The Future of Primary Care:
An Engineering System Approach to Fix the U.S. Health Care System

by

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Abstract

The ailing U.S. health care system faces two tremendous challenges: a rising health care bill and a growing number of uninsured individuals. Several policies have been enacted to tackle these challenges but they are short-term patchwork solutions rather than long-term holistic solutions needed to address structural issues. Despite the market-based aspect of the U.S. healthcare system, self-correction of structural inefficiencies is unlikely to happen. A new care model has to disrupt the current care system. In line with this observation, we propose to analyze the potential of a new primary care delivery as a solution to address the two key challenges threatening to destabilize the U.S. health care.

Based on our analysis of the literature, we note that chronic diseases account for a large proportion of the health care bill. Yet, the delivery model to provide chronic care, where primary care plays a central role, is inefficient, fragmented and insufficient. Compounding these ailments, primary care is facing its own crisis resulting from the shortage of generalist doctors and the inflating demand for primary care services. As primary care is critical for the continuity and coordination of medical care, resolving the urgent situation facing this branch of practice should be a top priority to improve quality of care while reducing health care costs. Every stakeholder in the current health care system should collectively contribute to the primary care model redesign endeavor.

To this end, we apply an engineering system approach to devise an appropriate course of actions for health care businesses, health care providers and policy-makers in redesigning primary care. We discuss insights gained through a collaborative project with a local hospital to model and simulate a new primary care practice. These insights were geared to guide decision-makers in the design of care processes, resources allocation and appointment rules.

In conclusion, we show that primary care has a critical role to play in the much-needed revolution of the U.S. health care system. It will require active collaboration of health care providers, business leaders and policy-makers to enable this disruptive change.

Thesis Supervisor: Dr. Mahender Singh
Research Director, Center for Transportation and Logistics

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Chapter 1: Introduction

1.1 Background

Health is perhaps the most valuable asset a person has, at least it is a truth that is revealed during an episode of illness. In fact, a reliable, high-quality, affordable and accessible health care system is crucial not only to the well being of the individual but also to the economy of a nation. Interestingly, countries have adopted different approaches to manage their health care systems. While most have adopted universal coverage with strong support from the government (i.e., France), a few have adopted a market-based system (i.e., the United States).

Every nation is faced with health care system challenges, for the difficulty to optimally allocate limited and costly resources to serve an ever-increasing demand. In particular, the U.S. health care system, where the costs are high compared to other industrialized nations[1], has been ailing for several decades. It is one of the most interesting health care systems to study as it is a complex system that encourages cutting-edge innovation in health care while at the same time managing to deliver subpar quality of care when compared to other countries. We will take a deep look into the confounding challenges of the U.S. health care system and apply engineering systems approaches to study them.

Various studies published by the Institute of Medicine have analyzed the U.S. system and recommended actions to mitigate problems pertaining to quality, efficiency and access[2]. Skyrocketing healthcare costs and growing number of uninsured individuals are exposing the existing inefficiencies and burdening an already struggling system. Local improvement initiatives pioneered by states and hospitals seem unable to handle nation-wide challenges.

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[1] OECD Health Data 2008

[2] The Institute of Medicine published several books on the U.S. health care challenges: The Err is Human: Building a Safer Health System (2000), Crossing the Quality Chasm: A New Health System for the 21st Century (2001)

1.2 Motivation

There is a pressing need for a game changing solution to stabilize the U.S. health care system. Given the idiosyncrasies of the U.S. healthcare system, as we will explain later, Adam Smith's "invisible hand" will not correct market inefficiencies. Compounding these shortcomings, the inherent uncertainty of health and medical delivery creates information asymmetry at every level, leading to frequent market failures such as adverse selection or moral hazard. The flow of information and the power relationships among health care stakeholders are obscured by these market failures, limiting their ability to interact and collaborate decisively.

Indeed, a patchwork of solutions will not be sufficient for this ailing health care system. A simple model focusing on a single aspect of the problem cannot capture the complexity of the situation. Every stakeholder has a role to play individually and collectively in helping to improve the U.S. health care system. A system-thinking driven approach presents a promising avenue to tackle such a critical challenge in an innovative and effective way. A comprehensive view of the situation will lead to effective actions for the betterment of the system as a whole.

My thesis is an attempt to shed some light on underlying issues and contribute to this endeavor, to offer a holistic view of a large-scale problem and provide a broad range of perspective for better alignment between policy makers, businesses and medical providers. Policy makers can promote and coordinate actions, businesses can innovate and help medical practitioners to do their job more efficiently, and medical providers can institute change and make effective change happen. Therefore, an engineering system approach bringing together health care providers, policy-makers and business leaders to work collectively on the U.S. imminent challenges can deliver tremendous value.

1.3 Problem Statement

Quality and costs are the top priorities in the government agenda to revamp the health care system. This challenge is at the heart of the research question as well, specifically: "How to improve quality of care while reducing costs in health care?" However, the essence of the question evolved throughout our research endeavor as we deepened our knowledge and understanding of the U.S. health care industry. At first, the research approach focused on leveraging business practices to improve operational efficiencies in hospitals, for instance practices from manufacturing and high-tech companies that faced similar challenges to produce high quality products at low cost.

To demonstrate the value of these management principles, we joined a project at a local hospital in Boston aiming at improving quality and efficiency in the Department of Anesthesia through the use of new Information Technology tools. As the project progressed, we realized that the bigger opportunities were available if we considered system-wide improvements rather than local improvements. The approach to the research question then broadened to look at how innovation could be fostered within health care to deliver system-wide improvements.

To this end, we obtained a unique opportunity to join an innovative project at a local hospital in Boston. This particular effort was interested in launching an entirely new primary care practice. Given the central role of primary care in the overall delivery of care, a new primary care practice has the potential to revolutionize the entire U.S. health care system and to provide system-wide improvements. Informed by this new development, we reformulated our research question as follows:

"Can a new primary care model be a solution to U.S. health care challenges?"

1.4 Research Approach

To better understand the complexity of the current situation in the U.S. health care, we conducted a thorough literature review on the health care system, its dynamics, and its challenges using multiple sources of information. We reviewed publications from large recognized institutions (World Health Organization, Institute of Medicine, OECD reports, etc) to gain significant insights into the U.S. health care as well as past initiatives designed to tackle these already existing challenges. We reviewed articles pertaining to the importance of primary care and its potential impact on the health care system. In parallel, we surveyed the literature on innovation from academic journals (Academy of Health Care Management Journal, Journal of Internal Medicine, etc) and from business reviews (Harvard Business Reviews, etc). We also leveraged the extensive experience and knowledge of the Engineering System Division faculty and researchers to learn about leading management practices and system approaches developed in other industries.

In order to grasp the state-of-the-art in hospitals' practices and particularly in primary care practice, we conducted informal interviews of medical practitioners to study IT integration in hospital setting. To understand the business planning challenges and opportunities in another industry, we undertook a project with a large consumer product company aiming at helping them improve their strategic planning process.

Finally, as part of a collaborative project with a local hospital in Boston, we contributed to their endeavor to design an innovative primary care practice. Our role was to build a simulation model of the future practice. We analyzed and presented the results to decision-makers to guide in the design of the future practice for optimal operational efficiency. We also provided medical practitioners' with our vision of innovative business practices and of design policies critical to the success of the practice. The project may significantly contribute to alleviate current issues in primary care by improving both patients' and doctors' satisfaction. If the new care model demonstrates its value, it can serve as a successful implementation of a disruptive business process eventually leading to a system-wide adoption and improvement.

1.5 MEHD Group

Throughout my research, I was sponsored by the MEHD research Group (The MIT Efficient Healthcare Delivery Group), which is a research consortium launched in Summer 2006 by the MIT Center for Transportation and Logistics (CTL) aimed at driving innovation in healthcare supply chain management. CTL believes that MIT's considerable expertise in tackling large-scale complex systems will lead to breakthrough developments in a domain that has traditionally been addressed in operationally focused and fragmented ways. The mission of The MEHD Group is to envision the future of the healthcare system and create new knowledge, new technologies, and new business practices that will help improve healthcare delivery everywhere.

1.6 Thesis Outline

In Chapter 2, we present the fundamental characteristics of the health care industry, and the specificities of the U.S. health care system in terms of its dynamics and its looming challenges based on general literature review. Chapter 3 introduces the basic role of primary care as well as the potential benefits of a strengthened primary care infrastructure compared to a strengthened specialty care infrastructure. Subsequently, we analyze the latent positive impact of primary care on U.S. health care challenges. In Chapter 4, we describe the current crisis in primary care based upon an analysis of financial and structural incentives of the practice. Chapter 5 is dedicated to the methods and tools to devise appropriate approaches to revamp primary care. In Section 5.1, we discuss the case study at a local hospital to help them set up their new primary care. The results are presented in Section 5.2. Finally, we draw recommendations for policy makers so as to deliver the promise of a better future health care system in Chapter 6.

Chapter 2: The U.S. Health Care System

In this chapter, we describe the U.S. health care system and its unique attributes. The description is based on information drawn from different sources of literature so as to present an objective perspective on health care. An introduction to the uniqueness of health care and the structure of the U.S. health care system is necessary to understand the current state of the system and the existing challenges. Various health policies have been enacted to alleviate these challenges, but none has focused on the structural deficiencies, possibly due to the long history of the U.S. health care system. We will analyze the stakeholders and the complex financing mechanisms in U.S. health care market. It will provide a quick overview of the dynamics of the health care system and present the two most critical challenges the system is facing: rising health care costs and growing uninsured individuals.

2.1 Health Care is a Special Industry

Before analyzing the U.S. industry in detail, it is important to outline the differences between health care viewed as a product and other commodity product. Reviewing the fundamental differences will help us better understand the health care industry, its particular dynamics and its profound challenges. This will in turn help us understand the design of health care delivery supply chain, from money, patients to medical resources.

A definition of Health Care

Health is perhaps the most valuable asset a person has, at least it is a truth revealed during an episode of illness. Unlike commodity product such as corn, where demand and supply follow relatively predictable patterns at least in the short-term, there are significant uncertainties in the demand and supply of health care. Specifically, the delivery process of health, the effectiveness of health delivery and how much health care is needed for a particular condition are all unknown to a large extent.

The World Health Organization defines health, as "Health is a state of complete physical mental and social well-being and not merely the absence of disease or infirmity"[3]. Interestingly enough, in this definition, health includes the notion of welfare in the comprehensive aspect of care, which goes beyond the simple model of "fixing" a disease, as is the case for a car repair shop. We can picture the comprehensive definition as a consumer-focused insurance company, which would perform regular check-ups for the consumer in order to better guide him into safe and lasting utilization of his car. In practice, however, the notions of welfare and comprehensiveness are often forgotten. We have evolved into a society of mass consumption of products and services, where freedom of choice is key to maximizing personal satisfaction and well-being. Health care is different; it is a unique type of service that requires an appropriate delivery mechanism.

Guided by the general definition of health, the health care industry has several unique features. Kenneth Arrow in his 1963 paper described the fundamental differences between health and the standard definition of a commodity[4]. Arrow characterized the demand for health care as irregular and unpredictable, while being costly to the patient as it can impair its personal integrity and affect its productivity for an uncertain period of time. Also, he outlined the expertise and trust driven nature of supply, as provision of health care requires significant amount of knowledge and involves the central role of trust in the delivery process.

Uncertainty of a disease condition, non-measurability of the treatment efficacy and unpredictability of health evolution are inherent characteristics of the health care industry. It requires health delivery mechanisms to be very adaptive and flexible to deal with unexpected health problems and health outcomes. There are various types of health delivery systems. Some delivery mechanisms are tailored to specific conditions, especially for complex and not well-understood diseases where the source of the disease has not yet been identified let alone the availability of specific drugs for the treatment.

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[3] Preamble to the Constitution of the World Health Organization (1946)
[4] Arrow, K. J. (1963)

The uniqueness of care delivery is a natural source of inefficiency as it is difficult to standardize care processes and to benchmark them for higher performance, which is a common practice in other industries.

New care delivery models

The traditional model of health care delivery, where a patient visits a physician for the treatment of a specific disease condition once symptoms arise, has evolved into a broad range of care delivery models due to innovations in medical science. Over time medical research has enabled better understanding of the onset and the evolution of certain diseases, which has allowed them to be treated in a standardized fashion. The improvements in the diagnosis, the treatment and the prevention of these well-understood diseases have empowered even non-medical staff to deliver reliable diagnosis, treatment and prevention. Even individuals can take care of their own health using simplified and robust self-delivery mechanisms.

A "service-driven" care model of medical service could now be designed to treat patients' latent or non-urgent conditions. It is not driven by the emergence of clear disease symptoms but by the awareness of something a patient would like to change in health. Eye or plastic surgery is an interesting example of the progress in medical science domain. Here the choices are safe and reliable procedures can be performed at the patient's request. This model has tremendous implications for medical care delivery in general since it created a whole new medical industry. At the same time, it may have influenced people's perspective on health care from a service provided *out of necessity* to a service provided *out of utility*.

Many other medical improvements initiated entirely different health care delivery channels that were based on self-diagnosis, self-treatment and self-prevention. By educating themselves, consumers are taking decisions on their own health. But the line between common diseases and complex diseases is blurring as some food or pharmaceutical companies would sell products claiming health benefits and enabling

consumers to cope with or to help fight complex diseases, such as cancer. Although not considered as medical drugs, herbal supplements appeal to consumers due to their alleged health benefits, fighting even cancer[5]. These practices may mislead consumers since it is inherently difficult to evaluate the accuracy of health claims made by various products. There are significant information asymmetries in the health care industry but also high uncertainty such that assessments of products and services are extremely difficult to conduct. Monitoring these "consumer-driven" delivery methods is then required to keep track of the performance, the quality and the costs. This delivery model has also changed the perception of health.

Complex diseases and chronic diseases are often age related. As the population ages and the baby-boomers are fast becoming a growing proportion of the population, more complex diseases and more chronic diseases are bound to surface. Compounding this factor, when people get older they lose their ability to treat themselves and they are reluctant to get educated. Suffering different types of diseases, requiring various types of treatment and lacking the independence to use appropriate treatment process, chronically ill and elderly patients face significant challenges due to the new care delivery mechanisms.

