in which the roles within the firm specialized and routinized (a description of most American hospitals) exhibit lower rates of entrepreneurial activity. In fact the nature of delivering reliable high quality medicine relies on this specialized and routinized culture (Gawande 2010, Gawande 2012).

Culture is one of the areas that we found most frequently overlooked when reviewing innovation ecosystems. When discussing medical innovation with one interviewee when discussing innovation at Mayo Clinic:

"You know the classic saying, if you have an innovation policy you aren't innovative. While there are a number of [important] structure programs to encourage innovation, the most important thing they [Mayo Clinic] do is to encourage a culture of innovation. They encourage individual physicians to participate in startups and test and prototype new ideas."

One example, we found of an organization encouraging an innovative culture was at Partners Healthcare in Boston (though there may be many more). They supported new innovation projects through an internal competition and fellowship, which empowered IT staff to commit a portion of their time to a specific project of their choosing for a year. We also observed an internal program at Aetna in which employees can apply for internal funding for project ideas. If awarded they are allowed to spin the project out as a separate company.

Culture is also very important in inspiring testing / validation because it encourages physicians to innovate without permission. When open innovation and risk are encouraged, it encourages clinicians at a grass roots level to collaborate with engineers and technologists. One impact of this as described above can be the innovation itself, however, in many cases it can also lead to the development of informal networks which lead to new ad-hoc pilots and opportunities to validate a new idea.

Better support for the pilot process is a key opportunity, especially for clinical organizations. One idea for doing this includes encouraging a culture among physicians that towards experimentation. For example, Google employees are allowed to spend 20% of their time on side projects. These frequently become the basis of new innovations such

as Gmail and Google News (Mediratta and Bick 2007). This could be done in medicine by encouraging physicians to spend 20% of their time developing new innovations of their own or piloting new innovations from others. Additionally, they could devote some of the innovation center resources to validating innovations as opposed to exclusively focusing on new innovations. In this process the healthcare ecosystem needs to acknowledge the iterative nature of software development and adapt its piloting processes (which were designed with drugs and devices in mind) to the process of piloting digital innovations.

As Brad Feld points out in *Startup Communities*, building an innovation ecosystem has to be lead by the innovators (in his terms that's the entrepreneurs) themselves. They have to make a 20-year commitment. One of the first steps is to encourage these leaders in your community to take a leading role. Part of engaging these leaders is that they can be key connectors which can lead to connecting younger innovators who might form the basis of autonomous innovations as well as help to accelerate the testing / validation steps, and they can also support the early company incubation through angel financing and more importantly mentorship.

Larger firms (hospitals, insurance providers, pharmaceuticals, device manufacturers, etc) can play a key role in the community. They can help to create more porous boundaries within their organization as well as to reward risk taking and even failure. These steps help to encourage an innovation culture. They also can be the basis of further encouraging autonomous innovation, supporting firm incubation, and more rapidly validating new ideas. There are many benefits of moving to an open innovation culture for established firms (include citation), while we wont repeat them all here, several key ones include accelerating learning within the established firm by exposing it to outside experts, enhancing existing regional clusters which can have a net benefit for the established firm, and giving that firm the capacity to test new ideas through alternative startup vehicles which can be acquired if an idea turns out to work. Similarly, the government can enhance the innovation process by encouraging and funding innovation, and celebrating its successes. In particular, policies which focus on reducing the barriers to testing and validating new ideas will encourage more rapid digital health innovation. Culture is the area that is most commonly overlooked in our experience. This may be because policy makers feel it is something that they cannot affect. As we have seen above, there are programmatic activities that can be encouraged which celebrate certain cultural ideals of experimentation and openness that can be critical to pushing an ecosystem's culture in the right direction.

