Technology, Productivity, and Price of Health-care

Introduction

1. General Inflation in Singapore: 5.5% per annum
2. Medical Inflation in Singapore: 8.5% per annum:
   - 2.1 Costs risen 78% in 20 years.
   - 2.2 Hypothetically: If you were born in 1998 and child-birth cost \$2,000, then today it costs \$3,500 and in next ten years will cost \$4,715

Why are expenditures on medical goods and services rising faster than expenditures on other goods and services?

Newhouse (1992): Technological change - and not imperfect competition, nor ageing population, nor generous insurance - is the biggest driver of increasing health-care expenditures.

Outline

1. Price vs Quantity Reasons
2. How to measure contribution of technology to inflation
3. Role of technology in increasing cost
4. Small area variation

Technology and Rise in Medical Expenditure

Health Expenditures: E=**P**×Q

1. Recall $P \times Q = W \times Z = TF + SI + PI + UI$
   1.1 Either P increases or Q increases
   1.2 Either W increases or Z increases.

Prices go up:

1. **Increased resource costs**: Increase in W: wages of doctors and nurses, prices of equipment.
2. **Less competitive markets** If market is more monopolistic, prices increase.
3. **Expensive new technology**: Expensive technology, price of treatment will increase.

[If increase in expenditure is due to price P, it *harms* consumers: Health is more expensive to produce due to resource constraints or lack of competition, combination of factors above, then people have to (a) cut back on healthcare; and/or (b) spend more money to stay healthy.]

Health Expenditures E=P×**Q**

Quantity demanded goes up:

1. **Ageing population**: People get older and sicker, demand more medical services.
2. **Richer population**:Health-care is normal good. Increasing income increases health-care consumption.
3. **More insurance coverage**: Reduces out-of-pocket price, increasing consumption.
4. **Increase quality of care**: Improvement in technology, each dollar spent generates higher marginal benefit, then demand increases.
5. **New types of health-care**: New technologies are introduced but do not replace old ones, then consume both.

[If increase in expenditure is due to quantity Q, may *not necessarily harm* consumers:
Consumers feel extra spending on health-care is worth it - due to better quality care; OR extra spending is due to moral hazard and supplier and induced demand.]

Measuring Medical Inflation

1. Service Price Index: Amount of money required to purchase the same bundle of goods over time

$$SPI_{t_0,t_1} = \frac{p(t_1) \cdot m(t_0)}{p(t_0) \cdot m(t_0)}$$

   1.1 Common Inflation measure: Laspeyres index:

$$I_{CPI} = \frac{p_1^A \cdot q_0^A + p_1^B \cdot q_0^B}{p_0^A \cdot q_0^A + p_0^B \cdot q_0^B}$$

   Ratio of quantity of yesterday's goods at today's price to quantity of yesterday's goods at yesterday's price.

2. Cost of Living Index: how much consumers would be willing to pay or would have to be compensated to accept changes in medical treatments and prices over time.

Measuring Medical Inflation

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$$SPI_{t_0,t_1} = \frac{p(t_1) \cdot m(t_0)}{p(t_0) \cdot m(t_0)}$$

2. E.g. Cost of treating heart-attack (Acute Myocardial Infarction (AMI)) in US between 1984 and 1991 has increased by 32%

Year	Costs ($)
1984	11,175
1985	11,691
1986	11,998
1987	12,253
1988	12,725
1989	13,019
1990	13,623
1991	14,772

Source: Table on Costs from Cutler (1998), BHT Chap 13

Measuring Medical Inflation - Mismeasurement

1. Service Price Index:

$$SPI_{t_0,t_1} = \frac{p(t_1) \cdot m(t_0)}{p(t_0) \cdot m(t_0)}$$

   Ratio of quantity of yesterday's goods at today's price to quantity of yesterday's goods at yesterday's price:

2. This simple inflation index mis-measures (a) the effect of new technology and (b) increase in quality of medical care.
   - 2.1 Interprets that for **same bundle of goods**, AMI patient worse off in 1991 than in 1984.
3. But heart-attack treatment (or bundle) changed over time:
   - 3.1 Aspirin gained usage as life-saving treatment (Discovery 1899; studies 1980s)
   - 3.2 Intra-aortic balloon pump was introduced (1980s at JHU)
   - 3.3 Coronary angiography (small probes threaded through veins and arteries and injected with radiopaque contrast agent) improved: visualise clots.
4. The AMI treatment bundle - innovations changed the quality of care.

Measuring Medical Inflation - Alternative Measures

1. Welfare:

$$U(t) = U(H(m(t)), Y - p(t) \cdot m(t) - T(t))$$

   1.1 H: Consumer's health - depends on disease and medical care m(t); Y is income and assumed constant over time, T(t) is lump-sum payments for medical care.