2.2 The United States Health Care System

The U.S. health care system is unique in many ways. In other countries, there is generally a central governmental entity (e.g. Ministry of Health) structuring and financing the entire health care system to coordinate operations of smaller systems in an orderly manner. In contrast, the U.S. health care system is highly decentralized and fragmented – see Figure 1 for a schematic representation of major health care stakeholders. The subsequent section will describe the fragmentation of the system.

[5] "The Growing Case Against Herbs - More Research Questions Safety, Effectiveness" by Chris Adams, The Wall Street Journal 08/29/2002

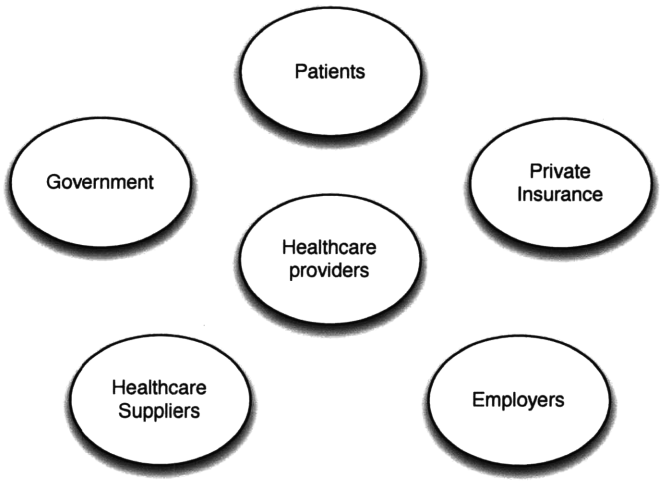

Figure 1: Schematic Representation of Health Care Stakeholders

2.2.1 A Decentralized and Fragmented System

There is no true central entity in charge of orchestrating healthcare delivery and healthcare financing. This is largely left to the pseudo market forces between large players in the industry to coordinate the entire system. In that sense, the U.S. can be deemed to be a market-based system.

This creates significant challenges for the patients since in order to receive care from providers; one has to deal with separate entities to treat a specific disease. There are no one-stop solutions in this U.S. health care system. Errors and miscommunications often result from poor coordination. To get an insurance coverage, to see a medical provider for diagnosis, to see the referred specialist for optimal treatment while working through administrative procedures to get reimbursement is particularly challenging for the chronically ill patients with multiple conditions, as they have to make their way through this health care maze.

Furthermore, there is no universal coverage in the U.S. and it is the only developed country in the world, except for South Africa, that does not provide health care for all of

its citizens[6]. Most people obtain their insurance through their employers, a likely reason behind the fact that significant proportion of the U.S. population does not have health insurance coverage. In 2008, the Kaiser Commission reported 45 million uninsured non-elderly people in the U.S.[7]. The U.S. healthcare system is driven by private and public health services, for-profits and non-profits resulting in a multi-payer, multi-state administrative structure. Given the decentralized structure of the U.S. system, we can anticipate independent behavior from stakeholders, optimizing locally for their own benefits.

If the objectives of various stakeholders are not aligned, this structure may lead to a suboptimal outcome for the entire system. As Jonas et al. pointed out, "it is amazing how much money and time these other areas of power and control, such as the pharmaceutical and insurance industries, spend to make sure that the United States does not have a single national structure for paying for, much less operating, its health care system"[8]. Proponents of the market based system in the United States argue that it is more efficient for the development and the diffusion of new technologies while opponents argue that it is detrimental to most Americans as it creates more inequalities in access, and quality, leading to a ever struggling health care system.

In a decentralized market-based health care system, every stakeholder is subject to competition to a certain extent. Based on the classical free market theory, competition among health care suppliers, providers, health insurance companies should give them incentives to innovate and provide patients with an array of products and services allowing them to choose the most appropriate service that meets their needs, expectations and resources. Healthy competition should force companies to strive for better quality, cost and service. Nevertheless, Michael Porter et al. outlined that "competition in the health care system occurs at the wrong level, over the wrong things, in the wrong

[6] Ayres (1996)
[7] Kaiser Commission on Medicaid and the Uninsured (2008)
[8] Jonas (2007)

geographic markets, and at the wrong time." Thus the healthcare system is producing inefficient outcomes[9].

2.2.2 Complex Financing Mechanisms

The cost of health care is borne by a complex combination of patient, employer, provider (doctors, hospitals) and a third-party payer (private and public insurers) resulting in convoluted and non-transparent financial streams – see Figure 2. Individuals pay for healthcare through four main channels:

- *government sponsored programs* (Medicare, Medicaid or state and federal programs)
- *employment-based health insurance* (discounted premiums)
- *individual health plans* (no benefits from group discounts)
- *out-of-pocket expenses*

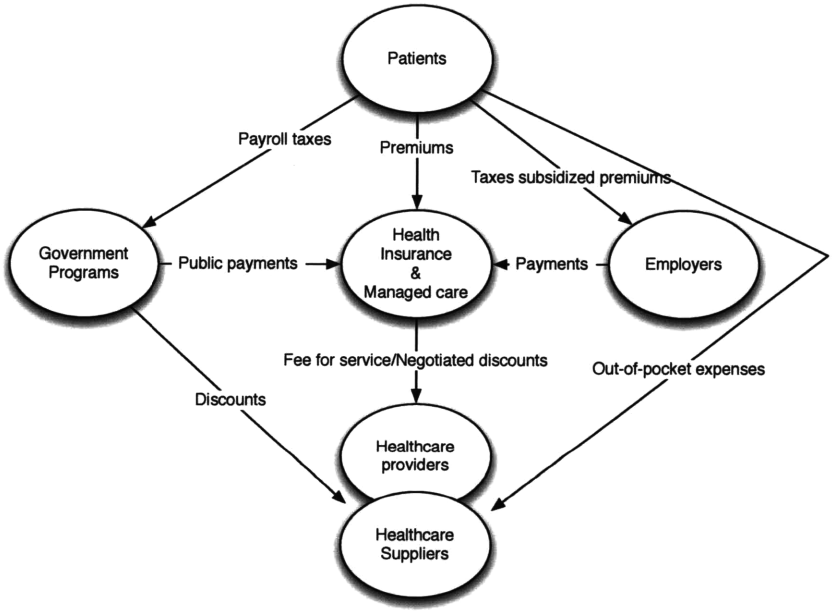

Figure 2: Financial Streams in the Health Care System

***Source*: OECD Health Data 2008**

Consequently, we can anticipate heavy procedural burden and high administrative cost to support the current health care system. Indeed, enormous amount of time, resources and money are spent to verify eligibility of patients for a specific procedure, to check health

[9] Porter et al. (2004)

benefits in the insurance plan, to calculate coinsurance and deductible, to collect payments, etc. According to Woolhandler et al., taken together, insurance carriers' overheads, employers' costs to manage health benefits, hospitals' spending on administration and physicians' expenses in administration was estimated to account for 31% of US health care expenditures in 1999, when the Canadian health care system spent half as much in administrative expenses[10].

In fact, a single payer system, where the government would cover most of the expenses incurred by its citizen, would enable dramatic savings on administrative costs. The administrative savings would probably account for more than $200 billion a year, exceeding the cost to cover all of the uninsured individuals[11]. However, universal coverage proposals face tremendous challenges given the aftermath of the Clinton's health care plan failure as well as the implementation of such a wide initiative in the context of a financial crisis.

2.3 The U.S. Health Care System Challenges

The U.S. health care system is one the most technologically advanced systems in the world providing new medical devices and drugs to deal with complex diseases fueled by the constant innovation brought by biotechnological and pharmaceutical companies. Yet, the health care system is facing tremendous challenges threatening its long-term sustainability. Given that the U.S. spends more than any other industrial country on health care, there is significant debate on the difference in equity and efficiency of health care as provided and population health outcomes relative to the country's total healthcare spending. According to the report "Why Not the Best? Results from a National Scorecard on U.S. Health System Performance" the U.S. ranks at the bottom among industrialized countries on healthy life expectancy at birth or age 60, and last on infant mortality[12]. Furthermore, there are large discrepancies between medical care access and quality

[10] Woolhandler et al. (2003)
[11] "One Nation, Uninsured" by Paul Krugman, June 13, 2005 NYTimes
[12] The Commonwealth Fund (2006)

across states, regions, hospitals and health plans.

There are two critical issues facing the United States healthcare system that have been highlighted by both presidential candidates during their campaign in 2008:

- the skyrocketing overall cost of healthcare
- the growing number of uninsured individuals

During the campaign, there was significant debate on how should both issues be addressed. President Obama planned to address the issue by reforming the health insurance system while reducing administrative costs with widespread adoption of IT solutions, which will reduce overall healthcare costs. Senator McCain proposed to contain rising healthcare costs so as to make health insurance affordable to the most in need.

2.3.1 Rising Healthcare Costs

In a multi-payer system such as the United States healthcare system, rising healthcare costs imposes significant burden on every healthcare payer. In 2006, the United States spent 15.3 percent of its GDP on health care expenditures compared with an OECD median of 8.7 percent[13]. Compounding the already higher expenditures on healthcare, total healthcare expenditures have been steadily increasing over the past years and are expected to continue their dramatic increase over the next decade. Projections by the Centers for Medicaid and Medicare Services estimated an annual growth rate of 6.6% through 2017. Given these predictions, health expenditures will grow faster than the US GDP. In 2007, it grew 1.8% faster than GDP and the United States will spend more and more of its GDP on healthcare in the future. Containing future healthcare costs is therefore a top priority for every future government.

2.3.2 Growing Number of Uninsured Individuals

One of the direct consequences of rising healthcare costs is the growing number of

[13] OECD Health Data 2008

uninsured individuals. An increasing number of people are taking the risk of being uninsured because health care coverage is too expensive. Some others overestimate their health or prefer saving money by not having health insurance when they are still young and healthy. A major consequence of people being uninsured is the higher risk of bankruptcy. "Every 30 seconds in the United States someone files for bankruptcy in the aftermath of a serious health problem."[14].

While most developed countries provide partial coverage for health care expenses of their citizens, there is no universal health insurance coverage in the United States. Individuals' out-of-pocket payments, private or public insurance policies, or publicly subsidized charity programs are the channels through which people pay for medical care. Over the years, insurance premiums have followed health expenditures and increased steadily making it harder and harder for the government to afford a universal coverage initiative throughout the country, even growing faster than inflation[15].

Employment is central to the United States insurance system. The employer provides most of the insurance coverage. This employment-based health insurance structure originates from the post World War II labor conditions where several limitations on wages forced corporations to offer additional health benefits to their employees to attract and retain them. Rulings from the US Supreme Court in favor of unions to negotiate health benefits packages for workers and additional government policies strengthened the employment-based insurance system with advantageous corporate tax policies[16]. The viability of such a system to pay for insurance may be questionable in today's environment.

There are serious ramifications of the uninsured on the overall U.S. health system and economy. When uninsured, individuals tend to forego preventive measures or preventive diagnosis; they have poorer health conditions than insured individuals, leading to worse

[14] Himmelstein et al. (2005)
[15] The Factors Fueling Rising Healthcare Costs 2006
[16] Thomasson (2003)

overall health outcomes[17]. The Institute of Medicine has analyzed the direct and indirect consequences of the uninsured individuals on the U.S. health system and economy – see Figure 3.

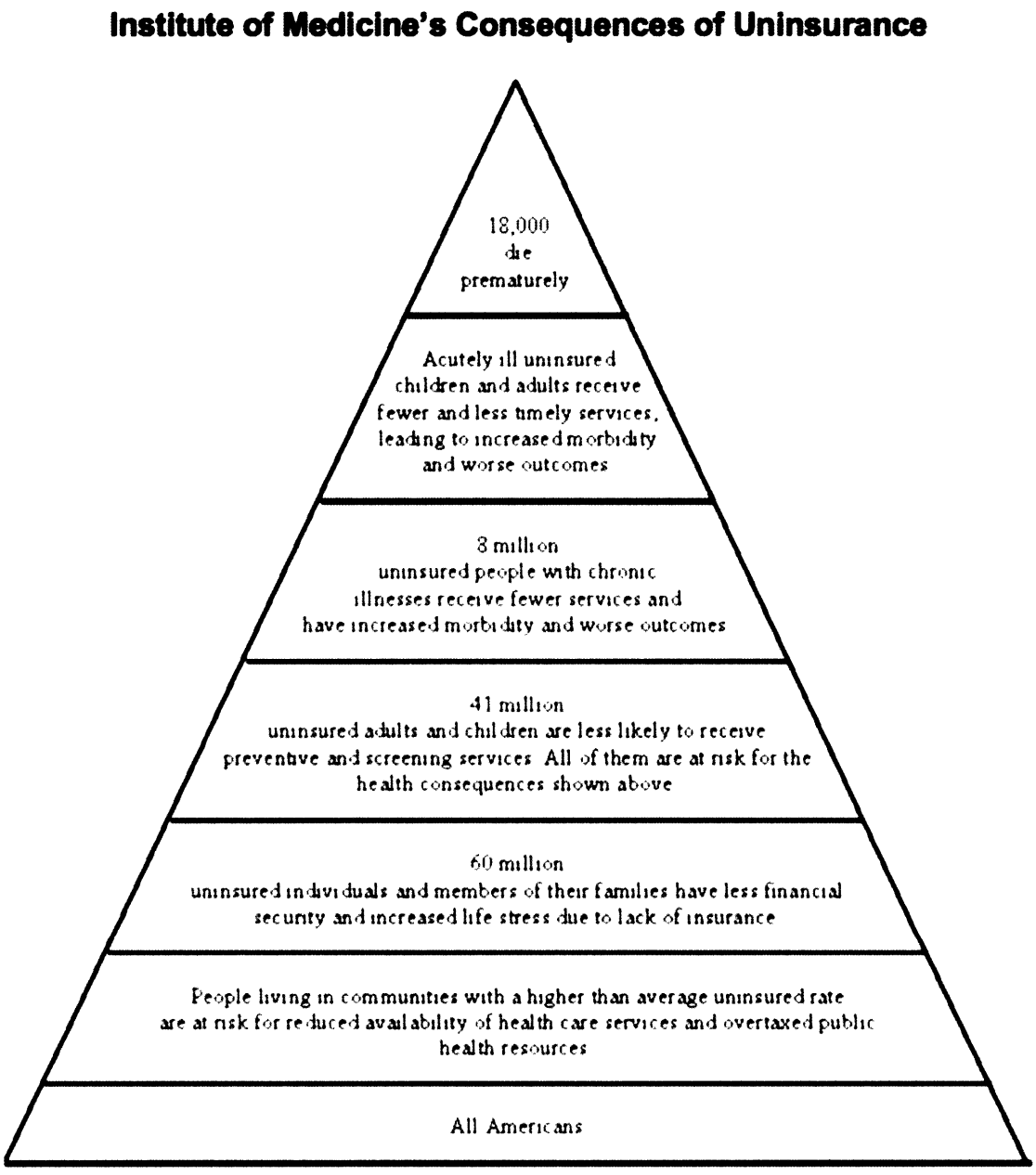

Figure 3: Impacts of the Uninsured on the U.S. System

***Source*: The Institute of Medicine (2003)**

[17] The Institute of Medicine (2003)

There are significant external and spillover costs imposed on the system to take care of the uninsured individuals. Indeed, they diminish the overall quality and availability of personal health services as they utilize community clinics and hospital emergency rooms. They also decrease the public health system capacity. As a consequence, there are higher taxes, budget cuts, and loss of other uses for public revenues diverted to uncompensated care. General workforce productivity also decreases as a result of overall population poorer health[18].

