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Health Returns to Medical Expenditures and Medical Expenditure Components across Age Groups

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Abstract of the Dissertation

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Medical expenditures as a percentage of GDP have doubled during the past three decades, reflecting technology advancement and an aging population. Understanding how medical expenditures affect health, and whether this relationship differs by important sociodemographic characteristics such as age, are important for the appropriate allocation of scarce health care resources. Given the current environment of health care reform, further evidence on the health returns to medical investment is both timely and policy-relevant.

This study focuses on health returns to medical spending for the adult population in the United States. It assesses health benefits from overall medical expenditures as well as medical expenditure components (pharmaceutical expenditure and spending on physician services). I consider both objective (EuroQoL) and subjective (rating scale) measures of health. The conceptual point of departure for this study is Grossman's classic model of health investment. This study employs two-stage least squares estimation techniques to address the endogeneity of individual medical expenditures (e.g., that sicker people spend more).

Using the objective health measure, the elasticity of ***overall*** medical expenditure with respect to health is approximately 0.26. That is, a 10% increase in medical expenditures

increases health by 2.6%. For subjective measure, the elasticity of overall medical expenditure is 0.19. However, the returns to medical expenditures differ by age group and whether I use an objective or subjective health measure. Using the objective measure, the returns to medical expenditure are greatest for the middle-aged group (e.g., 46 to 64 years of age). However, using the subjective measure, I find that the perceived returns to health are greatest for seniors (e.g., $>$ 64 years of age) cohort. If objective health measures provide better evidence of actual gains in health, these findings suggest that reallocation of spending from seniors towards middle-aged cohorts can improve overall health without affecting expenditures. Given the strong perceived benefit for medical expenditures among seniors, however, such a reallocation may meet with considerable resistance.

To better understand the source of health benefit for different age groups, health returns to medical expenditure components are further examined (prescription drug expenditure and physician services expenditure). I find that middle-age group and younger population gain positive health returns (captured by objective measure: health-related quality of life) from prescription expenditure, while no statistically significant correlation has been found between health benefit and prescription drug expenditures for seniors. The period of this study was before the Medicare Part D plan was implemented. Prescription compliance among seniors may have been adversely affected by limited coverage during this period, which could account for this result.

Considering the relationship between physician services spending and health outcome, the results suggest that senior group gains higher health returns (captured by self-rated health status) comparing to the middle-age and younger group. It indicates that senior group may yield higher "perceived" health benefit from office-based visits , where the type of care is "face-to-face" contact. These findings could inform public policies designed to more closely match specific types of care with those groups likely to benefit the most from them.

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Chapter 1

Introduction

1.1 Motivation

Growth in health care spending has exceeded overall economic growth in the United States for many years. During the past three decades, the percentage of GDP spent on health care nearly doubled, from 8% 1975 to 14.9% by 2005 (Congressional Budget Office 2008) [1]. The increasing cost of health care has been attributed to the development and diffusion of improved health technology (Newhouse 1993) and an aging population (Hartman et al. 2008; Shrestha 2006). Large geographic differences in Medicare spending without evidence of corresponding variations in health outcomes pointed to possible waste in Medicare spending (Fisher et al. 2003a,b). According to the recent Health Care and Education Reconciliation Bill, subsidies to the Medicare Advantage plan will be cut to reduce government spending (Health Reform Bill 4872).

Understanding how medical care expenditures affect health is important for the proper allocation of health care resources. Given the current environment of health care reform, further evidence on the health returns to medical investment is both timely and policy-relevant.

[1] This figure is cited from the Congressional Budget Office: The Long - Term Outlook for Health Care Spending 2007. Under plausible assumptions of health care cost growth rates based on historical trends, health care spending is projected to reach 31% of GDP by 2035 and 41% by 2060.

Yet, there is relatively little research on this relationship, and previous studies provide conflicting evidence. Moreover, prior studies have typically been limited to specific groups of individuals (e.g., Medicare beneficiaries), specific treatment settings (e.g., inpatient care), or individual diseases (e.g., heart disease).

No previous study has examined the returns to medical expenditures using general health-related quality of life measures. Such evidence would be valuable because this would provide a more comprehensive assessment of the health returns to medical expenditures. To help bridge this gap in the literature, this study seeks to examine the relationship between overall medical expenditures, medical expenditure components (pharmaceutical expenditure and physician services expenditure) and health using both objective and subjective general health measurements. The EuroQoL (EQ-5D) is the objective health measure. Self-assessed health status based on a rating scale serves as the subjective health measure.

The conceptual motivation for this study is Grossman's health investment theory (Grossman 1972), where overall health is regarded as a special form of human capital and medical expenditure as a key input into health. Because I examine how medical expenditures affect overall health, this study provides an empirical test that is more consistent with this model.