2. Amount consumers would be willing to pay (or would have to be compensated) to have today's medical care at today's prices, when the alternative is base period medical care and base period prices: C.

$$U(H(m(t_1)), Y - p(t_1) \cdot m(t_1) - T(t_1) - C) = U(H(m(t_0)), Y - p(t_0) \cdot m(t_0) - T(t_0))$$

3. Fixed-basket Laspeyres COL: $COL_{t_0,t_1} = 1 - C/Y_0$

   3.1 If $C > 0$, then benefits are greater than costs.

COL: Benefits

Need benefits for implementing COL.

1. Simplest measure of treatment quality - average years of survival after AMI.
2. Average years of survival improved significantly: from 5 years and 2 months to 5 years and 10 months (13% improvement)

Year	Costs ($)	Life-Expectancy
1984	11,175	$5\ ^{2}/_{12}$
1985	11,691	$5\ ^{4}/_{12}$
1986	11,998	$5\ ^{4}/_{12}$
1987	12,253	$5\ ^{5}/_{12}$
1988	12,725	$5\ ^{6}/_{12}$
1989	13,019	$5\ ^{8}/_{12}$
1990	13,623	$5\ ^{9}/_{12}$
1991	14,772	$5\ ^{10}/_{12}$

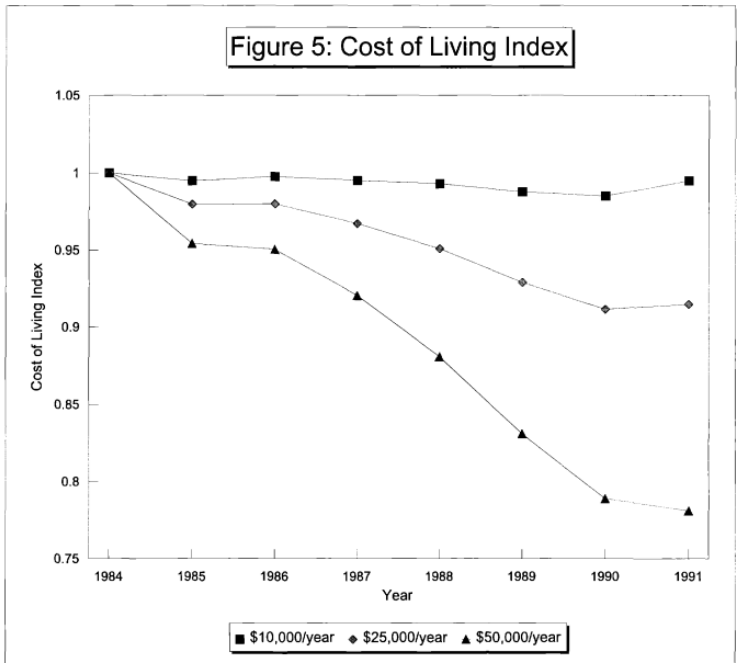
3. Life-expectancy in elderly increased by 4 months over same time-period. So at least 4 months of increase in life-expectancy can be attributed to improvement in AMI-care.

Cost of Living (COL) Index

1. Paid more in 1991 than in 1984; AND received many more months of life in exchange. $\rightarrow$ COL Index accounts for both.
2. If COL index **goes up** over time, achieving same amount of post-heart-attack survival is **more expensive in 1991 than in 1984**.
   - 2.1 Increase in cost of treatment outweighs marginal improvement in survival; OR
   - 2.2 Shortage of inputs (Z) is driving up their price (W); OR
   - 2.3 Moral hazard is increasing with availability of new expensive technologies.
3. If COL index **goes down** over time, achieving same amount of post-heart-attack survival is **cheaper in 1991 than in 1984**.
   - 3.1 Input prices (W) have fallen; OR
   - 3.2 Care can be delivered cheaply; OR
   - 3.3 Improved tech allows patients to get more health out of each dollar on healthcare.

Cost of Living (COL) Index

1. COL index declined by 0.5% each year from 1984 to 1991 (if value additional years of survival at \$25,000/year).



2. Cost of heart-attack survival fell by 3.4%
   2.1 In 1991, costs 96.6% as much as it did in 1984 to achieve 1984 outcome.
3. Technological change allowed consumers to stretch their dollars more in 1991 than in 1984
4. Welfare improved despite increase in prices.