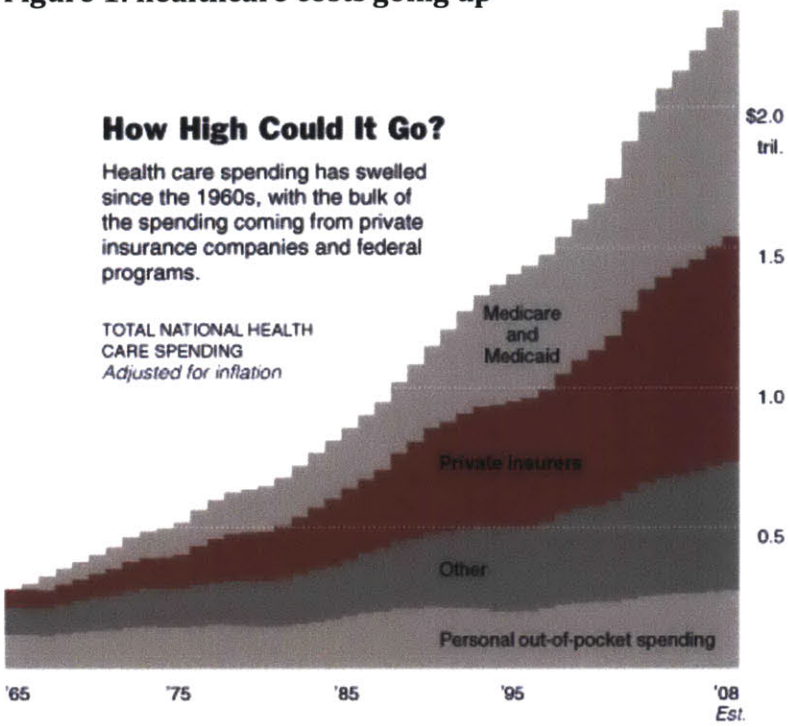
Conclusion

In this paper we have presented a framework for understanding the digital health innovation ecosystem as well as a methodology for analyzing a given ecosystem to look for opportunities for improvement. Innovation ecosystems can be constructed in a variety of ways and should not be dependent on a singular model of innovation (such as a science push model). More research needs to be done to validate the specific values of the different elements of our framework. While motivated by empirical evidence from the literature, future research should seek to validate specific program activities and the degree to which

they support each stage of the process. Finally, community leaders, policy makers, and large firms can help to drive these innovative ecosystems by collaborating on programs that encourage each stage of the innovation lifecycle as well as by focusing on the culture of a region in order to encourage it to be more porous, more focused on experimentation and taking risk, and ultimately more supportive of innovation.

Appendix

Figure 1: healthcare costs going up



Out-of-pocket spending includes co-payments and deductables. Other includes spending for the Department of Defense, Veterans Affairs, children's health and other programs.

Source: Centers for Medicare and Medicaid Services, Office of the Actuary THE NEW YORK TIMES

Figure 4: Increasing Healthcare Costs

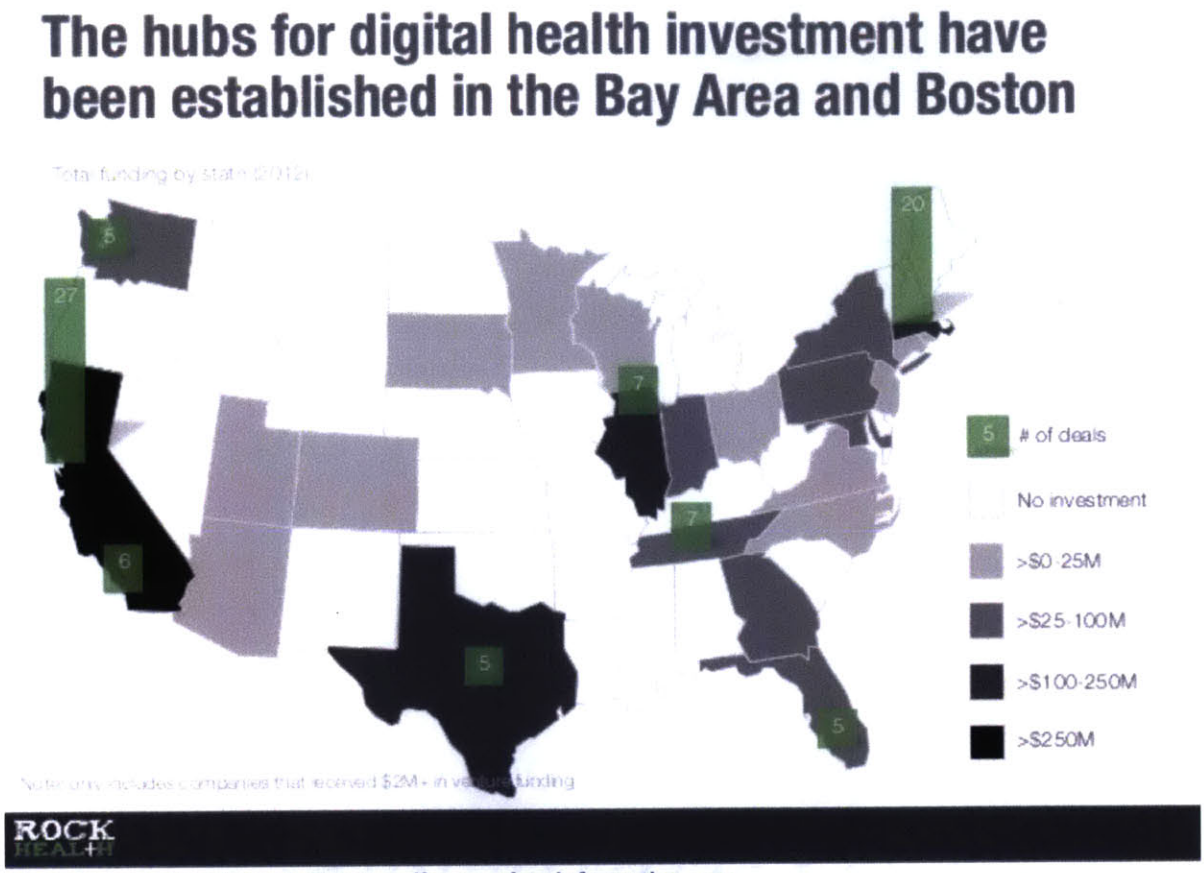


Figure 5: Rock Health Funding Report (for complete information, see: http://www.slideshare.net/RockHealth/2012-year-end-funding-report)

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