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HEALTHCARE SYSTEMS ENGINEERING

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Healthcare Systems Engineering

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Healthcare Systems Engineering

The Healthcare Delivery System

“In nothing do men more nearly approach the gods than in giving health to men.”

—Cicero

Overview

Health care (or **healthcare**) is the maintenance or restoration of the human body by the treatment and prevention of disease, injury, illness and other physical and mental impairments. Healthcare is delivered by trained and licensed professionals in medicine, nursing, dentistry, pharmacy, and other allied health providers. The quality and accessibility of healthcare varies across countries and is heavily influenced by the *health policies* in place. It is also and dependent on demographics, social and economic conditions.

A health system (healthcare system or health care system) is organized to facilitate the delivery of care. The World Health Organization (WHO) defines health systems as follows:

A health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health. This includes efforts to influence determinants of health as well as more direct health-improving activities. A health system is therefore more than the pyramid of publicly owned facilities that deliver personal health services. It includes, for example, a mother caring for a sick child at home; private providers; behavior change programs; vector-control campaigns; health insurance organizations; occupational health and safety legislation. It includes inter-sectoral action by health staff, for example, encouraging the ministry of education to promote female education, a well-known determinant of better health. (*Everybody’s Business: Strengthening Health Systems to Improve Health Outcomes. WHO’s Framework for Action*, 2007)

WHO goes on to say that:

A good health system delivers quality services to all people, when and where they need them. The exact configuration of services varies from country to country, but in all cases requires a robust financing mechanism; a well-trained and adequately paid workforce; reliable information on which to base decisions and policies; well-maintained facilities and logistics to deliver quality medicines and technologies. (“World Health Organization. Health Systems,” n.d.)

1.1 HEALTHCARE DELIVERY COMPONENTS

The delivery of healthcare to a patient population depends on the systematic provision of services. WHO suggests that “People-centered and integrated health services are critical for reaching universal health coverage. *People-centered care* is care that is focused and organized around the health needs and expectations of people and communities, rather than on diseases. Whereas *patient-centered care* is commonly understood as focusing on the individual seeking care (the patient), people-centered care encompasses these clinical encounters and also includes attention to the health of people in their communities and their crucial role in shaping health policy and health services. Integrated health services encompass the management and delivery of quality and safe health services so that people receive a continuum of health promotion, disease prevention, diagnosis, treatment, disease-management, rehabilitation and palliative care services, through the different levels and sites of care within the health system, and according to their needs throughout the life course.”

Table 1.1 summarizes the major types of levels and sites of care components and gives some examples of providers and the conditions they address. While there is no universal definition of each type, there is some consensus in usage (except where specifically noted). Improvement of the healthcare system will depend on the provider professionals performing as a team that can act and influence patients as they may transition from one care delivery mode to another.

While Table 1.1 shows delivery types as distinct, in practice there is often overlap and intersection. Primary care can be delivered in urgent care settings (e.g., walk-in clinics). Emergency rooms may often be the *de facto* provider of primary care. Similarly, quaternary care may be an extension of tertiary care.

The *International Classification of Primary Care*, Second Edition (ICPC-2), is a reference (accepted by WHO) that allows classification of

Table 1.1 Delivery of Healthcare Services

Type	Delivery Focus	Providers	Conditions/Needs
Primary care	<ul style="list-style-type: none"> • Day-to-day healthcare • Often the first point of consultation for patients 	<ul style="list-style-type: none"> • Primary care physician, general practitioner, or family or internal medicine physician • Pediatrician • Dentist • Physician assistant • Nurse practitioner • Physiotherapist • Registered nurse • Clinical officer • Ayurvedic 	<ul style="list-style-type: none"> • Routine check-ups • Immunizations • Preventive care • Health education • Asthma • Chronic obstructive pulmonary disease • Diabetes • Arthritis • Thyroid dysfunction • Hypertension • Vaccinations • Oral health • Basic maternal and child care
Urgent care	<ul style="list-style-type: none"> • Treatment of acute and chronic illness and injury provided in a dedicated walk-in clinic • For injuries or illnesses requiring immediate or urgent care but not serious enough to warrant an ER visit • Typically do not offer surgical services 	<ul style="list-style-type: none"> • Family medicine physician • Emergency medicine physician • Physician assistant • Registered nurse • Nurse practitioner 	<ul style="list-style-type: none"> • Broken bones • Back pain • Heat exhaustion • Insect bites and stings • Burns • Sunburns • Ear infection • Physicals