2.4 An Overview of U.S. Health Policy History

Health care challenges have always been a priority on governmental agendas. Various policies were enacted to contain costs and to improve quality of care. However effectives these policies were, it is useful to underline the past major health policies that shaped the current health care system, giving an overview of the current policy landscape.

2.4.1 President Clinton's Healthcare Plan

National health insurance initiatives were on the US political agenda during the late part of the 20th century. In 1994, President Bill Clinton sponsored the Health Security Act, proposing to achieve universal coverage in the United States. It would have mandated all employers to provide health insurance to their employees while giving subsidies to small businesses and unemployed individuals to pay for their medical coverage. The Clinton plan faced aggressive retaliation from the insurance industry, the business community and the lobby groups. The insurance industry financed lobbying and advertising campaign to fight against Clinton's plan[19]. Facing such an opposition, without the liberal majority in Congress, the act was sure to be defeated[20]. The Clinton's health plan demonstrated the difficulty to implement universal health coverage in the United States and significantly deterred further proposals targeted at covering most Americans.

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[18] The Institute of Medicine (2003)

[19] "One Nation, Uninsured" by Paul Krugman, June 13, 2005 NYTimes

[20] Oberlander (2002)

2.4.2 Managed Care Organizations Revolution

Another characteristic of the US health care system is the prevalence of managed care systems. According to Roemer et al., Health Maintenance Organizations (HMO) were promoted by the first Nixon administration (1969-1973) to modify the U.S. health care delivery system in order to contain health care costs, primarily by reducing hospitalization[21]. Robert G. Shouldice (1991) provides a simple definition of an HMO: "any organization, either for-profit or nonprofit, that accepts responsibility for providing and delivering a predetermined set of comprehensive health maintenance and treatment services to a voluntarily enrolled population for a pre-negotiated and fixed periodic premium payment".[22]

Gradually, HMO evolved into Managed Care Organization (MCO), which stress on the financial management components to better manage patient utilization and provider practices. Austrin (1999) provides the definition of MCO as a "system that uses financial incentives and management controls to direct patients to providers who are responsible for giving appropriate, cost-effective care. Managed care systems are intended to control the cost of health care by emphasizing prevention, early intervention and outpatient care"[23].

The cost-effectiveness is central to the existence of Managed Care. Their central objective is to contain costs as much as they can, relying on tight control of resources and on enrolled patients' choices of providers and practices, generating substantial revenues. According to the Kaiser Family Foundation report, 93% working Americans not on Medicare with insurance coverage are enrolled in an MCO through their employer[24].

However, there are significant concerns on the real value of managed care organizations in terms of quality improvements of medical care and its direct implications in terms of

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[21] Roemer et al. (1973)
[22] Shouldice (1991)
[23] Austrin (1999)
[24] Kaiser Family Foundation (2006)

focusing on cost controls, and subsequently maximizing potential profits. Bodenheimer et al. observed that primary care gate keeping, which is promoted by managed care and motivated to reduce patient referrals to reduce costs, is not an adequate system[25].

Immediate consequences of the organization of health care financing and delivery into MCO are the substantial loss of patient's freedom in providers' choice, the type of procedures and the loss of convenient access to care. Overall, the managed care revolution has failed to address the structural issues of the U.S. medical delivery system by trying to solve it on the sole objective of costs.

2.5 Health Care Cost Drivers Analysis

There are several studies aimed to identify the root causes and the consequences of both growing healthcare costs and the rising number of uninsured individuals. Governmental agencies, insurance companies, policy makers as well as the academia are interested in better understanding the cost drivers to reduce cost of the health care system. Yet, no systematic and pragmatic approaches are available to address the issues that are consistent with the analysis.

While there is no clear consensus on the factors fueling costs, the interdependence of multiple forces obviously increases the difficulty in devising an appropriate course of action to curb rising health care costs. In this section, we will explain succinctly the methodologies, assumptions and conclusions of a series of selected studies on health care costs from various sources that looked at this issue from different perspectives. We will present a summary of the key factors influencing the increase in health care costs from a global perspective in an objective manner. Subsequently, we will outline another segmentation of costs based on its distribution across diseases and population. It will offer a practical approach to address health care costs: strengthening primary care.

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[25] Bodenheimer, T. et al. (1999)

2.5.1 Internal and External Drivers of Cost

Thomas Bodenheimer conducted a series of analysis to find a potential explanation to high and rising health care costs[26]. His findings concluded that the aging of the population was not an adequate explanation and neither was the overutilization by the consumers during the spread of insurance coverage in the 1950's. However, the incomplete structure of competitive markets in health care may be partially responsible for high health expenditures. In his second article, he probed the potential health care cost of innovative technologies[27]. He found that technological innovation, in itself, was not responsible for increased cost as long as it provides benefits to patients, outweighing costs of care. It is the rapid technological diffusion and the uncontained use of new devices that is primarily responsible for high and rising costs. A potential solution to this spiraling trend is to establish strong containment costs measures. However, when looking at the Canadian system and HMOs in the US characterized by tight budgetary controls, technological advance is slower to develop but eventually drives costs upward. Another important source of excessive costs is related to the complex administrative structure of the U.S. health care system, as discussed earlier.

A study published in the Academy of health care management journal detailed the factors behind U.S. health care costs[28]. The key drivers identified were related to:

- Hospitals emergency rooms' utilization
- Upward pressure on physicians' pays due to cuts on Medicare and litigation
- Increased utilization of prescription drugs
- Rapid development of technology with limited emphasis on cost-effectiveness
- Pressure on nurses' wages due to labor shortage
- Uninsured burden on overall health care costs

2.5.2 Approach to Deal with High Health Care Costs

In 2006, the Agency for Healthcare Research and Quality published a paper on healthcare

[26] Bodenheimer (2005)
[27] Bodenheimer (2005)
[28] Bolton et al. (2005)

costs segmentation. It revealed an uneven distribution of actual healthcare spending across individuals, different segments of the population, specific diseases and payers[29].

They found that in 2002, 5% of the population accounted for almost half (49%) of total health care expenses while half of the population accounted for only 3%. The 15 most expensive health conditions account for 44% of total health care expenses. Patients with multiple chronic conditions cost up to seven times as much as patients with only one chronic condition. The elderly (age 65 and over) represented 13% of the U.S. population in 2002, consumed 36% of total U.S. personal health care expenses; they accounted for 43% of the 5% of top spenders.

Chronic conditions also made up for a large proportion of total health care costs. The major chronic conditions include: mood disorders, diabetes, heart disease, asthma and hypertension. It is estimated that 25% of the U.S. population have at least one of these conditions. When other illnesses are counted with these chronic conditions, total spending of these individuals accounted for 49% of health care cost.

2.5.3 Primary Care to Manage Chronic Illnesses Costs

Chronic care spending is responsible for a large proportion of health care costs and they are very concentrated in a small segment of the population, especially the elderly since chronic diseases tend to be age-related. Given these results, the aging of the population poses a significant threat and expected to exert upward pressure on health care costs. As it is, the current health care system cannot be sustained in the near future with an already extremely costly structure and the inadequate insurance coverage. Wagner found that "chronically ill patients receive limited assistance from their providers in their efforts to maintain function and quality of life as they cope with their illness", while "practitioners often fail to assess their patients' understanding of their illness, their ability to function or their insight into self-management."[30]

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[29] Stanton (2006)
[30] Wagner (1997)

Primary care plays a critical role in helping to cope with chronic diseases, as primary care is the main platform of interaction between patients and medical practitioners. It is designed to ensure coordination, continuity and effectiveness of care throughout the episode of illness including chronic diseases.

As Steve Jonas concluded in the section on primary and ambulatory care: "in the U.S. a disproportionate share of health care resources is devoted to inpatient care, both acute and long term. If, overall, health care is to be improved, this imbalance needs to be addressed. Furthermore, given the current profile of disease and disability in the United States, it is obvious that significant improvements in the health of the American people could be achieved by the widespread implementation of known health-promotion and disease-preventive measures in the ambulatory setting. This is the central element of comprehensive primary care."[31]

[31] Jonas (2007) p 101

Chapter 3: Primary Care: a Solution to U.S. Health Care Challenges

As we described earlier, there are significant improvements to be made in primary care, which can contribute to alleviate the U.S. health care challenges. In this section, we discuss the role of primary care in detail and its potential value as a solution to ailing problems related to cost and quality of care in the U.S.

3.1 Definition of Primary Care

In the U.S. health care delivery model, primary care is the major point of entry of any health services. As the first contact between sick individuals and medical services, primary care physicians have to perform a large number of tasks to best prepare and guide patients in the flow of care delivery. While it may be difficult to precisely define the practice of primary care, Grumbach et al. view it as a practice that encompasses a comprehensive array of services for preventive, acute and chronic needs provided by personal clinicians who are responsible for the overall ongoing health of their patients[32].

Preventive care involves the identification of a patient's current health status and lifestyle through diagnosis and discussion, and patient education to recommend behavior change to promote wellness. Acute care, on the other hand, requires an appropriate set of measures to diagnose patient's condition, the referral to the most relevant specialist(s) and the coordination of care among other necessary health services. Chronic care entails regular diagnosis during follow-up visits to check patients' health evolution, ongoing necessary treatments and procedures, psychological support to ease the burden of chronic disease, as well as lifestyle counseling or recommendations on how to improve overall health.

[32] Grumbach and Bodenheimer (2002)

Given the centrality of primary care in the healthcare system, it is important to outline the pivotal role of communication and collaboration between the patient and his primary care physician. The primary care clinician acts as a personal advisor and a health care specialist to ensure his patients' well-being, adequate coordination and continuity of care throughout the episode of illness be it preventive, acute or chronic. Building a strong and lasting relationship with the patient is thus fundamental to help the patient endure his illness and to make him comply with recommended care or behavior change. The concept of the central and comprehensive role of primary care is not new. The major challenge of primary care is in the implementation of the concept.

In modern practice of primary care, especially in managed care context, the relationship between primary care physician and his patient is usually neglected. McGinnis et al. noted that coordination of preventive and curative services ensured by effective primary care occurs less often than it should in much of American medical practice[33]. The reason being the fanatical emphasis on cost reduction by managed care, since the value of primary care does not materialized at the time of the visit but throughout the entire length of the care process. As a result, it is inherently difficult to monetize and then reward primary care physicians adequately. Compounding this factor is the redefinition of the role of primary care in the context of managed care. Bodenheimer observed the gate-keeping role of primary care physicians set by managed care organizations, which is to reduce patient referrals to specialists in order to reduce costs, is leading to inadequate practice of care[34].

3.2 Value of Primary Care

Primary care holds the key in the coordination and continuity of care. Given the intangible nature of coordination and continuity, the intrinsic value of primary care cannot be directly measured and captured using quantitative methods. Schematically, it

[33] McGinnis et al. (2002)
[34] Bodenheimer, T. et al. (1999)

can be viewed as a centerpiece of an interdependent health care system. Good primary care has positive externalities that benefit the entire system while poor primary care leads to negative externalities hurting the whole system. By taking a holistic perspective on the entire health care system to assess the value of primary care, we can capture this "ripple effect".

3.2.1 Indicators of Health Care System Overall Quality

Drawing on the international comparison of industrialized countries' health care system overall quality and costs relative to their primary care infrastructures, Starfield & al. found robust results supporting the value of primary care for the entire system: "the stronger the primary care, the lower the costs. Countries with very weak primary care infrastructures have poorer performance on major aspects of health"[35]. Given these findings, the level and quality of primary care provision in a country can then be key indicators of a nation's health care system overall quality and costs in the long run.

In the case of the U.S. although the country spends more per capita on health care than any other industrialized country, it ranked last in a study comparing 10 Western industrialized nations' primary care system. The ranking criterion includes 12 statistical measures of national health quality indicators and the overall satisfaction of the population with their system[36]. The data displayed strong correlation between good primary care system and overall health system performance. It should be noted that the overall results can be caused by difference in population, types of diseases related to the country's lifestyle and its environment.

Fragmented and insufficient primary care infrastructure in the U.S. is certainly an indicator and source of the structural deficiencies in the entire U.S. health care. There is not, however, enough evidence of the correlation between the current ailing state of the U.S. health care system and its level of primary care infrastructures. Nonetheless, it can

[35] Starfield and Shi (2002)
[36] Starfield (1991)

be derived from several studies that the U.S. lacks a strong and robust primary care practice compared to its industrialized peer countries that is deemed to be a key characteristic of a high quality and low cost health care system. Therefore, significant improvements on the quality of the overall health delivery system in the U.S. may materialize if primary care is strengthened.

3.2.2 Improvements in Mortality Outcomes and Costs

There is an increasing body of research focused on evaluating the impact of primary care on health outcomes and costs within a nation so as to identify the intrinsic value of primary care. For instance, a study led by Shi et al. assessed the relationship between health outcomes and physician supply over 4 separate five-year periods across states in the U.S. [37] It found that an increase in the primary care physicians-to-population ratio was associated with a decrease in mortality, the same conclusion was drawn for family physicians. Conversely, an increase in specialist physician-to-population ratio was associated with higher mortality. However, it is interesting to note that an increase in the ratio of primary care physician-to-population does not necessarily guarantee a proportionate increase in primary care access or better delivery. Primary care physicians supply is as important as the delivery channel by which primary care reaches out the population in need.