Recap: Measuring Costs and Benefits

Two benefits of medical innovations:

1. **Value of better health** - (a) longer life; (b) better quality of life.
   - 1.1 Longevity usually dominates quality of life improvement
   - 1.2 1 Year of life in absence of disease valued at USD100,000

2. **Financial situation** - (a) Productivity; (b) Medical/Non-Medical costs
   - 2.1 + Productivity increases: Allows you to work more
   - 2.2 - Medical and Non-medical costs of additional years of life.

Net value: Difference between benefits and costs.
Positive value implies change is worth it.

Is Technology Worth It? ⋆

Measure the costs and benefits of technology at *disease level*, not at level of medical spending as a whole.

Technological change affects treatments in two ways:

1. **Treatment Substitution**: A new technology substituting an older one for established patients.
   - 1.1 Unit costs may increase or decrease;
   - 1.2 Outcomes are likely to improve (goal of new technology).
   - 1.3 Overall, net effect on welfare is unknown.

2. **Treatment Expansion**: A new technology leads *more* people to be treated for disease.
   - 2.1 Doctors diagnose diseases more frequently when treatments are safer and easier
     - E.g. Diagnosis for depression doubled after Prozac was available.
   - 2.2 Patients pay more attention to conditions when therapy is more effective
     - E.g. Cataract surgery performed frequently as procedure improved.
   - 2.3 Increases costs but also improves outcomes.
   - 2.4 Worth it if marginal patients benefit more than they cost.

Source: Cutler (2001)

Technology Substitution and Expansion

Condition	Substitution	Expansion
Low-birthweight infants	pre-1990s not much; Post 1990s: special ventilators, artificial surfactants	Survival and Quality of life have improved
Depression	New medications like SSRI (Prozac) partially replaced psychotherapy; SSRI dropout rate is lower Reduced in spending by 20%	SSRI manufacturers asked doctors to watch out; Reduced stigma Reduction in time spent depressed: $6,000
Cataracts	1960-1990s invasive surgery and 3 nights in hospital; Late 1990s outpatient surgery 30 mins	operated on much less severe measures of visual acuity. Improvements valued at $95,000 vs cost of $2,000
Breast cancer	Treatment moved out of hospital but Chemotherapy is longer and complex	Detection technology and public awareness increased

Source: Cutler (2001)

Is Technology Worth It?

EXHIBIT 3
Summary Of Research On The Value Of Medical Technology Changes

Condition	Years	Change in treatment costs	Outcome		
			Change	Value	Net benefit
Heart attack[a]	1984–98	$10,000	One-year increase in life expectancy	$70,000	$60,000
Low-birthweight infants[b]	1950–90	$40,000	Twelve-year increase in life expectancy	$240,000	$200,000
Depression[c]	1991–96	$0	Higher remission probability at some cost for those already treated		
		<$0	More people treated, with benefits exceeding costs		
Cataracts[d]	1969–98	$0	Substantial improvements in quality at no cost increase for those already treated		
		<$0	More people treated, with benefits exceeding costs		
Breast cancer[e]	1985–96	$20,000	Four-month increase in life expectancy	$20,000	$0

1. Technological innovations are on net positive:
   1.1 Technology leads to more spending but outcomes improve by even more
2. Treatment substitution: Among those already treated, innovation changes how people are treated. Per case cost rises/falls. Overall worthwhile.
3. Treatment expansion: Depression, cataracts, breast cancer. Generally cost-increasing as no previous therapy.
4. Treatment expansion effect may cause medical care system to succeed/fail.

Source: Cutler (2001)

Technology Overuse

1. Better Technology has *lowered* price of *better* health-care despite *rising* health expenditure.
2. But Technology may not always a be a boon
   2.1 E.g. Aspirin is cheap and Plavix is expensive and only marginally more effective than Aspirin but costs a lot more.

Findings from Dartmouth Atlas on technology use and outcomes:

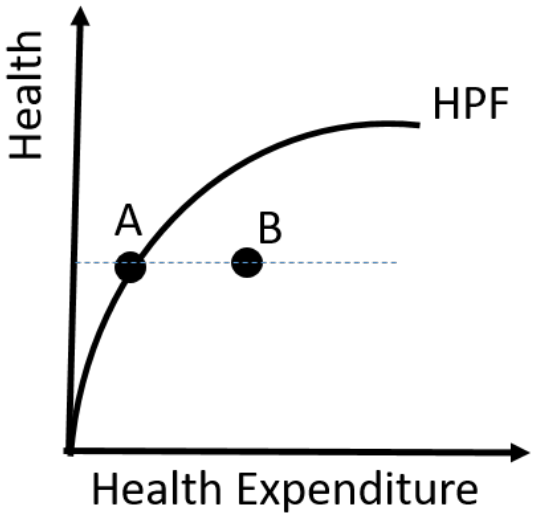
1. More expensive treatment does not correlate with better outcomes.
2. Amount of care depends on where patients live. **Reimbursement** **Eye Exam**
   2.1 Treatment differences persist after controlling for similar patients with same condition.