(continued)

Table 1.1 Delivery of Healthcare Services (Continued)

Type	Delivery Focus	Providers	Conditions/Needs
Ambulatory or outpatient care	<ul style="list-style-type: none"> • Consultation, treatment, or intervention on an outpatient basis (medical office, outpatient surgery center, or ambulance) • Typically does not require an overnight stay 	<ul style="list-style-type: none"> • Internal medicine physician • Endoscopy nurse • Medical technician • Paramedic 	<ul style="list-style-type: none"> • Urinary tract infection • Colonoscopy • Carpal tunnel syndrome • Stabilize patient for transport
Secondary or acute care	<ul style="list-style-type: none"> • Medical specialties typically needed for advanced or acute conditions including hospital emergency room visits • Typically not the first contact with patients; usually referred by primary care physicians 	<ul style="list-style-type: none"> • Emergency medicine physician • Cardiologist • Urologist • Dermatologist • Psychiatrist • Clinical psychologist • Gynecologist and obstetrician • Rehabilitative therapist (physical, occupational, and speech) 	<ul style="list-style-type: none"> • Emergency medical care • Acute coronary syndrome • Cardiomyopathy • Bladder stones • Prostate cancer • Women's health
Tertiary care	<ul style="list-style-type: none"> • Specialized highly technical healthcare usually for inpatients • Usually patients are referred to this level of care from primary or secondary care personnel 	<ul style="list-style-type: none"> • Surgeon (cardiac, orthopedic, brain, plastic, transplant, etc.) • Anesthesiologist • Neonatal nurse practitioner • Ventricular assist device coordinator 	<ul style="list-style-type: none"> • Cancer management • Cardiac surgery • Orthopedic surgery • Neurosurgery • Plastic surgery • Transplant surgery • Premature birth • Palliative care • Severe burn treatment

Table 1.1 Delivery of Healthcare Services (Continued)

Type	Delivery Focus	Providers	Conditions/Needs
Quaternary care	<ul style="list-style-type: none"> Advanced levels of medicine that are highly specialized and not widely accessed Experimental medicine Typically available only in a limited number of academic health centers 	<ul style="list-style-type: none"> Neurologist Ophthalmologist Hematologist Immunologist Oncologist Virologist 	<ul style="list-style-type: none"> Multi-drug-resistant tuberculosis Liver cirrhosis Psoriasis Lupus Myocarditis Gastric cancer Multiple myeloma Ulcerative colitis
Home and community care	<ul style="list-style-type: none"> Professional care in residential and community settings End-of-life care (hospice and palliative) 	<ul style="list-style-type: none"> Medical director (physician) Registered nurse Licensed practical nurse Certified nursing assistant Social worker Dietitian or nutritionist Physical, occupational, and speech therapists 	<ul style="list-style-type: none"> Post-acute care Disease management teaching Long-term care Skilled nursing facility/assisted living Behavioral and/or substance use disorders Rehabilitation using prosthesis, orthotics, or wheelchairs

the patient's reason for encounter (RFE) with primary care or general care ICPC-2). The classification structure addresses the problems or symptoms/complaints, infection, injuries, diagnosis managed, and interventions. It also codes processes such as medical exams, laboratory tests, and how the encounter was initiated (e.g., by a provider or other person), referrals to physician/specialist, referrals to a clinic/hospital. A simplified two-page version is available that makes it conducive for use by a range of medical providers. A systematic review of the literature on ICPC showed

that it has been used with the greatest frequency in the Netherlands, Australia, United States, Norway, United Kingdom, and France (Mariana et al., 2009). As the tool becomes more widespread, it may also become a source of data on the reason for healthcare delivery consultation from the perspective of the patient.

1.2 MAJOR STAKEHOLDERS

There are many stakeholders in the healthcare system, including patients, caregivers, healthcare providers, insurers, and institutions, as well as employers and regulators. Major stakeholders are outlined in the Table 1.2 which is from the Agency for Healthcare Research & Quality (AHRQ).