Another study led by Baicker & al. analyzed quality of care and Medicare spending across states. They observed that: "states where more physicians are general practitioners show greater use of high-quality care and lower cost per beneficiary. Conversely, states where more physicians are specialists have lower-quality care and higher cost per beneficiary"[38]. Even across states, we can observe difference in terms of quality and costs associated with difference in primary care level of infrastructure and access. These studies show the correlation between strong primary care and high quality and low-cost care delivery. Although, the studies do not demonstrate direct causation of primary care

[37] Leiyu Shi et al. (2003)
[38] Baicker and Chandra (2004)

delivery efficiency, higher quality, and lower cost of care, there is a growing consensus on the value of primary care and its direct impact on health outcomes. Real applications of primary care reinforcement initiatives would help test the hypothesis of the value of primary care and would promote action across the country.

Potential solutions to the ailing U.S. health system can also be examined in other directions than primary care as well. Specialists can also contribute in the care of chronic diseases. For instance, expanding current supply of specialists trained to cope with chronic care may be a solution. Yet, a study reviewed available publications to evaluate the alternative solution of specialists or disease management programs taking care of chronic diseases and it showed no superiority of the alternatives to primary care[39].

3.2.3 Importance for Chronic Disease Management

Strong primary care seems to be a logical way to manage chronic diseases for better diagnosis, better monitoring, better counseling on lifestyle change and better referral to specialist. It is also a solution to prepare for the rapid shift from acute diseases to chronic diseases caused by the aging of the population and unhealthy lifestyles. All in all, strong primary care offers a robust approach to health care given the current and future challenges the U.S. is facing.

3.3 Primary Care Crisis

While the U.S. needs to rely more heavily and to strengthen its primary care, the practice is facing its own crisis and is on the verge of collapse as more and more medical school students are abandoning internal medicine even though its demand is growing rapidly.

Primary care practice in the United States is struggling. Obtaining an appointment with a primary care physician has become a daunting task across the United States. General

[39] Rothman and Wagner (2003)

medicine practices are almost shut down in both the University of California San Francisco General Hospital and the Massachusetts General Hospital[40].

How did the system arrive at this stage? Over the last few years, the situation in primary care has been exacerbated by the growing lack of primary care physicians combined with the rising demand for primary care. Now, scenarios of total collapse of primary care practice, where no primary care physician would be available, are possible. Given the time required to train a qualified primary care physician and the time to build effective relationship with patients, every stakeholder involved in the health care system should urgently act constructively and effectively. With primary care being the backbone of the entire healthcare system, policy makers and hospitals managers must work together and renew the primary care delivery model[41].

Recently a roundtable was held on primary care redesign where four experts in primary care discussed the current crisis in primary care and key elements to consider in the future of the practice. Dr. Thomas Lee observed, "there are too many patients, too many demands, too much information flowing through, too little time to do a good job."[42] There are 3 major factors that have an impact on the shortage of primary care physicians, namely money, prestige and controllable lifestyle.[43]

The roundtable of experts fostered discussion around the key factors leading to the current primary care crisis. To this end, we built a system dynamics model to capture the essential variables involved in the system's crisis. This model was developed based on literature review on primary care crisis and interviews with primary care practitioners. The presence of reinforcing and feedback mechanisms responsible for the current crisis in primary care is easily captured by the model logic. We do not intend to develop a quantitative model to simulate the system for the lack of precise data regarding the qualitative influencing factors.

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[40] The Watcher's World Blog (07-20-2008)
[41] Bodenheimer (2006)
[42] Lee et al. (2008)
[43] Lee et al. (2008)

As part of further research projects, we suggest the development of a more detailed system dynamics model in order to assess the impact and effectiveness of policy actions. Nevertheless, the causal loop diagram is an effective tool to better grasp the current situation in primary care and sum up key factors to convey effective ideas to policy-makers and hospitals' decision-makers.

The following schema was developed iteratively with medical practitioners, particularly primary care physicians, at a local hospital in Boston area.

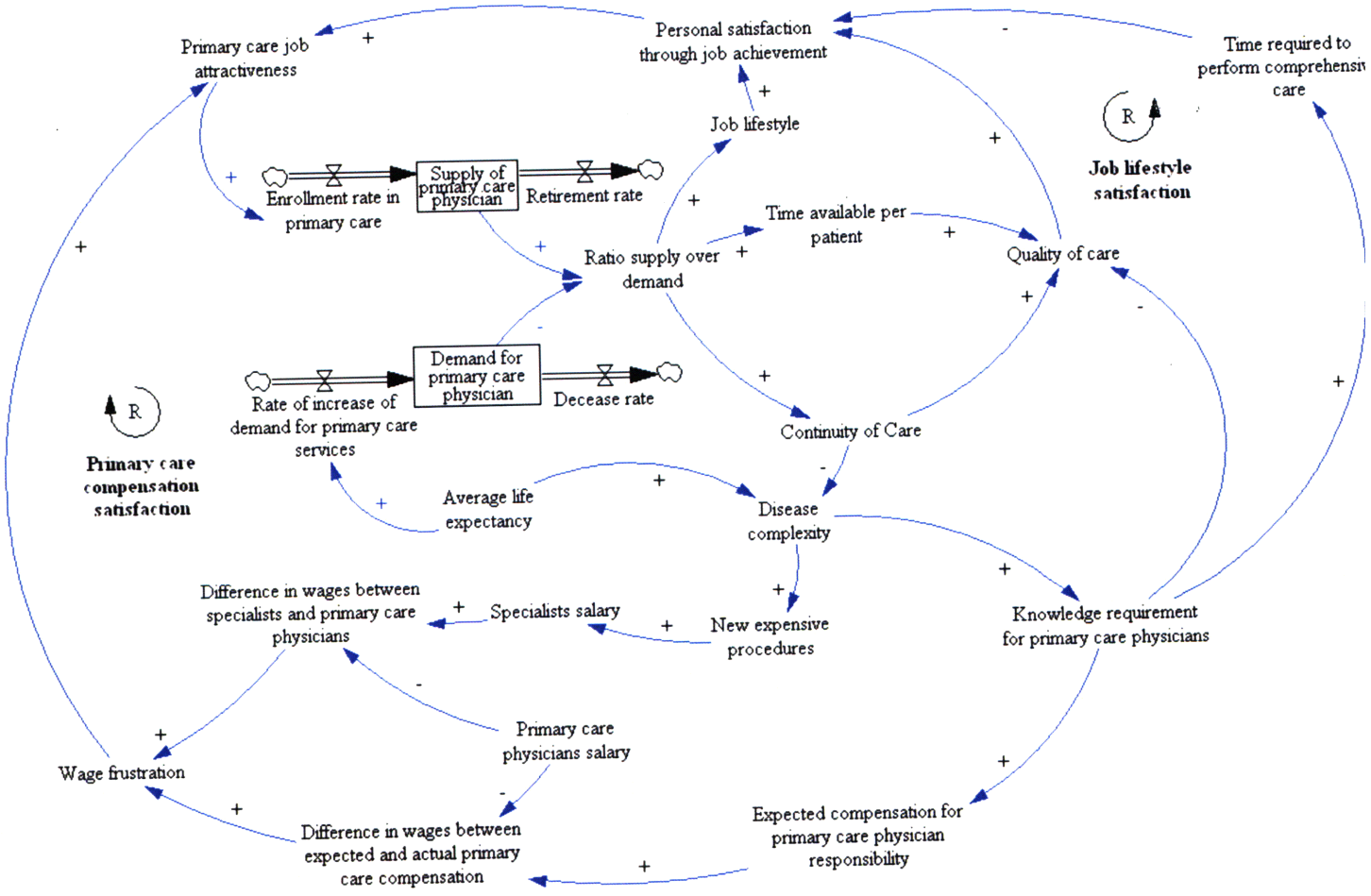

Figure 4: Causal Loop Diagram of the Primary Care Crisis

Chapter 4: Analysis of Primary Care Dynamics

In this chapter, we explore the dynamics driving primary care practice crisis. First, we draw on basic literature on economics of incentives to better understand financial incentives of primary care physicians and the associated difficulty in designing appropriate contracts. Second, we review the structural incentives associated with the work environment and work lifestyle. Given these considerations, we obtain a better overview of primary care practice with which we can generate insights to devise targeted and appropriate policies to tackle primary care challenges and improve U.S. health care.

4.1 Incentives Analysis

To analyze financial incentives in primary care settings, we draw on classical theory of principal-agent problem, or agency theory, which studies the problems associated with rational agents under contractual agreements. To give a simple representation of the situation, a principal wants to achieve a certain objective but cannot do it by himself, so he pays an agent to do the job. Agency theory studies the rational behavior of the agent under such contract, problems of information asymmetry associated with the contract and contract design.

4.1.1 Basic Financial Incentive Schemes

There are three major basic payment schemes (linear compensation formulas) in health care settings that are also widely used in other industries, namely salary, fee for service and capitation. Under these different payment schemes offered by the principal, a rational agent may rationally act differently. The outcomes can be optimal or can deviate from the principal's intended objective depending on the type of task to be performed and the design of the payment contract.

Salary

Salary corresponds to the straight payment of a pre-determined level of compensation agreed by both the agent and the principal. The level of compensation is fixed and not linked directly to any particular performance measure. Therefore, salary is said to have weak financial incentive because it has no direct effect on the productivity or on specific tasks desired by the principal. Given the insensitiveness of salary to productivity, the agent may be more sensitive to non-financial incentives. The scheme can be then combined with other types of incentives, related to the job design for instance, to influence behaviors in a more appropriate manner.

Capitation

Capitation represents the payment scheme where the agent's payment is related to the total number of patients served by the agent. From the agent's perspective, maximizing monetary payment is equivalent to maximizing patient served. It ties the agent's total future payment to his ability to attract the largest number of clients possible and to his capability to churn them out at the fastest speed possible. Depending on the principal's objective, it can lead to optimal or detrimental behaviors. In the case of simple, standardized processes with low variability, maximizing throughput can motivate the agent to devise innovative means to improve processing times for faster turnover. When the variability in patient conditions is high and tasks to be performed complex, it may lead to a selective behavior from the agent, which corresponds to the agent avoiding difficult and long cases to keep simple and faster ones. The agent then transfers responsibility of treating complex cases to other agents that follow his work in the service delivery chain.

Fee for service

Fee for service is another payment scheme where the agent is rewarded according to the type of service provided to the patient. Fee for service ties payment streams with specific set of tasks delivered by the agent. Intuitively, it is designed to reward the agent with bonuses for complex tasks. Therefore, it works particularly well in specialty shops where customized work has to be done for a specific client with specific needs. However, when

the client does not know what his needs are, there are incentives for the agent to perform additional but unnecessary tasks so as to maximize payments.

4.1.2 Alternative Payment Methods

Information asymmetry is central in the deviation of behavior from optimal behaviors envisioned when a payment structure is designed. In health care, it is particularly difficult because there is uncertainty both in the patient's condition and in the medical delivery process and there are information asymmetries at multiple levels: between the patient and the doctor, between the patient and the insurance company, between the doctor and the medical provider structure, between the medical provider structure and the insurance company covering the patient.

Building on these basic payment schemes and information asymmetries, we can think of more complicated payment design to strengthen incentives on specific tasks rather than others. They can link rewards with pre-defined performance measures tied with specific outcomes. However, there are several disadvantages in this customization of payment structures and incentives.

Obviously, there are costs associated with the measurement of the defined performance criteria. Gathering data requires resources in terms of personnel, technology, process and time. The associated benefits of agents' performance do not necessarily offset the additional administrative costs of complex contracts. Also, the complexity of payment structures tends to result in a lack of visibility in the objectives of both the principal and the agent, diluting the value of overall incentives. A complex contract may be difficult to be understood and to administer. Simple contracts are often more effective than complex ones.

4.1.3 Factors to Consider in Payment Design

Thinking that the exact behavior of an agent under a specific contract is predictable is

misleading since unexpected outcomes will certainly arise when implementing a complex payment scheme. There is no silver bullet in payment structures that would achieve precisely what the principal intended nevertheless there are schemes, in which the basic behaviors are quite well understood. When designing a complex or hybrid payment structure, there are several other factors that should be considered for the payment scheme to be as effective as hoped. We will not provide an exhaustive list of factors to include in the design of incentives but present a short discussion of key ones along with the well-known impacts of these factors and how to approach the design of payment incentives for primary care physicians.

Risk aversion

The question of risk aversion arises when the agent's future financial payments fluctuate according to certain performance measures. These performance measures may be influenced by other factors beyond the agent's control. Depending on the controllability of these performance measures, or the signal-to-noise ratio, the agent would prefer a straight salary to a variable payment structure. Then, the principal has to pay a risk premium to the agent so as to cover for the variability of payments. The optimality of the contract depends on the extent to which some outcomes are controlled by the agent's efforts.

Distortion

In many cases, it is not possible to measure the principal's objective directly. Therefore, firms use an alternative performance measure serving as a proxy for the principal's end objective. However, the main issue in designing incentives tied to this alternative performance measure is the divergence between the alternative performance measure and the principal's objective, i.e. distortion in measures.

Multi-tasking

Often the principal desires multiple tasks to be performed by the agent. The range of tasks adds to the complexity in incentives design. It can lead the agent to over invest time to perform one specific task while under investing in others if incentives are structured in

such a way to favor one task over the others.

4.1.4 Principles of Payment Schemes Design

Milgrom and Roberts (1992) identified four basic principles in compensation design laying the ground for incentives design based on intensity of incentives and risk tradeoffs[44].

Informativeness Principle

Given the lack of perfect information measures, the principle states that compensation formula design should select performance measures that reduce the error in estimating agent's efforts and rejecting those that increase estimation error. An application of this principle is the use of comparative performance evaluation, as comparison with similar agents removes common exogenous noise.

Incentive-Intensity Principle

The principle states that optimal intensity of incentives should consider four factors: the incremental profits created by additional effort, the precision of performance measurement, the agent's risk tolerance and the agent's responsiveness to incentives, which is associated with the agent's discretion about work aspects (pace, tools, methods, etc).

Monitoring-Intensity Principle

The principle states that when incentive intensity in an optimal contract is high, the principal should pay to measure performance carefully.