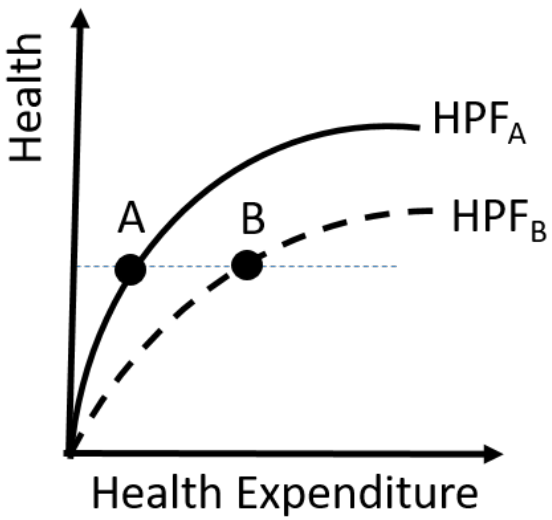
Conflicting Viewpoints:

1. Medical practice should be same across regions $\rightarrow$ variation in spending without variation in outcome is inefficient
2. Different regions require different care $\rightarrow$ variations are not necessarily inefficient.

Small-Area Variation

Theories for Small-Area Variation





1. Health Production Function (HPF): Maximum health achievable for each given amount of health expenditures.
   - 1.1 Increasing with health expenditure
   - 1.2 Diminishing marginal returns to health-care spending.
2. **Top: Cities A and B have same HPF**
   - 2.1 Assume, same technologies, same input prices, same health needs.
   - 2.2 City B: Inside of curve
   - 2.3 Vertical distance from B to HPF: Improvements could achieve for free
   - 2.4 Horizontal distance from A to B: Wasted resources in B.
3. **Bottom: Different HPF for A and B**
   - 3.1 Both cities are investing optimally
   - 3.2 B cannot achieve more health without spending more money
   - 3.3 It is harder in B to produce health.

Theories for Small-Area Variation

1. **Different Input Costs**:
   - 1.1 Hypothesis: Living costs differ and Physician wages differ hence costs differ.
   - 1.2 Empirical evidence: Adjusting for local prices only slightly reduces geographic variation.
   - 1.3 Empirical evidence: Does not explain variations within small localised areas.

2. **Different Hospital Inputs**:
   - 2.1 Hypothesis: Higher spending hospitals spend more resources in patient-satisfaction even if don't contribute to health. (Different HPF)
   - 2.2 Empirical evidence: Same satisfaction in high and low spending regions
   - 2.3 Empirical evidence: High-spending regions have worse-access due to longer waiting times, and lower percentage of patients have regular source of care.
   - 2.4 Conclusion: Hospitals in high-spending areas appear to not offering better health-care amenities to improve satisfaction

Theories for Small-Area Variation

1. **Different Malpractice Environment**:
   - 1.1 Hypothesis: Hospitals in regions with high-malpractice suits practice defensive medicine, hence high-volume health services but no difference in outcomes.
   - 1.2 Empirical evidence: Does not explain variations within small localised areas (within areas with same malpractice laws).

2. **Different Health Habits**:
   - 2.1 Hypothesis: Health disparities in residents would translate in higher costs.
   - 2.2 Empirical evidence: There are health disparities across regions.
   - 2.3 Empirical evidence: Dartmouth Atlas data is on per-person basis, and differences in health disparity do not explain local variations.

Theories for Small-Area Variation

1. **Different levels of illness severity**:
   - 1.1 Hypothesis: Variations reflect different levels of illness severity.
   - 1.2 Atlas treats all diabetics as same but diabetics in area A might be better controlled than B. Hence spending is different
   - 1.3 Outcomes are same because sicker patients need more resources to reach same health as less sicker patients. (Different HPF)
   - 1.4 Empirical evidence: Atlas adjust for disease-severity for some conditions like cancer.
   - 1.5 Empirical evidence: Number of physician visits varied by 400% for cancer and heart-failure patients.
   - 1.6 Conclusion: Neither due to local variations in patient characteristics not to improved health outcomes.
   - 1.7 Conclusion: Dartmouth Atlas argues that variates are due to *Supply-Sensitive Care* or moral hazard.

Supply-Sensitive Care and Moral Hazard

1. **Supply-Sensitive Care**: health services whose use depends greatly on supply or availability of that service.
   - 1.1 E.g. Use of MRI services depends on how accessible that service is. If within the hospital, more likely to request it.
   - 1.2 E.g. The more the number of beds in hospital, more likely it is to admit patients.
   - 1.3 Hypothesis: Expect hospitals with large resources to have large expenditures.