As illustrated in Table 1.2, different stakeholders play different roles and have different needs and desires from the healthcare system. Often, these perspectives may be in conflict; e.g., some pharmaceutical companies may want to pursue a profit-maximizing strategy while some policy makers may want to increase access. Further, there are asymmetries in information between the parties, for example, in the provider-patient relationship. At the end of the day, however, developing approaches that can build partnership and collaboration as well as improving communication between the various stakeholders will be essential to fully realize value-based healthcare. This is clearly demonstrated in the Institute for Healthcare Improvement's access-quality-cost triangle.

1.3 GLOBAL ISSUES IN HEALTH

Healthcare varies significantly by country. This includes how healthcare is financed, who is covered, what services are delivered, and the corresponding health outcomes from the system. We discuss each of these below.

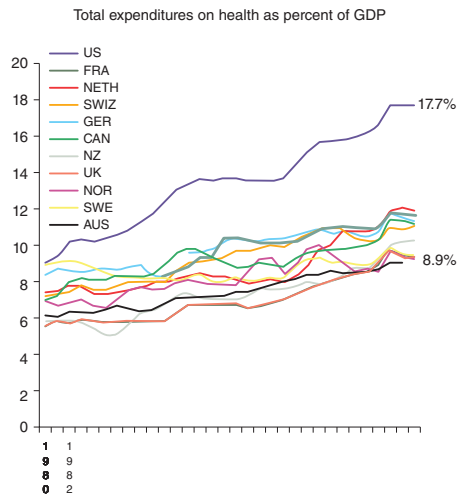
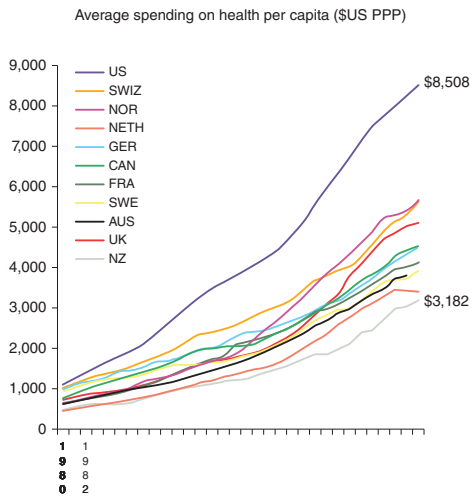
Global Spending

As will be discussed in Chapter 4, healthcare is financed in many different ways, ranging from private insurance to universal coverage. Further, the amount of spending is quite different by country. Figure 1.1 provides data on some of the Organization for Economic Cooperation and Development (OECD) countries. In 2011, the United States spent \$8,508 per capita (in U.S. dollars) while New Zealand spent \$3,182 (in U.S. dollars, accounting for purchasing power parity). According to the World Bank

Table 1.2 Stakeholder Groups

Stakeholders	Stakeholders' Perspective
Consumers, patients, caregivers, and patient advocacy organizations	It is vital that research answer the questions of greatest importance to those experiencing the situation that the research addresses. Which aspects of an illness are of most concern? Which features of a treatment make the most difference? Which kinds of presentation of research results are easiest to understand and act upon?
Clinicians and their professional associations	Clinicians are at the heart of medical decision making. Where is lack of good data about diagnostic or treatment choices causing the most harm to patients? What information is needed to make better recommendations to patients? What evidence is required to support guidelines or practice pathways that would improve the quality of care?
Healthcare institutions, such as hospital systems and medical clinics, and their associations	Many healthcare decisions are structured by the choices of institutional healthcare providers, and institutional healthcare providers often have a broad view of what is causing problems. What information would support better decisions at an institutional level to improve health outcomes?
Purchasers and payers, such as employers and public and private insurers	Coverage by public or private purchasers of healthcare plays a large role in shaping individual decisions about diagnostic and treatment choices. Where does unclear or conflicting evidence cause difficulty in making the decision of what to pay for? Where is new technology or new uses of technology raising questions about what constitutes a standard of care? What research is or could be funded?
Healthcare industry and industry associations	The manufacturers of treatments and devices often have unique information about their products.
Healthcare policymakers at the federal, state, and local levels	Policymakers at all levels want to make healthcare decisions based on the best available evidence about what works well and what does not. Comparative effectiveness research/patient-centered outcomes research can help decision makers plan public health programs, design health insurance coverage, and initiate wellness or advocacy programs that provide people with the best possible information about different healthcare treatment options.
Healthcare researchers and research institutions	Researchers gather and analyze the evidence from multiple sources on currently available treatment options.