It would be useful to know what the actual health returns per dollar of medical expenditure are and how this relationship varies by demographic factors such as age. Studying the health returns to medical investment by age is particularly pertinent, given the changing demographics in the United States toward an older population. The percentage of the population aged 65 and older has risen steadily from 8.1% in 1950 to 12.4% by 2000. It is projected to reach 20.6% of the total population by 2050 (Shrestha 2006). An aging population poses critical challenges to the health care system since older persons typically develop more medical conditions and demand more care.

While the Medicare population is increasing, the percentage of uninsured among the non-

elderly population is high. On average, 15% of the non-elderly population is uninsured and these rates are highest among young adults. For example, 35% of people aged 25 are uninsured (CEA Report 2009). These rates are projected to grow as health care costs, insurance premiums and out-of pocket costs continue to increase. These patterns suggest that health care access and spending is generous for Medicare beneficiaries relative to many younger persons.

Are health care spending patterns for different age groups efficient? To help answer this question, one needs to investigate how the health returns to medical investment vary by age? Under the assumption that the health depreciation rate increases with age, health investment theory concludes that the marginal cost of health capital rises with age (Grossman 1972; Muurinen 1982). This implies that the returns to medical expenditures would be less for older age groups. That is an empirical question, however, a focus of this study.

The remainder of this chapter provides a context for the dissertation research. It gives a brief overview of the literature on health returns to overall medical expenditures and medical expenditure components. Then this chapter will conclude with the summary of the main contribution of my research to the current literature.

1.2 Literature Review

1.2.1 Health Returns to Overall Medical Expenditures

Theoretical Work – Health Investment Model

According to health investment theory, medical care is considered a key element in the production of health and medical services is a derived demand for "good health". The notion of modeling health as a special form of human capital was first introduced in Grossman's (1972) paper. In his model, individuals spend time and money to produce good health. People have incentives to invest in health to increase their utility and market productivity.

Implications are derived from Grossman's (1972) model for age, education and wealth that are independent of consumers' tastes or preferences for health. The model predicts that the demand for health and medical care will be positively related to the wage rate. Provided that education increases the efficiency of investments in health, more educated individuals would demand a higher optimal health stock. But with relatively inelastic medical demand, the relationship between education and medical outlays would be negative. Of note, the model derives conditions under which the quantity of health capital demanded declines with age even though expenditures on medical care increase with age.

Muurinen (1982) expanded Grossman's study and introduced a more generalized model by allowing the health capital depreciation rate to depend not only on age but also on the intensity of use. Individuals working in polluted environments had higher health capital depreciation rates. This led to similar implications as found in the Grossman model. Later extensions of Grossman's work considered the endogeneity of longevity (Ehrlich and Chuma 1990; Ried 1998; Grossman 1999; Ehrlich 2000).

Other extensions introduced uncertainty into the health investment model (Cropper 1977; Dardanoni and Wagstaff 1987, 1990; Picone et al. 1998). For instance, Dardanoni and

Wagstaff (1990) considered uncertainty over the probability of illness and the effectiveness of medical treatment. Picone et al.(1998) studied the effects of uncertainty on disease incidence and medical care demand on health capital and wealth for retired individuals. They found that subjects respond to uncertainty by smoothing their expected utility over time through their medical spending, and that such spending depends in part on an individual's degree of risk aversion.

Empirical Studies on Health Returns to Medical Expenditures

The health care industry in the United States has been referred to as "flat of the curve" medicine for the past several decades, as marginal spending on health care has been thought to bring little or no improvement in health outcomes (Fuchs 2004; Gruber 2006). Although wide geographic variations in Medicare spending have been reported (Dartmouth Atlas of Health Care 2008), there is no strong evidence that greater expenditures have led to better health outcomes. There are also wide geographic variations in health care spending for the general population. While per capita health spending in 2004 was approximately $4,000 in regions such as Utah and Arizona, it exceeded $6,500 in areas such as New York and Massachusetts (Congressional Budget Office 2008).

Such wide variations in health care spending suggest possible inefficiencies and opportunities to reduce costs without sacrificing quality of care (Skinner and Fisher 1997; Skinner et al. 2005). Baicker and Chandra (2004) studied the relationship between physician workforce and service quality, finding that states with more specialists have higher costs but lower quality. Sirovich et al. (2006) showed that physicians in high expenditure regions find it harder to provide needed services for their patients . Fisher et al. (2003a, 2003b) studied Medicare patients with hip fracture, colorectal cancer and acute myocardial infarction (AMI). They found that patients in higher spending areas received 60% more health care

services, with no apparent improvement in quality of care. Skinner et al. (2006) combined cross-section and time-series data using a Medicare dataset from 1986-2002 for subjects with AMI. They presented trends on 1-year survival rates for patients, finding that regions with higher expenditures were not associated with better outcomes.

Other evidence, however, points to benefits from greater medical spending. Cutler and McClellan (2001) studied the costs and benefits associated with technology dispersion over time. The dollar-valued benefits from improved longevity were compared to the greater costs associated with newer health care technologies. They found that the benefits from technology advances exceeded their costs. The most striking results were for heart disease, where benefits greatly exceeded costs .