Health-care Use and Supply of Hospital Beds

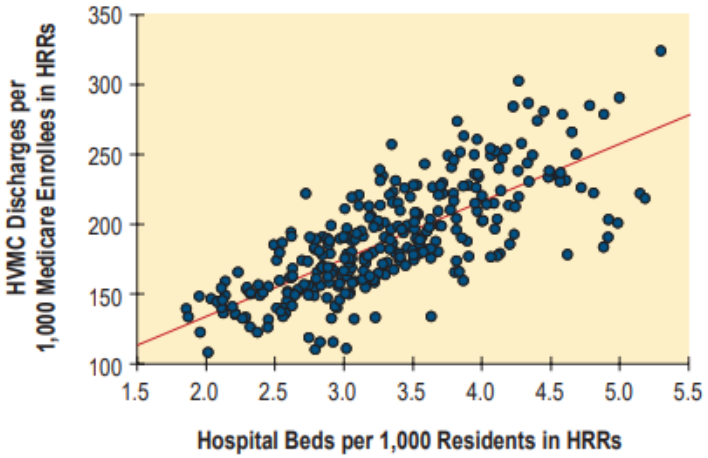


Figure 3.5. The Association Between Allocated Hospital Beds and Medicare Hospitalizations for High Variation Medical Conditions (1992-93)

There is a strong relationship between hospital capacity and its utilization for the treatment of patients with high variation medical conditions (R^2=.57). In hospital referral regions with fewer than 2.5 beds per thousand residents, the average discharge rate for patients with these conditions was 145.0 per thousand; in regions with more than 4.5 beds per thousand residents, the rate was 219.8.

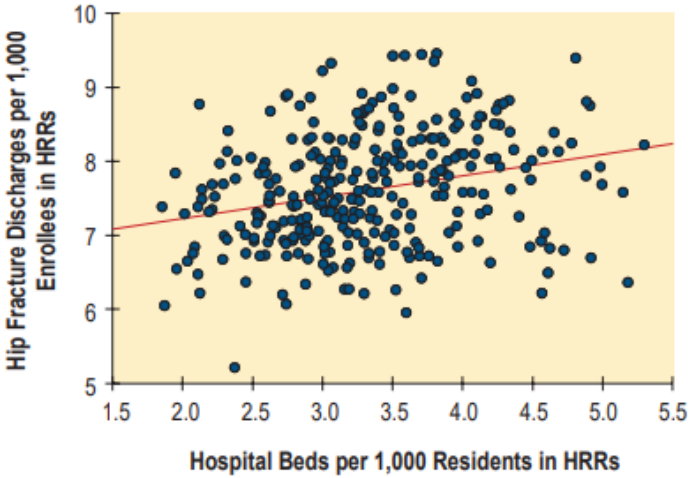


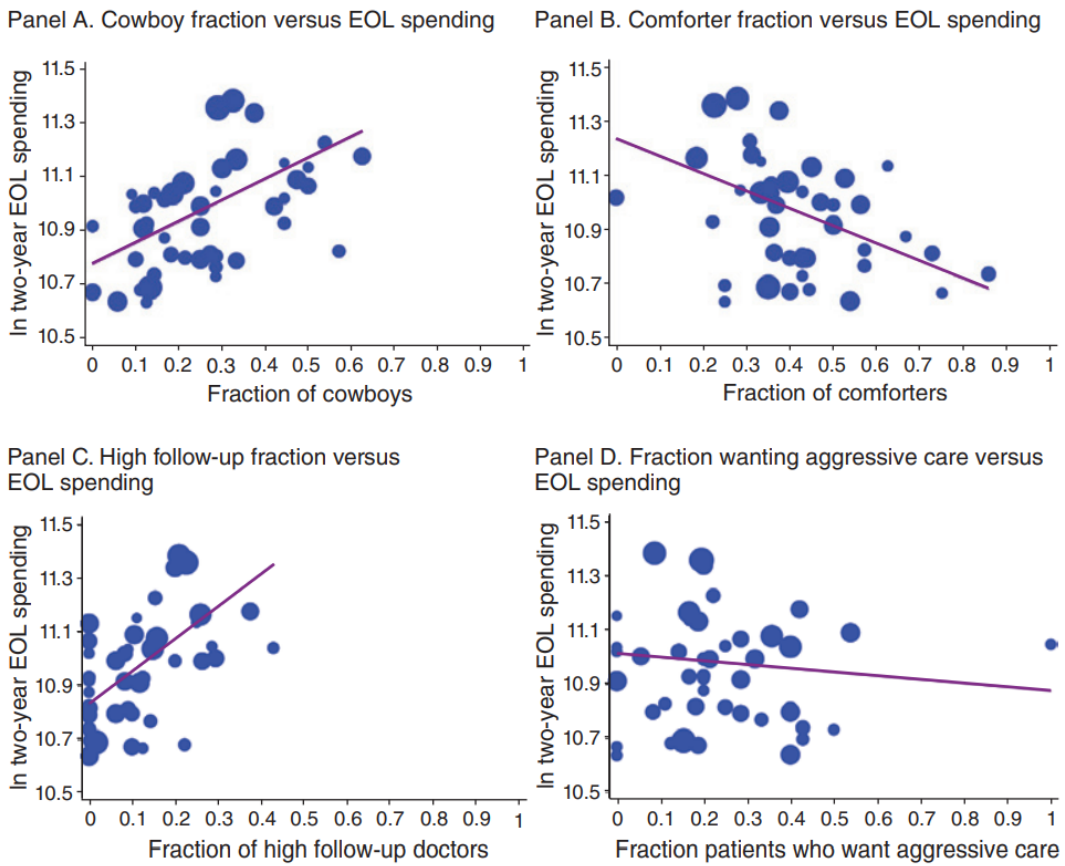
Figure 3.3. The Association Between Allocated Hospital Beds and Medicare Hospitalizations for Hip Fractures (1992-93)