Equal Compensation Principle

When the agent has two tasks to perform and the principal cannot monitor the allocation of time or attention, the principle states that two activities valued equally by the principal should have equal incentive intensity.

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[44] Milgrom and Roberts (1992)

There are further developments of Milgrom and Roberts' principles in incentives design to include notions of scale, alignment and distortion in performance measures, as follows.

Balanced incentives in scale and alignment[45]

Robert Gibbons (1998) outlines the importance of scale and alignment of alternative performance measures with desired outcomes materialized by outputs in the design of payment contracts. Alignment corresponds to correlation between measured outcomes and desired outcomes. Scale corresponds to the level of impact of the alternative measure on the desired outcome. Optimal incentives contract should consider more balanced incentives in both scale and alignment of the performance measures.

Low distortion and low risk[46]

Baker (2002) explains the notion of distortion, which corresponds to the correlation of the effects of the agent's actions on measured outcomes with the effects on the true objectives. It underlines the existence of some performance measures that can be manipulated by the agent to fulfill measures outcomes while not achieving desired objectives. For instance, in a relative performance evaluation scheme, if a CEO's compensation depends on the benchmark of his company with a selected set of companies and he can affect the results of the benchmark, the performance measure is distorted. He concludes that the objective of an optimal incentive system design is to discover and create low distortion and low risk performance measures.

4.2 Primary Care Job Structure

The current crisis in primary care sheds light upon critical features of job designs that should be reconsidered. In shaping a new and effective model for primary care, careful consideration should be given to financial and non-financial incentives design.

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[45] Gibbons (1998)

[46] Baker (2002)

4.2.1 Financial Structure of Primary Care

To be consistent in the payment structure, we have to align tasks performed by a primary care physician with adequate incentive schemes. First, we categorize chronic diseases according to their characteristics and their requirement of doctors' expertise based on Clayton Christensen's segmentation as shown in Figure 5[47].

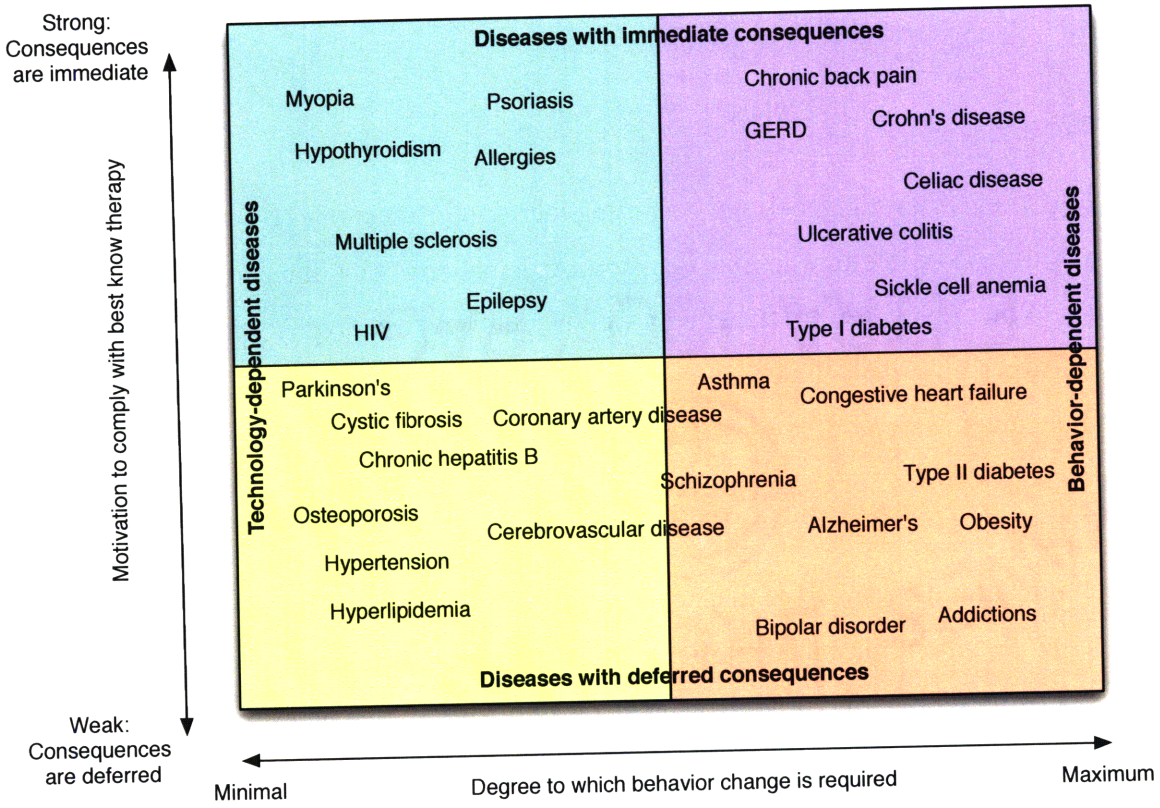

Figure 5: Chronic Quadrangle

***Source*: Clayton Christensen et al. (2008)**

Christensen segments chronic diseases along to two dimensions. The first dimension corresponds to the immediacy of the consequences of the patients' actions, and the second dimension is the importance of behavioral change in the care process. The top of the quadrant represents chronic diseases with immediate consequences. Therefore patients are directly motivated to take actions on their health once diseases are diagnosed. The bottom of the quadrant represent chronic conditions that bear consequences in the

[47] Clayton Christensen et al. (2008)

long run, therefore they are significantly dependent on a patient's effort over time to behave as prescribed.

Based on this segmentation, we can develop a more effective description of primary care physicians' job. We can then design incentives system rewarding these jobs to improve quality of care while controlling costs. There are two phases in the chronic care delivery process: diagnosis and recommendation (prescription and/or behavior change counseling).

Diagnosis

As technology progresses, diagnosis are becoming increasingly accurate. However, the physician is still responsible for the final decision. As a matter of fact, the current reward system tends to favor type I errors (labeling a well person sick) over type 2 errors (labeling a sick person well)[48]. Indeed, punishments for type 2 errors are real: guilt, embarrassment and the threat of lawsuit. Conversely, type 1 errors are often considered as "sound clinical practice" or conservative.

Given the continual improvement of diagnosis capabilities, diagnosis will become more precise, leaving less room for misdiagnosis. In this case, type 1 errors in the decision to diagnose may be preferable to type 2 errors in terms of quality of outcomes, as diagnosis will reveal the error. At the same time, health care providers are becoming increasingly cost-conscious and they are concerned about the over-utilization of costly technological diagnosis procedures. Therefore, a well-balanced payment system should not reward type 1 errors without imposing additional burden on type 2 errors. For instance, a payment stream tied to the number of diagnosis but only the ones that revealed a problem can be an effective payment design. An alternative could be delivered by technological progress in decision support system, which would help identify appropriate decision for diagnosis based on a thorough and rules-based assessment of symptoms.

[48] Kerr (1975)

Recommendation

Prescription: If a chronic disease has been identified and belongs to the top quadrant, i.e. the consequences of the patient's actions are immediate. Then the primary care physician's role is to prescribe the correct medication list or appropriate course of action the patient has to follow to treat his condition. Further monitoring will be needed to follow the patient's status. Since the consequences of actions are immediate, the patient will most likely comply with the prescription. In this case, the primary care physician does not add substantial value to the care process. A payment design based on fee-for-service can achieve the intended behavior.

Behavior change counseling: In the case of a chronic condition belonging to the lower quadrant, the consequences of actions are remote in time. The primary care physician has then a substantial role to play in the care process of the patient. There should be careful consideration of the alignment of incentives for the doctor to be rewarded for the patient's wellness.

In the current managed care organization era, primary care physicians are paid by capitation to keep a tight control on cost. They are not rewarded for ensuring continuity and coordination of care. Continuity of care requires extensive communication with the patient to build a close relationship with the patient throughout repeated visits to perform accurate diagnosis, to provide personal guidance on disease management and to ensure behavior changes to name a few tasks required to adequately serve a patient. Coordination of care requires extensive knowledge of diseases and up-to-date treatment procedures to best reorient patients' to specialists. Most of these tasks are not on the fee schedule of primary care physicians paid on fee-for-service let alone on a capitation contract.

4.2.2 Structural Incentives of the Practice

The effects on the overall practice of primary care can be segmented into two separate categories: the effects on the medical students that chose to go into primary care career

and the effects on the primary care physicians that leave the practice, either for retirement or for a career change to other specialty or for part-time work. According to a study on factors impacting career choice in primary care practice, income, working hours and loan repayment had significant influence on some students' choice to go into non-primary care specialties[49]. Both incoming primary care physicians and general physicians are affected by the job design either for the structural specificities or financial schemes.

Complex and variable tasks

A primary care physician has to perform various tasks ranging from administrative tasks to completing patient information, filing prescription forms, identifying relevant information from patient's family to forming an accurate judgment on the patient current state of health. As argued above, multi-tasking has been a problem in the design of financial incentives to achieve optimal behavior from primary care physician. Job design can help solve the issue of multi-tasking. Since medical doctors do not achieve their highest potential while working on certain tasks, for example resolving administrative issues, such tasks could be performed by medical assistant or even nurses, leaving health related tasks to medical doctors as they are the critical resources in primary care practice.

Schedules

The preeminence of managed care organizations had the effect of restricting patient face time to increase throughput and increase overall utilization of expensive resources. The effect on physician workload and lifestyle has been deleterious. In current primary care practices, visits are constrained to either 15 minutes or 30 minutes slots per patient. It is far from enough to review all relevant information to make appropriate decisions let alone to build a decent relationship with the patient during the scheduled visit. Now, primary care physicians are under administrative pressure to finish their tasks, leaving a sense of dissatisfaction and frustration in their job executed in urgency and subsequently of poor quality.

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[49] Rosenthal et al. (1994)

Teamwork

Given the hectic lifestyle of primary care physicians, medical doctors tend to adapt their schedule to accommodate their private life. There is no defined care team to take responsibility of a patient. It is creating problem since working part time or taking leave is becoming increasingly common in primary care practice. Due to the tedious nature of primary care, team building is hampered and efficient teamwork is difficult given the lack of familiarity and communication. Teamwork conditions also impact physicians' job satisfaction.

4.2.3 Medical Training Implications

As discussed earlier, loan repayment is one of the factors influencing career choice of a physician. Hence, if we want to attract more students towards the primary care route, there should be adjustments on the prospective salaries in primary care compared to salaries in specialty practices as primary care providers generally earn less than specialists. A net budget adjustment, which corresponds to decreasing specialists' salaries in oversupplied fields to finance an increase in primary care physicians' salaries, could help attract students in primary care. However, there should be careful analysis of the current state of the system and shortage of skills, both in primary care and specialty care. Incentives for primary care practice should be balanced enough not to deter too many students from specializing.

In line with this objective to mitigate primary care physicians' shortage by considering mild incentives, a financial subsidy to students going into primary care practice can be offered. For instance, a financial aid or bonus program could be set up to compensate medical students for entering primary care training, giving them access to a special loan repayment assistance. It will help medical students to make their career choice based upon their career goals and their intrinsic motivation rather than future cash flows.
For non-financial incentives designed to attract students in primary care, career prospects in primary care and prestige of primary care practice can be enhanced in academic settings by offering a prestigious prize or award to recognize primary care physicians for

their outstanding achievement and contribution to health care improvement. It will attract inherently motivated students concerned about taking a path that can be fulfilling and rewarding in terms of image and prestige.

Selecting motivated primary care physicians gives more "flexibility" in the design of the fee schedule, as an adequate job design will rely less on financial incentives. The main idea is to limit financial incentive as it can distract some physicians in the profession by redirecting focus on maximizing financial returns. This is particularly relevant in primary care, where collaboration with care team and the relationship with patients are far more important to quality of care than in other practices having greater procedure-focused.

Drawing on an analogy of primary care practice and non-profit organizations, where outputs and contributions are difficult to measure, there are two ways to optimally reward a good quality behavior. One way is to design a set of low distortion / low risk performance measures (as explained in the previous section), a second by selecting people based on their intrinsic motivation in the job provided the value and the vision of the profession are clearly stated[50]. Therefore, financial incentives should be considered with great care in primary care setting compared to specialty practices. Non-financial incentives work more effectively when people have a sense of mission and a higher vision than looking at financial returns over the years. It is particularly the case in primary care in today's world, as students entering the practice are taking on this path for the purpose and the experience in the practice rather than financial returns alone. However, just as there is a concern for sustained high productivity in non-profit organizations since there is a lack of monitoring and limited downside payments for poor performance, intrinsic motivation and job prestige should be considered simultaneously so as to attract the right people in primary care.

4.2.4 Payment Design Implications

In "The theory and practice in the design of physician payment incentives", Robinson

[50] Baker (2002)

recommends blended methods that would build upon capitation and add-in fee-for-service carve outs to reward certain behaviors and tasks essential for a high quality primary care[51]. It is fundamentally hard to design an ideal payment scheme that would reward primary care physicians in such a way that it would maximize quality of care while containing costs for two reasons. First of all, it is simply difficult to assess the range of tasks to be performed in primary care settings. Secondly, it is even more difficult to identify the tasks that contribute to higher quality and lower cost of care.

Robinson also underlines the fact that the widespread adoption of capitation payment structure for primary care physicians has lead to successful cost containment. However, the insensitivity of capitation to variations overcompensate narrow practice and under-reward broad scope of practices. In the extreme case, it may lead to converting primary care physicians into triage agents. This is a clear example of how poor design payment scheme can be detrimental.

Quality of care in primary care settings is related to patients' health outcomes, which depends on several factors, in particular the physician's ability to build a lasting relationship with the patient to enable effective recommendations on future course of actions and guiding the patient to appropriate specialists. Indeed, continuity and coordination of care are generally functions that primary care has to perform well in order to ensure higher quality of care delivery in a health care system. To compound the difficulty of payment incentives design, not only does the design have to consider cost containment but it also has to evaluate the produced outcomes. Cost-effective utilization of resources for obtaining desired outcomes should be always thought out upfront in the incentives design. Given the qualitative nature of most proxy variables of quality, we have to think of alternative measures. We discuss a few such measures below.