Source: Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services, The effective health care program stakeholder guide. <http://www.ahrq.gov/research/findings/evidence-based-reports/stakeholderguide/chapter3.html>



Note: \$US PPP - purchasing power parity.
Figure 1.1 Comparison of Healthcare Spending for OECD Countries, 1980–2011 Source: Commonwealth Fund (2014)

(2015), the country with the lowest healthcare expenditures in 2011 as a percentage of gross domestic product (GDP) was Timor-Lest (0.7%), while the highest was Tuvalu (18.5%), with the United States coming in second place (17.7%). Further, in Tuvalu 99.9% of the total was public spending. This value was 47.1% for the United States, and the global average was 59.6%.

Spending in and of itself is not the best measure of healthcare for a country. What is important is the value that is received as a result of the spending, that is, the resulting health outcomes.

Global Outcomes












There are several outcomes that are commonly used as a measure of health, including life expectancy at birth by gender, malnutrition prevalence, and infant mortality rate. Although healthcare spending per person in the United States was more than double that in New Zealand, New Zealand performed better on all three outcomes (infant mortality rate of 5% compared to 6%, life expectancy at birth for females of 83 versus 81, and malnutrition prevalence of 0% compared to 0.5%). Among the higher income countries, the United States performed poorly on most measures compared to its peers.

There is little agreement, however, on what the best outcome measures are, and thus it proves difficult to directly compare healthcare systems. For example, in the United States, many have argued that the ability to choose healthcare providers is highly valued. Further, the United States pays much higher prices for prescription drugs compared to other countries due to government laws that protect the special interests of the pharmaceutical industry. These kinds of issues are not necessarily a reflection of inefficiency in the healthcare system.

A report that compares OECD countries was released by the Commonwealth Fund (2014). In this comparison, five classes of outcomes were used: quality care, access to care, efficiency, equity, and healthy lives (details of the measures are found in the report). The results of the study are shown in Figure 1.2. The United Kingdom ranked first in eight of the measures, and had the lowest cost per capita in the group; it was rated overall as the best healthcare system. The United States ranked worst in the comparison in spite of the much higher rate of spending. The authors of the study argue that a key reason for the poor performance by the United States is the lack of universal health insurance. The lack of insurance coverage is a primary driver of lack of *access* and lack of *equity*. Another key reason stated

COUNTRY RANKINGS

Top 2*
Middle
Bottom 2*

											
	AUS	CAN	FRA	GER	NETH	NZ	NOR	SWE	SWIZ	UK	US
OVERALL RANKING (2013)	4	10	9	5	5	7	7	3	2	1	11
Quality Care	2	9	8	7	5	4	11	10	3	1	5
Effective Care	4	7	9	6	5	2	11	10	8	1	3
Safe Care	3	10	2	6	7	9	11	5	4	1	7
Coordinated Care	4	8	9	10	5	2	7	11	3	1	6
Patient-Centered Care	5	8	10	7	3	6	11	9	2	1	4
Access	8	9	11	2	4	7	6	4	2	1	9
Cost-Related Problem	9	5	10	4	8	6	3	1	7	1	11
Timeliness of Care	6	11	10	4	2	7	8	9	1	3	5
Efficiency	4	10	8	9	7	3	4	2	6	1	11
Equity	5	9	7	4	8	10	6	1	2	2	11
Healthy Lives	4	8	1	7	5	9	6	2	3	10	11
Health Expenditures/Capita, 2011**	\$3,800	\$4,522	\$4,118	\$4,495	\$5,099	\$3,182	\$5,669	\$3,925	\$5,643	\$3,405	\$8,508

Notes: * Includes ties. ** Expenditures shown in \$US PPP (purchasing power parity); Australian \$ data are from 2010.

Figure 1.2 OECD Country Health Rankings Source: Commonwealth Fund (2014)

is the United States is lagging behind other countries in the sophistication of the health information system, which makes coordinated care difficult to achieve. The United States also has high levels of chronic conditions including diabetes, obesity, and congestive heart failure and hence scores low in *health lives*.