There is little relationship between the hospital bed capacity and the discharge rate for hip fractures (R^2=.07). In hospital referral regions with more than 4.5 beds per thousand residents, the average discharge rate for hip fracture was 7.3; in regions with fewer than 2.5 beds per thousand, it was 7.2 per thousand Medicare enrollees.

Source: Dartmouth Atlas https://www.dartmouthatlas.org/downloads/atlases/96Atlas.pdf Accessed 27 Feb 2020

Physician Styles and Health-care Use

1. Physicians within same hospital have different practice styles (Doyle, 2010)
2. Physicians with different practice styles have significant effect on costs (Cutler 2019)



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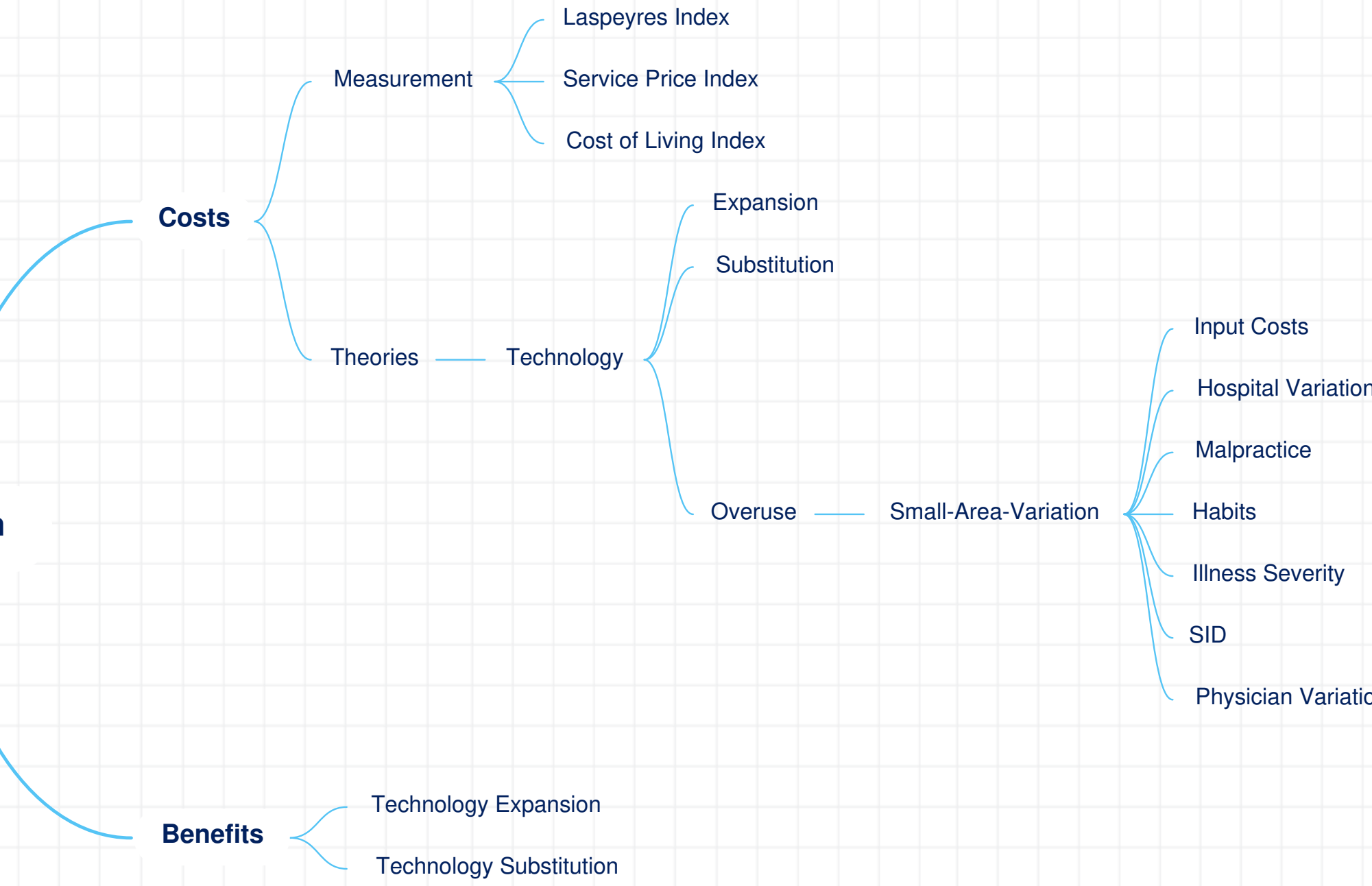
Conclusion