Patients' health outcomes

A primary care physician often manages a panel comprising certain patients with multiple and complex conditions. There is high degree of uncertainty about these patients' current

[51] Robinson (2001)

health condition and about the efficacy of available methods to treat their conditions. Therefore it is very risky to tie financial returns on such patients' health outcomes. Given the uncertainty about health outcomes and the interdependence of factors, exogenous and endogenous, influencing health outcomes, primary care physicians can be averse to the risks involved in a variable payment scheme based on health outcomes.

Patient satisfaction

Primary care physicians can be rewarded based on patient satisfaction in order to emphasize the importance of the relationship built with the patient. However, this alternative performance measure is highly subjective and risky due to the high variation in health treatments. This alternative measure is also a distorted measure as physician can alter his standard practice to avoid any practice beneficial to the patient but involving painful episode of care.

Risk adjusted care

Age and disease categories based segmentation to reward primary care physicians who are taking care of certain types of patients seem to promise adequate rewards for complicated procedures and complex tasks required to treat most difficult cases. However, the difference between treating "complex" cases and treating "simple" cases should be well calibrated according to the amount of effort spent to take care of those cases. A proxy variable measuring effort could be time spent to see a specific patient the amount of resources seized or the frequency of visits for instance.

Relative comparison

Since primary care physicians work with different panel groups of population having unique set of characteristics, comparing performances between different primary care physicians does not remove the common noise related to primary care profession to assess higher productivity, higher quality of care between physicians.

4.2.5 Job Design Implications

Given the complexity of tasks and the difficulty to tie high quality of care with undistorted measures, designing optimal financial incentive is challenging. Therefore, primary care job design plays a significant role in the productivity, quality and cost-effectiveness of the practice. We should learn from the current primary care crisis that has demonstrated the limits of the prevailing model and highlighted the importance of the job environment. We can draw conclusions on basic design features and reconsider the design to launch a new practice. Specifically, appointment schedules may have to be extended in order for the physician to have time to perform correctly his tasks to take care of his patients. Flexibility of lifestyle should be incorporated in the design of the job to allow control of working hours and vacations without disrupting too greatly the operations of the practice. In this redesign process, teamwork has a unique role.

When pondering on the teamwork environment and on how team can increase the flexibility of medical doctors work, it requires rethinking of the role of medical assistant, care coordinator and nurses in the care process. Indeed, assistants can easily perform certain tasks, thereby giving the doctor more time to focus on "value added" tasks. A team will act as a single care provider, where the patient contact is the care team. In the mean time, we have to ensure that it does not affect the quality of primary care practice. In order for this change to happen, there will have to be involvement of the government in changing policies regarding training, certification and recruitment of medical assistant, care coordinator and nurses.

4.3 Conclusions

We reviewed the theory of incentives design and the structure of primary care practice, which suggested a significant redesign of the type of tasks a primary care physician is required to perform effectively. A redesign of the training of care teams operating in primary care should be considered in order to relieve work from medical doctors and improve quality. In some cases, the tasks are very straightforward and can be easily

managed by trained medical assistants. Such an initiative is of course subject to regulation on medical practice in terms of qualification, certification and liability. Yet, we think that physicians' should focus on real value added tasks. Additionally, while attempting to apply the principles in physicians' payment schemes, we offer two approaches to primary care physicians' job redesign:

- The first approach consists of defining metrics with both low distortion and low risk to measure quality of care associated with primary care physician work along the dimensions of continuity and coordination of care. At the same time, an evaluation of the effect on total cost should be done that result in motivating physicians to be cost-efficient. To this end, pilot projects in practical settings should be conducted to monitor and track behaviors of primary care physicians under different payment contracts.

- The second approach is to design a payment scheme based upon minimal financial incentives (salary), which is associated with a selection effect of primary care physicians for their intrinsic motivation. Concurrently, job design should be emphasized to offer a better workplace and a flexible schedule for primary care physicians.

Chapter 5: Redefining Primary Care

Primary care practice and its role in the collaboration and coordination of health care services resemble the relationships between suppliers and retailers in an industrial ecosystem. Collaboration and coordination are hard to measure quantitatively but they can create significant value for businesses if utilized carefully. For instance, Toyota pioneered the importance of lasting and strong relationship of automotive manufacturers with suppliers and retailers[52]. Toyota redefined the way businesses used to operate and redesigned relationships contracts to be more transparent and long-term focused. The main idea is that lasting and sound relationship will create more value for the entire supply chain including suppliers, manufacturers, retailers and customers. In line with these principles, health care services should consider the practices leveraged by Toyota to unlock intangible benefits from collaboration and coordination.

Following this analogy, governments and businesses should plan to work together to create an environment where medical providers can experiment and develop innovative care model solutions and initiate a breakthrough in health care, especially in primary care.

5.1 Redefining Primary Care: Business Innovation

New business models are emerging that can potentially disrupt primary care and facilitate its transition into a new care model that delivers higher value and lower costs. Concurrently, new technology can also spur the innovation in care models of primary care models. An effective way to reconsider the primary care practice would be to think along the categories defined by Christensen as discussed earlier.

[52] Womack et al. (1991)

Technological innovation

Point of care technology

Researchers are pushing to develop new diagnosis technologies. New tools and techniques have emerged in the health care market, which enable medical practitioners to perform various laboratory tests directly on site. This has eliminated the need for the patient to schedule two separate appointments: the first one to take the test and the second one to see the medical practitioner again with the results. Such a change has significant impact on the primary care practice, as doctors will be able to perform tests and have immediate access to the results. With the associated increase in operational efficiency, new technologies will improve the care delivery chain allowing the primary care physician to focus on real value added care processes.

Information technology

Information technology is the key enabler of effective coordination of care. Increasing digitization of patient health record and the ability to exchange information will easily enable care providers to recommend better course of action to patients and integrate decision support tools to assist medical doctors in their decisions. Also, the use of new technologies will allow medical practitioners to deliver care remotely thereby increasing the accessibility of health care.

Business model innovation

The emergence of retail clinics

A new channel of care delivery model is emerging, known as retail clinics. Retail clinics are small facilities usually present inside a discount retailer, offering convenient access to primary care service for a limited set of diseases. A nurse practitioner is trained to take care of patients in a very standardized and rapid fashion. All in all, retail clinics are increasing the accessibility, the convenience and the affordability of primary services. It intends to disrupt primary care practice in hospitals so as to "outsource" what can be done easily, more efficiently and cost effectively, elsewhere. However, instead of directly

displacing the low-end segment of primary care services, retail clinics mostly serve patients who do not have a primary care physician[53].

The emergence of patient networks

For behavior-dependent diseases, medical compliance and personal counseling are critical to the care process. Yet, the patient is left unsupported to comply and to follow often-unclear guidelines given by medical practitioners, since most of the time visits are either too short in length or far apart. It is inherently difficult to monitor and to advise patients appropriately. With the emergence of chronic patients networks, a patient can easily get access to resources to learn about his condition and learn about the behavior change pathway with the help of experienced patients sharing their experience. Such networks have a powerful effect on compliance as patients can get access to numerous resources specifically targeting their conditions, exchange information and experience with other individuals suffering from the same disease and know appropriate course of action to take care of themselves[54]. It serves the purpose of providing continuity of care and behavior counseling usually performed by the primary care physician, and it works particularly well with chronic diseases that are behavior-dependent conditions whose consequences are immediate.

5.2 Redefining Primary Care: a Hospital Case Study

A local hospital in Boston recently launched an initiative to revamp its primary care practice. It is a real world, small-scale experiment to test the effectiveness of a new care model centered on the patient's experience with primary care teams. The objective is to change the way primary care currently operates. Not only does the practice attempt to introduce new technologies from point of care diagnosis tools to web-based interactive platform but it also emphasizes on care processes and services enhancing continuity and

[53] Mehrotra et al. (2008)

[54] Sean O'Meara, "Diabetes Education Goes Multimedia", Nurses World, May 2007

coordination of care. Through this initiative, the hospital intends to demonstrate the value of primary care and its impact on the quality and cost of care.

As discussed earlier, this experiment complements the theoretical foundations of the academia and medical practitioners on the value of primary care. Few hospitals have tried to launch a large-scale initiative on primary care because they either the lack funding for new technologies or they are already overwhelmed by demand leaving no room to experiment. Boston area is particularly fertile for innovation in health care as it is a breeding ground for technology innovators, business experts and medical leaders that can build constructive innovative initiatives.

Given the innovative aspect of the initiative, careful considerations of the future practice design before its implementation is key to ensure the success of the practice without too much rework. Alignment of the new practice's strategy, organization, processes, people, technologies and metrics is critical. Just as any corporate strategic move, the care elements of planning have to perfectly fit together to deliver a successful model for primary care.

5.2.1 Study Objectives

To best serve the purpose of the new practice, it is critical to learn as much as possible from prevailing best practices in terms of business process planning before the implementation phase of the project. Many businesses, such as IBM, Nokia or Toyota, have successfully undergone dramatic changes in their business model to compete successfully in turbulent times. Decision-makers are better served if they get a better sense of the new system behavior before the project is physically launched. To this end, simulation tools can be useful to bring about useful insights.

We worked on this project from January 2009 to May 2009. The main objective of the simulation study is to provide project managers with operational insights on the likely behavior of the new primary practice. Other associated objectives that can help decision-makers in the design of the practice include the assessment of the feasibility of the

initiative, the evaluation of the performance of new practice such as open access schedule, the assessment of required staffing for the care team depending on the panel of patients.

5.2.2 Study Approach

We built a simulation model to represent the future state of the practice. We chose a discrete-event simulation software package, Arena, for the project. The Arena software package is one of the most suitable software for this study as it provides a user-friendly interface with advanced modeling modules. It also offers convenient tools to analyze output data.

We started with a base model replicating the mental representation of the practice using simplifying assumptions on care processes and service times. Thereafter by working closely with practice leaders, we fostered constructive debates to challenge the model's assumptions. It was an insightful exercise as it helped medical practitioners to structure their plan of daily work and envision the future of the practice in a concrete way. We then iteratively refined the model based on their comments.

As we calibrated and validated the model for the new practice, we tested various scenarios to assess the impact of different practice policies. The project team created different scenarios to study the behavior of the system. For instance, we defined different input design variables related to the number of visits by visit type, the complexity of patients by visit type, the number of resources allocated in the new practice, the service times of care processes and the time period. Depending on the significance of the impacts of these variables on the system, we drew insights on critical variables that are crucial for decision-makers and designers.

As part of the learning potential of the simulation study, we are also training the project team to use the scenario analysis module for them to customize the scenarios they want to test and to obtain useful results subsequently.

5.2.3 Model Description

Patient types

As an experimental effort, the new practice will recruit a certain patient panel with specific disease profile. Since the practice will start its operations with a new set of patients panel, we will model three different types of visits, namely new visits for patients who have just enrolled in the practice, follow-up visits for established patients and unexpected visits. The new practice will begin with a ramp-up phase. During the first months of the practice, there will be only new visits then follow-up visits will gradually increase. After most of the patients in the panel are enrolled, the practice will only have follow-ups visits. A schematic representation of the ramp-up phase of the practice is given in Figure 6.

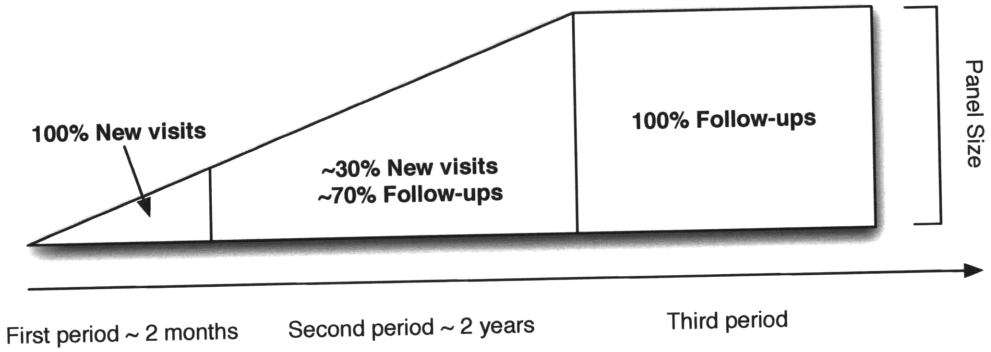

Figure 6: Ramp-up of The New Practice

From modeling perspective, we are particularly interested in the second period with the mix of new visits and follow-up visits while accommodating flexible time for unexpected visits. Furthermore, we defined various levels of complexity of patients' health status to refine the segmentation of visit types. A segmentation based on types of diseases may not be relevant because patients often have more than one type of condition, i.e. comorbidities. Based on our discussion with the care team, we made a set of assumptions on the proportion of different level of patient complexity – see Figure 7.

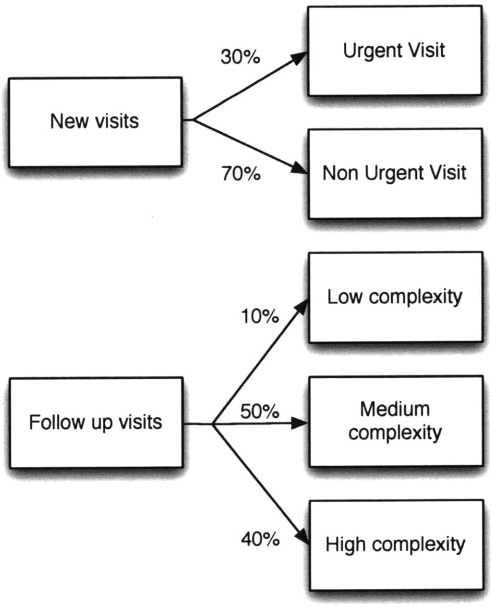

Figure 7: Visits Segmentation

Service processes

The initial care team in the new care practice comprises one medical doctor (MD), two nurses (a care nurse and a triage nurse), one medical assistant (MA) and one care coordinator (CC).

The base model considers a simple sequential process for every type of patient in the new practice. We did not consider exceptions or patient redirection in this first model. The patient first self-checks in at the kiosk, then the Greeter welcomes the patient and takes her in the examination room. The Medical Assistant (MA) then sees her in the examination room and reviews with her basic patient information. Subsequently, depending on the type of visit and the level of complexity, the patient sees either a MD and a nurse (for new visits), or a MD or a nurse (for follow-up visits of medium and high complexity), or only a nurse (follow-up and low complexity). Finally, a Care Coordinator (CC) performs the End of Visit procedure (EOV). This is shown schematically in Figure 8.