The Economist (2014) performed a 166-country health outcome report. Figure 1.3 shows a plot of ranking based on health outcomes versus ranking on healthcare spending. The outcome measure was a function of life expectancy at age 60, adult mortality in 2012, disability-adjusted life years (a measure of years of life lost due to poor health), and health-adjusted life expectancy. They found that health outcomes (and hence ranking) were correlated with health spending. Further, they found several regional differences. For example, Asia, Europe, and North America make up the top tier; Latin America, the Middle East, and former Soviet countries make up the middle tier; and the lower tier was made up almost exclusively of African countries.

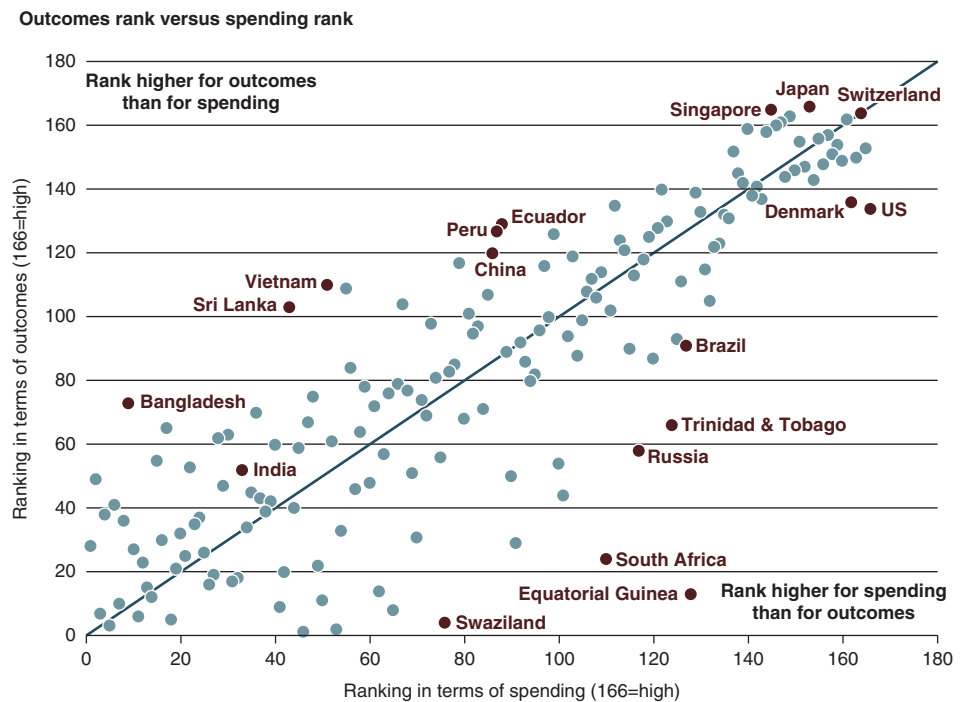


Figure 1.3 Health Outcomes Rank versus Spending Rank by Country

Source: *The Economist* (2014)

performed well in outcomes per spending, and the United States was a poor-value healthcare system (33rd on outcomes index).

Unique Challenges

One of the more troubling aspects of global health is the growing gaps in health outcomes. For example, the WHO World Health Report (2013) states that 35% of African children were at higher risk of death in 2013 compared to 2003. African adults above 30 have a higher death rate than they had 30 years ago. HIV/AIDS is killing 5,000 persons daily in the 15- to 59-year-old age group (and 1,000 children daily below the age of 15) in sub-Saharan Africa. In fact, HIV/AIDS is responsible for 60% of all child deaths in Africa. Life expectancy increased globally by roughly four months per year from 1955 to 2002, but the gap between developed and developing countries also grew over this range. Further, in 2002, over 10 million children (5 years or younger) died; 98% of these deaths occurred in developing countries.

As a response, the Gates Foundation launched Grand Challenges in Global Health. The components are:

- *Develop improved childhood vaccines* that do not require refrigeration, needles, or multiple doses, in order to improve immunization rates in developing countries.
- *Develop new vaccines*, including vaccines to prevent malaria and HIV/AIDS.
- *Develop new ways of preventing insects from transmitting diseases* such as malaria and dengue fever.
- *Discover ways to prevent drug resistance* because many drugs are losing their effectiveness.
- *Discover methods to treat latent and chronic infections* such as hepatitis and AIDS.