Summary


Costs
Measurement
Laspeyres Index
Service Price Index
Cost of Living Index
Theories
Technology
Expansion
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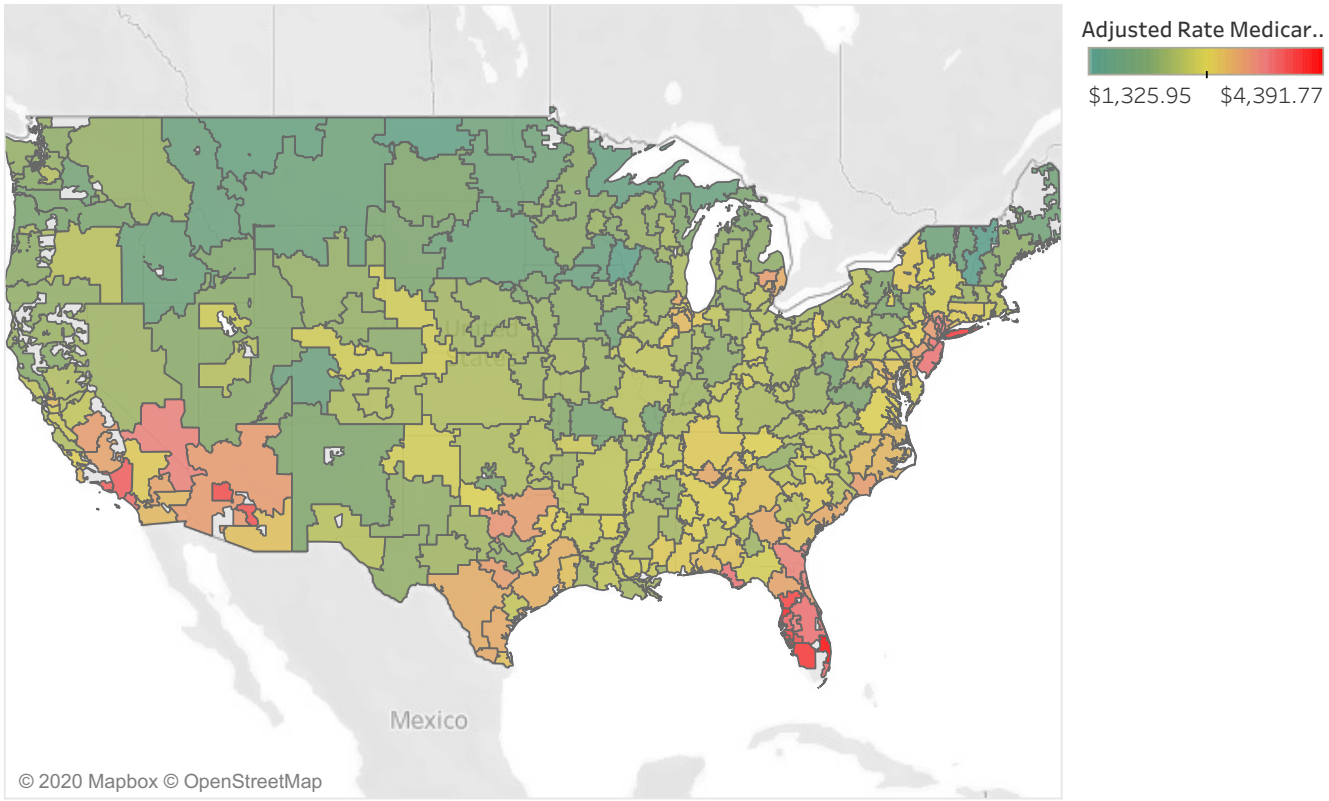
Overuse
Small-Area-Variation
Input Costs
Hospital Variation
Malpractice
Habits
Illness Severity
SID
Physician Variatio
Benefits
Technology Expansion
Technology Substitution