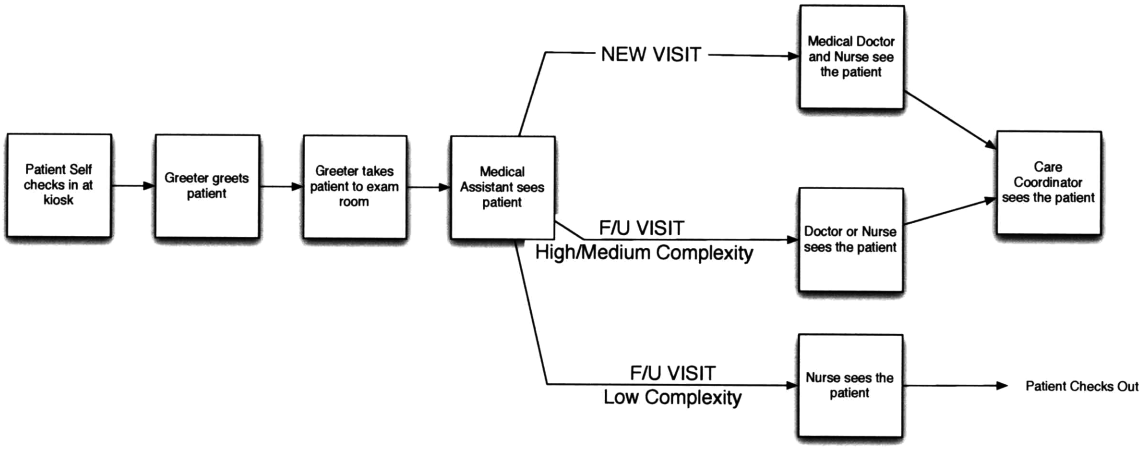

Figure 8: Care Processes

The main assumptions on service times were discussed during our interviews with the care team. These are compiled and presented in the appendix. Unexpected visits are supposed to follow the same kind of care process as medium complexity follow-up visits.

Control variables

Total capacity and throughput of the new practice are of key interest, depending on the type of visit. To this end, we have designed control variables representing the number of patients arriving in the practice during day:

Number of new visits per day

Number of follow-up visits per day

Number of unexpected visits per day

We are also interested in the allocation of resources among the care team. How many nurses are we going to allocated to the care team? How much time of the second nurse can we allocate to the care for patients? To serve this purpose, we have defined two variables as proxy of the time the second nurse is working in the care team[55]:

The starting hour of the triage nurse

The number of hours worked

[55] See Appendix for details

Outputs variables

To evaluate the feasibility of the new practice, track the overall performance of the system and assess patient satisfaction in the practice, we are considering several output variables, as follows.

Resources Utilization:

- Medical Doctor Utilization
- Nurse Utilization
- Medical Assistant Utilization
- Care Coordinator Utilization

Patient Satisfaction:

- Number of patients in waiting lounge
- Patient average waiting time in lounge
- Patient average waiting time in examination room

The total number of new and follow-up visits throughout the year gives the number of visits that were scheduled. We have not implemented no-show rates in the current model. In effect, it may increase the variability of visits processed in the care practice. The total number of unexpected visits accommodated throughout the year gives an indication of the amount of flexibility we have in the system, i.e. the amount of open slots we can accommodate while keeping resource utilization and quality within acceptable range.

Medical doctor is the most critical resource in the system. MD utilization rate in new practice is expressed in percentage, where 100% corresponds to the doctor spending all of his time to take care of patients as defined by the care process in the model. It does not account for instance, the administrative tasks required to prepare the visit nor lunch breaks or group meeting. In the same manner, nurse, medical assistant and care coordinator utilizations are expressed in percentage and represent the same criteria. It is useful to note that the nurse utilization will be compared to the medical doctor utilization, and we will try to balance as much work as possible by relying on the second nurse (who is supposed to be assigned to triage) or by changing resources allocation in care processes. An appropriate target range for resources' utilization is around 65-80%.

Patients' satisfaction in the new care practice is represented by the number of patients waiting in the lounge and the average waiting time in the practice. The total number of patients waiting in the lounge can be used to make recommendations on the physical design of the waiting lounge. We are considering average values for waiting time, because extreme episodes can occur and maximum number can have significant peaks.

5.2.4 Calibration and Validation

Since the practice we intend to model does not yet exist, we calibrated our model using available data on current primary care practices. For this we extensively relied on the care team's experience in primary care settings. As we built our model, we put a great deal of emphasis on communicating the model details as well as the model logic to the care team to give them a better grasp how the model works and how it can represent a simplified view of the new practice. Through multiple presentations in front of the entire project team, we fostered constructive debates on the model logic assumptions and on the model data assumptions. Thus, the entire model was developed collaboratively and iteratively with the project team. This helped immensely in developing a valid model of the proposed care practice.

5.2.5 Analysis and Results

In this section, we discuss and analyze the system's responses to varying input variables, such as the number of unexpected visits per day and the number of hours the triage nurse is working in the care team. As suggested by the project team, the new practice will set a standard scheduling rule to accommodate 5 to 6 new visits per day, while scheduling twice as many follow-up visits. For the purpose of the simulation, we have set the number of visits to 5 for new visits and 10 for follow-up visits.

We defined 3 different sets of scenarios where we have different combinations of various variables. In set 1, the system operates without unexpected visits and we are just changing the working schedule of the triage nurse – See Table 1.

	Number of visits per day	Number of follow up visits per day	Number of unexpected visits per day	Second nurse's time spent in care team per day (7h)
Scenario 1	5	10	0	0
Scenario 2	5	10	0	3
Scenario 3	5	10	0	5
Scenario 4	5	10	0	7

Table 1: Set 1 Scenarios

Set 1 scenarios

With no surprise, we observe nurse practitioners' utilization rate decreases with the involvement of the second nurse in the care team. In fact, it results in a more balanced utilization rate across the care team. Based on this basic analysis, we can better define the role of the triage nurse in the care team. A refinement in this analysis would be to tie costs associated with each team member and identify which scenario offers the most cost-effective mix of personnel in the care team – See Figure 9.

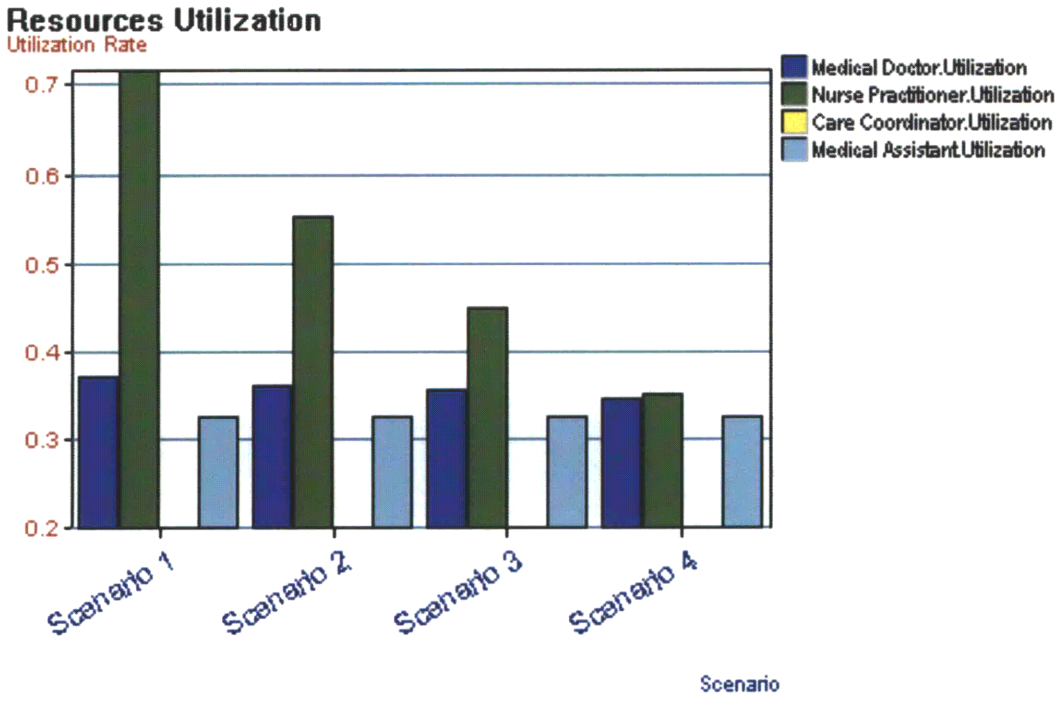

Figure 9: Set 1 Resources Utilization

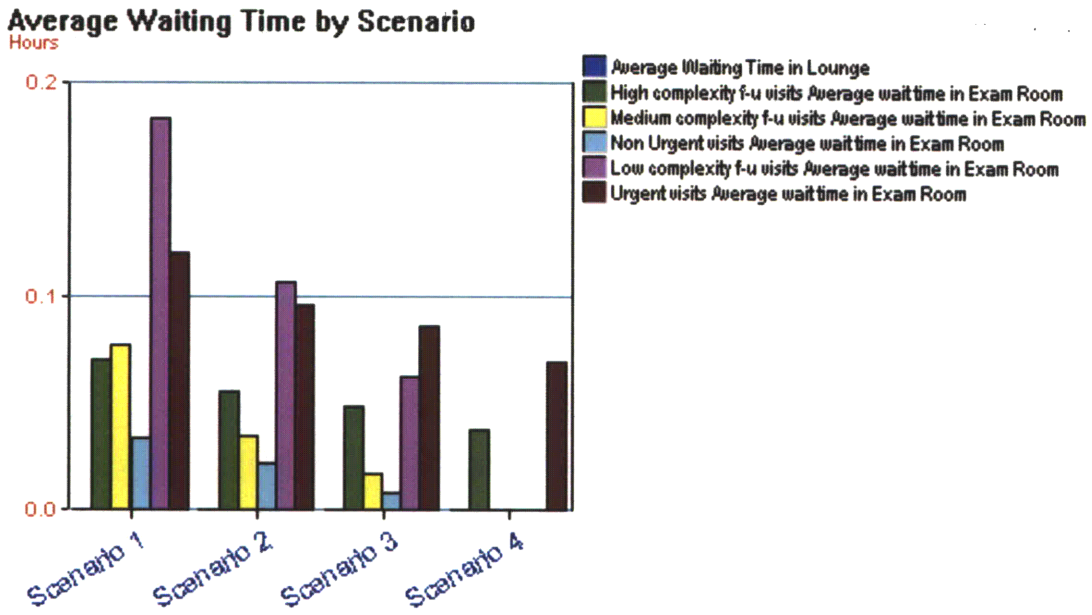

Figure 10: Set 1 Average Waiting Time

Again, as anticipated, the average waiting times in examination rooms decrease significantly when the second nurse gets more involved in the care practice. It is particularly significant for low complexity follow-up visits, where availability of nurses is critical in the care process as it is modeled. Additionally, the second nurse can also be needed for urgent visits and high complexity follow-ups, where doctor and nurse are both required. Recall that the results in Figure 10 represent the average waiting times and not the distribution of the waiting time throughout the year. Modeling such details can be undertaken in subsequent studies when more information is available on the operational requirements of the practice as well as the seasonality of demand.

Based on this initial analysis, we defined a second set of scenarios, in which we assess the capacity of the practice to accommodate unexpected visits throughout the day. We vary the number of unexpected visits from 1 to 7 visits per day. Details of scenarios are provided in Table 2.

	Number of visits per day	Number of follow up visits per day	Number of unexpected visits per day	Second nurse's time spent in care team per day (7h)
Scenario 5	5	10	1	0
Scenario 6	5	10	2	0
Scenario 7	5	10	3	0
Scenario 8	5	10	4	0
Scenario 9	5	10	5	0
Scenario 10	5	10	6	0
Scenario 11	5	10	7	0

Table 2: Set 2 Scenarios

Set 2 results

As we increase the number of unexpected visits per day, the medical care resources are working more intensely, since they require all the resources to take care of them in the practice. This is shown in Figure 11.