What complicates the picture is that many of the health outcomes are due to social problems such as poverty, education, sanitation, housing, and government. Some have criticized the Grand Challenges as being too focused on science at the expense of these other issues, as well as being too narrowly focused on HIV, malaria, and tuberculosis. It also ignores the

delivery and resource allocation issues. In response, the Grand Challenges are updated regularly (e.g., a current focus on women and girls).

The Centers for Disease Control and Prevention (CDC, 2011) released a Healthy People 2020 Report that discusses approaches to improve global health outcomes. They emphasize the importance of global disease detection, response, prevention, and control strategies. They also stress the importance of quickly responding to infectious disease threats (e.g., severe acute respiratory syndrome [SARS], Ebola) as well as real-time infectious disease surveillance. Specific chronic conditions called out in the report are diabetes and obesity, mental illness, substance abuse (including tobacco use), and injuries.

It is clear that global health presents many unique challenges. Much of it involves improving access to care and reducing the cost of care. However, it is also important for these changes to be considered in concert with the social issues of primary education, extreme poverty, effective governments, shelter, and clean water and sanitation.

1.4 DRIVERS FOR HEALTHCARE SYSTEMS

There are several important drivers needed to improve healthcare delivery. These include appropriate financing mechanisms, improving access to a primary source of care, and continued advances in technology. Although not an exhaustive list, in this section we discuss the most important of them.

Financial

High costs are one of the most frequently cited barriers for effective healthcare delivery. Several factors contribute to these costs including advances in technology, population aging, incentives, the price of prescription drugs, and the wealth of the country. The health industry is somewhat unique in that prices tend to increase with technological advances. In comparison, advances in manufacturing technology bring the costs of production down, which are then passed on to the consumer. In healthcare, technological advances can help to increase life expectancy (which bring a corresponding demand), but they can also simply be more expensive, with little or no additional efficacy. Proton therapy for prostate cancer is one such example. It costs over twice the amount of standard radiation therapy, although there has not been shown to be an increase in efficacy. In spite of this, there was

a 67% increase in the number of cases paid by Medicare between 2006 and 2009 (Jarosek et al., 2012).

Much of healthcare spending occurs at the end of life. In 2006 in the United States, for example, Medicare spent on average \$38,975 per descendant compared to \$5,993 per survivor. The Centers for Medicare & Medicaid Services (CMS) estimates that 27% to 30% of total Medicare spending goes to the 5% of beneficiaries who die each year. Elderly patients are also more likely to have serious chronic conditions. Part of the challenge is helping patients and their families to make the most appropriate choices of care. This includes better ways to explain risks and outcomes of medical procedures. In addition, there is currently little internalization of the costs by the patient or family in many cases. Both of these issues can lead to unnecessary, ineffective, or unwanted treatments.

Drug prices differ significantly by country and for some can be a significant burden. The United States pays the highest drug prices in the world, which have doubled in the past decade. In 2012, 11 of the 12 drugs approved by the Food and Drug Administration (FDA) had a cost of over \$100,000 per year (Experts in Chronic Myeloid Leukemia, 2013). Some of the high price is due to the cost of bringing a new drug to market, which includes research and development and extensive clinical trials. However, much of the reason for high drug prices in the United States is simply due to government policy. According to Alpern, Stauffer, and Kesselheim (2014), many firms are taking advantage of laws that require insurers to include expensive drugs in their coverage. Further, they can buy the rights to inexpensive generics and block out competitors. One example is a drug for parasite infection (albendazole), which sold for \$5.92 per day in 1996 when it was developed. Currently, the price is \$119.58 per day.

Several other reasons may also contribute to high costs, including the overuse of specialty care, rising administrative costs, physician fees, and malpractice costs. Government policy, consumer demand, and market incentives all play a strong and interconnected role in defining costs. Developing a sustainable financing model that provides value-based medicine is of utmost importance; this may be unique for each country. We discuss different financing models in Chapter 4.

The Dartmouth Atlas for Healthcare has documented significant geographic differences in healthcare costs, with no significant differences in health outcomes. The conclusion is that there can be significant healthcare operational inefficiencies that lead to these high costs. Focusing on