1 Amount of Care Depends Where Patients Live

Map: Price-Adjusted Physician Reimbursements per Enrollee, by HRR (2016)

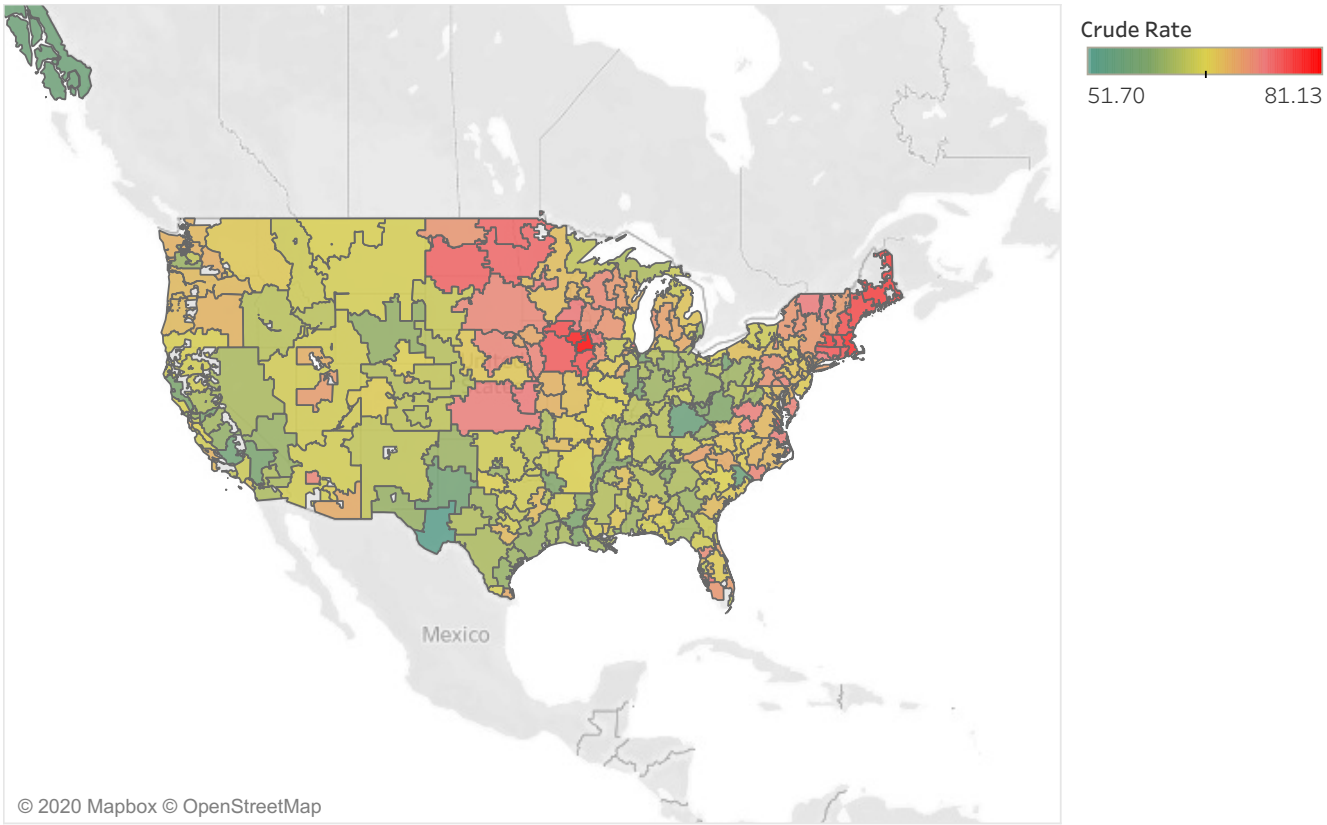
(Price, Age, Sex, and Race adjusted)



Source: Dartmouth Atlas https://www.dartmouthatlas.org/ Accessed 27 Feb 2020

1 Amount of Care Depends Where Patients Live

Map: Percent of Diabetic Medicare Enrollees Age 65-75 Receiving Eye Exam, by HRR (2015)



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