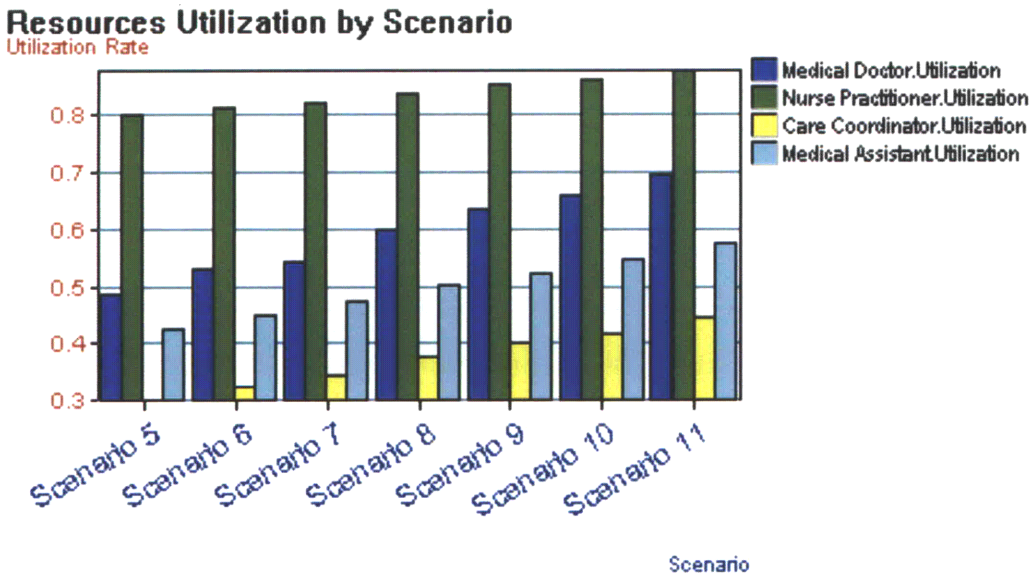

Figure 11: Set 2 Resources Utilization

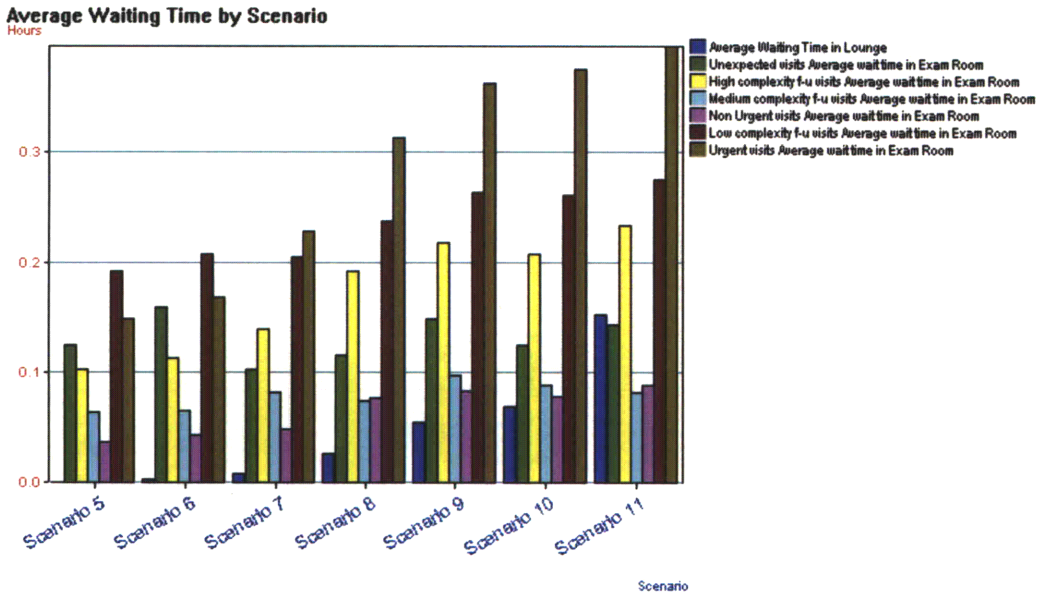

Figure 12: Set 2 Average Waiting Time

When there are more unexpected visits per day, we note that urgent visits are the most affected. Average waiting time in examination room for urgent visits jump from 9 minutes to 24 minutes. Also, average waiting time in Lounge increases from 0 minutes to 15 minutes. It is important to insist that the waiting times are averaged over the entire simulation time, thus small changes in average values may reflect significant change in the distribution. Again, more detailed analysis should be performed to look at the distribution of waiting time across types of visits to gain deeper insights. Results are given in Figure 12.

Subsequently, we defined four other scenarios, where we make the triage more involved in the care of patients while accommodating seven unexpected visits per day. We intend to observe how much relief does the second nurse offer to the system. This is set 3 of scenarios and detailed in Table 3.

	Number of visits per day	Number of follow up visits per day	Number of unexpected visits per day	Second nurse's time spent in care team per day (7h)
Scenario 12	5	10	7	0
Scenario 13	5	10	7	3
Scenario 14	5	10	7	5
Scenario 15	5	10	7	7

Table 3: Set 3 of Scenarios

Set 3 results

The results show that the second nurse can dramatically reduce the utilization rate of the doctor and nurse in the new practice. By changing the second nurse schedule, we can balance resources utilization to provide a more flexible schedule for all medical practitioners. Nurses' utilization rate goes from 85% to 50% if the triage nurse dedicates her time to the care team as shown in Figure 13.

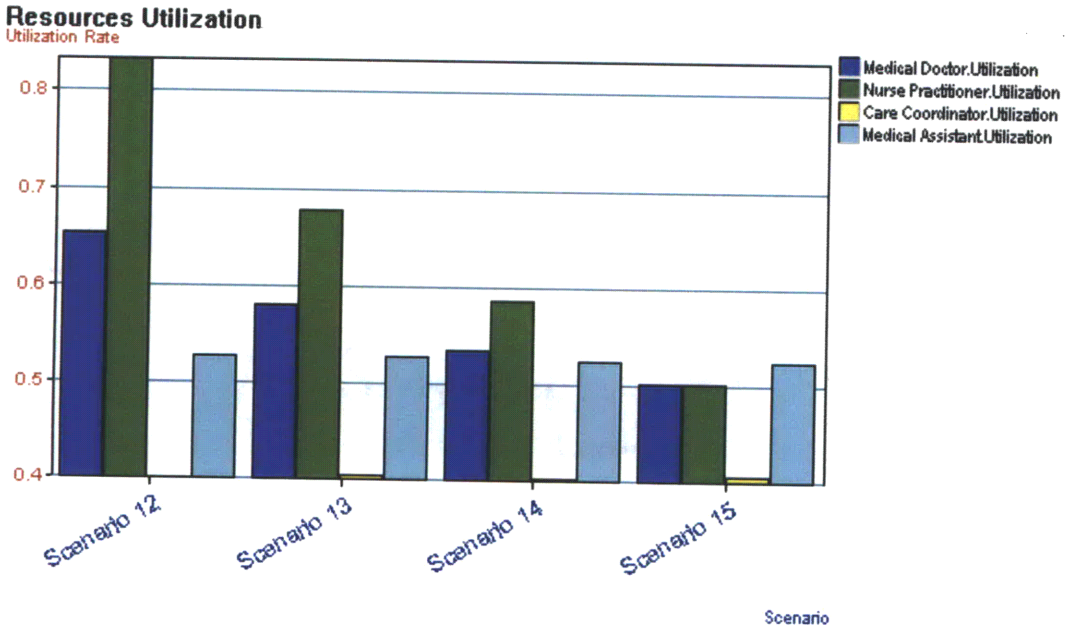

Figure 13: Set 3 Resources Utilization

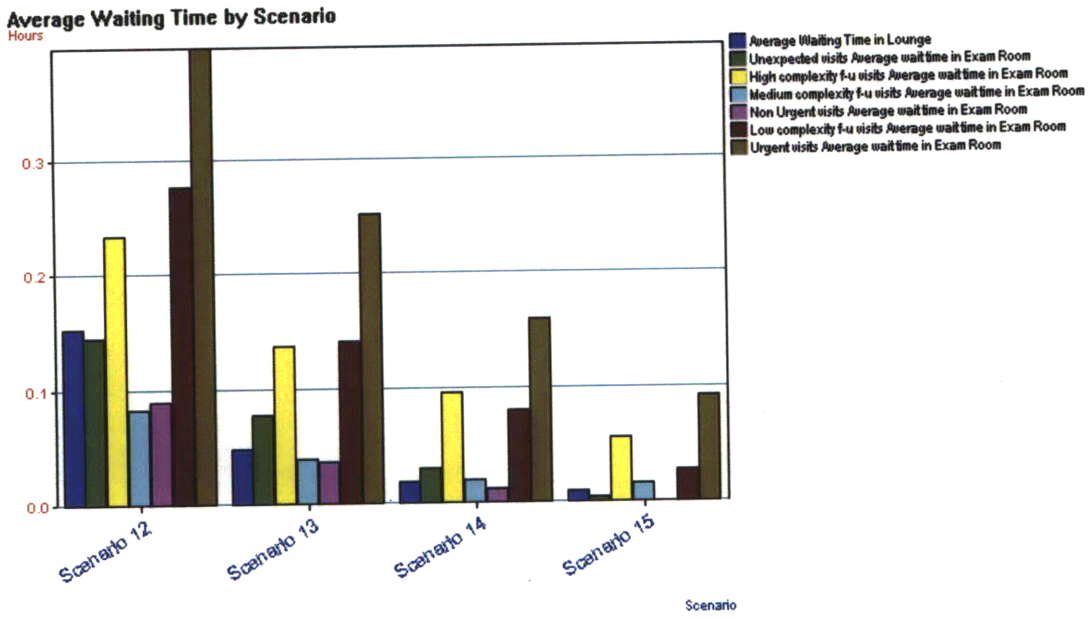

Figure 14: Set 3 Average Waiting Time

By allocating the second nurse in the care team, we can reduce the average waiting time of every type of patients in the new care practice. It dramatically improves the quality of service as represented by waiting times. Average waiting time for urgent new visits decreases from 24 minutes to 6 minutes. For high complexity visits, the average waiting time decreases from 13 minutes to 3 minutes – see Figure 14.

These preliminary scenario analyses were conducted to demonstrate the potential benefits of simulation tools to decision-makers in hospitals trying to design a new care practice model. More detailed investigation is required to guide the project team to optimize the cost of resources, the satisfaction at work, the quality of care and the accommodation of urgent cases, which at the end of the day can prevent patients to utilize costly Emergency Department services.

Chapter 6: Synthesis and Recommendations

As we review the roles of business leaders and hospitals in the future of primary care, policy-makers must move forward to provide a fertile regulatory environment to support and to enable disruption in U.S. health care. Since the health care industry is highly regulated, no significant system-wide improvements is possible without appropriate governmental actions. New regulations in the training of medical practitioners, the payment structure of primary care, the insurance industry and the health care businesses have to be adopted.

Yet, faced with significant uncertainty around the interdependence of factors in the system and around the future evolution of the system in the short-term and long-term, it is complex and costly to precisely predict the impacts of policy actions. As shown with the simulation study performed at the hospital, it requires a lot of time and money to build a comprehensive and detailed model to represent reality of operations and to gain insights into the system. For example, in climate change, policy-makers have encountered similar uncertainty challenges in trying to better understand the behavior of carbon dioxide lifecycle. Combining immediate policy actions based on the most up-to-date data on the evolution of a system under regulation and adaptive features embedded in the same policies may be a solution toward improved policy-making under looming challenges.

Along those lines, Professors McCray and Oye analyzed the adaptation and anticipation features in policy-making in the U.S.[56]. Anticipative and adaptive policies should be designed based on a first thorough front-end integrated assessment of the situation with most up-to-data data and models and should also incorporate a back end integrated implementation of adaptive capacity to improve the quality of decisions over time. However, the reevaluation of policies should be made based on predefined performance measures. It represents a tremendous challenge to define appropriate metrics that will guide correct intended behaviors. Similar to the theory of incentives, several trade-offs have to be made on the design of targeted, adaptive policies. Professors McCray and Oye

[56] L. McCray and K. Oye - NSF-EPA Trans-Atlantic Uncertainty Colloquium, 2006

offer a segmentation of the types of metrics that can be used to track performance of policy actions as follows.

Concrete Actions: define goals in terms of behavioral indicators

Intervening States of Links: define goals in terms of observables on causal path

Ultimate Objectives: define goals in terms of proxies for consummatory values

Strengths and weaknesses of these actions are discussed in Table 4.

	Behavioral Indicators	**Intervening Indicators**	**Consummatory Indicators**
Strength	Assigning Responsibility	Nominal Measurability and Ostensible Objectivity	Legitimating Policy
Weakness	Legitimating Policy	Relevance to Legitimacy and Responsibility	Assigning Responsibility

Table 4: Strengths and Weaknesses of Three Types of Performance Metric

Our preliminary analyses of the primary care practice lead to some policy recommendation guidelines. However, in order to execute these recommendations, we have to develop complimentary performance metrics to keep track of the impacts of the policy actions. Further research is needed to focus on balancing the trade-offs of legitimating policy and assigning responsibility to guide intended behaviors from businesses, health care providers for higher quality of care and reduced costs.

APPENDIX

General assumptions

The general assumptions on the new practice operations are: 180 operating days per year, 7 hours of operation per day.

Service times

Based on the first discussions with the care team, we made a set of assumptions on the future service times, which depend on the type of visit and its associated level of complexity. In the following table, we put together the service times in minutes for the model as shown in Table 5.

Service Times

In minutes	**MA**	**MD**	**NP**	**CC**
Type of patient				
New patient				
Non urgent	15	30 (MD or NP)		10
Urgent	5	20 (MD & NP)		5
Follow-up patient				
Low complexity	5		15	0
Medium complexity	10	20 (MD or NP)		10
High complexity	15	30 (MD & NP)		15
Unexpected patient	10	20 (MD or NP)		10

Table 5: Service Time Assumptions

In this first model, we are using deterministic values for service times. Every visit is booked in advance for a certain amount of time, then medical practitioners use all the allocated time to see the patient, and keep the visit within the constrained schedule. In current practice, arrival of urgent unexpected cases changes doctors' schedule by spreading the delay throughout the day.

Control variables

Number of visits per day:

For modeling purposes, we have assumed that the inter-arrival time between two visit of the same type (new, follow-up or unexpected) is constant. Therefore if the number of visits per day is n, the inter-arrival time is equal to 7 / n hour.

For example: 7 visits per day corresponds to 1 visit every hour, 14 visits to 1 visit every half hour.

Nurse working hours:

In order to change the involvement of second nurse in the care team, we defined the starting hour of her work in the care team and the total hour worked per day in the care team. The two parameters we are controlling are the starting hour and the hours worked. They are defined as follows in Figure 15.

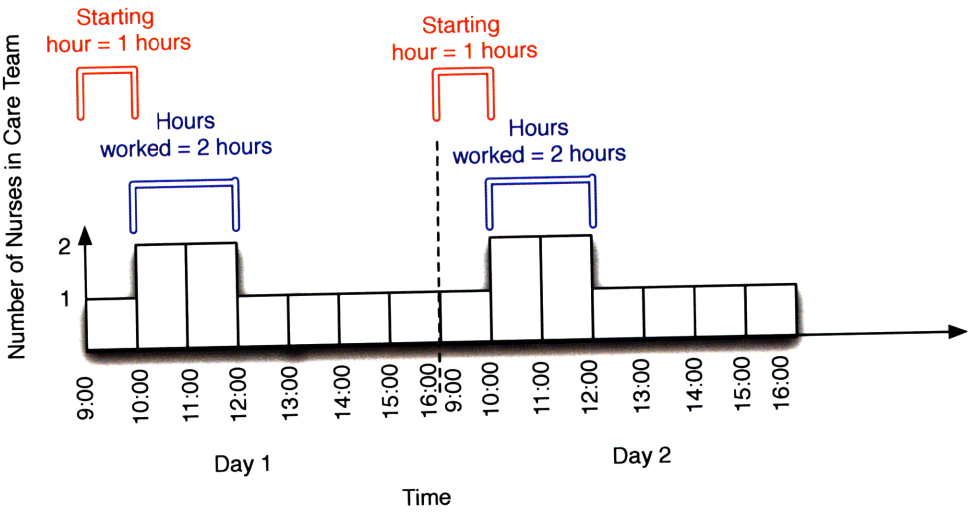

Figure 15: Second nurse schedule

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