Kaestner and Silber (2009) examined the medical effectiveness of inpatient spending for Medicare patients admitted to hospital for surgery. They found that greater inpatient spending is associated with lower mortality and lower "failure to rescue rates" [2]. Moreover, the magnitude of the benefit they report is impressive: a 10% increase in inpatient spending improves the survival rate by 3 - 6 %. Doyle (2007) conducted a natural experiment to assess the "flat of the curve" medicine hypothesis by studying visitors in Florida who were seeking medical treatments with heart-related emergencies. The results indicate that a 10% increase in medical spending leads to an 8% decrease in the mortality rate, with an estimated cost per statistical year of life gained of approximately $50,000 . Previous studies thus provide mixed evidence on the health returns to medical expenditures.

[2]Failure to rescue rate is an outcome measurement used in evaluating hospital quality of care. Failure to rescue is defined by the Agency for Health Research and Quality (AHRQ) as deaths per 1,000 discharges in patients undergoing elective surgery. Causes of death included in the definition are pneumonia, deep vein thrombosis/pulmonary embolus, sepsis, acute renal failure, shock/cardiac arrest or gastrointestinal hemorrhage/acute ulcer.

1.2.2 Health Benefit from Medical Expenditure Components

Pharmaceutical Expenditures

Aging population has affected many aspects of the society, nothing as much as health care industry. With escalating health expenditure in the Untied States (from 7% of GDP in 1975 to 14.9% in 2005) , expenditure on prescription drugs has been the fastest growing components, comparing to physician expenditure and hospital expenditures[3]. Spending on prescription drugs was increased from $40.3 billion in 1990 to $234.1 billion in 2008, more than five folds growth in past 20 years (CMS). Fast growing prescription drug expenditure has been attributed to increasing drug price, prescription drug utilization, increased insurance coverage, drug innovation, and explosive direct-to-consumer advertising (Kaiser Family Foundation 2010; Aitken et al. 2009). According to the recent statistics, 90% of elderly and 57% of non-elderly population in the United States have prescriptions drug expenses (AHRQ 2010). The prescription drug expenditure is projected to rebound after a temporary pause[4] , and it is projected to exceed physician services expenditure and inpatient expenditure by 2019 (Truffer et al. 2010).

Empirical Studies: Cost-Effectiveness of Pharmaceutical Expenditures

A series of studies by Lichtenberg investigated the relationship between pharmaceutical innovation and longevity. Using FDA drug approval to measure pharmaceutical innovation, Lichtenberg (2004) found cost-benefit ratio was higher for pharmaceutical investment com-

[3]During the period of 1994-2003, the annual percentage increasing rate for pharmaceutical expenditure reached double digits, comparing to the single digit percentage increasing rate in physician services expenditure and hospital expenditures. (Centers for Medicare & Medicaid Services, National Health Expenditure Accounts, Historical, http://www.cms.hhs.gov/NationalHealthExpendData/)

[4]According to the projections by Truffer et al. (2010), the pharmaceutical expenditure will experience temporary pause around 2012 because of top brand-name drugs loosing patent, and consumers switching to less expensive version of the drugs. However, it will rebound back because of increasing drug price, utilization and introduction of more expensive specialty drugs.

paring to public spending on longevity. The dollar amount required for saving one life-year was $9640 for public spending, while it was only $926 for pharmaceutical investment. A later study (Lichtenberg 2007a) showed that higher percentage use of newer drugs was associated with lower mortality rate, less hospital discharge and long-term care admission. Newer drugs were also associated with better after treatment health status, less physical limitations, and less overall medical expenditure (Lichtenberg 2007b).

Cutler et al. (2007) investigated the effect of antihypertensive drugs on blood pressure using national level data. The authors concluded that the benefit to cost ratio for antihypertensive drug was 6 to 1. Appropriate antihypertensive drug use for hypertension individuals would reduce 89,000 pre mature deaths from major cardiovascular disease. Also there would be 38% and 25% fewer hospital discharges for stroke and myocardial infarction respectively.

Other studies also justified the benefit of prescription drugs in Medicare patients. Shang and Goldman (2007) examined the impact of Medigap prescription drug coverage on Medicare Part A hospital spending and Medicare Part B physician services spending. The authors found Medigap prescription drug coverage increased average prescription drug spending by $170. However, hospital spending was decreased by about $350, which yielded a cost benefit ratio of 1 to 2.06 . Stuart et al. (2009) examined the effect of prescription drug usage on hospital costs for hospitalized Medicare beneficiaries, finding that each additional prescription could reduce hospital cost by $146, around 5% of average hospital costs. Accounting for the increased cost of prescription $47, the net benefit was $53.

Prescription drug adherence (prescription compliance) has also been studied and evidence showed copayment rate significantly affected drug compliance and better drug compliance could achieve overall cost saving (Rizzo and Simons 1997; Goodman 2004; Sokol et al. 2005).

Rizzo and Simon (1997) examined the drug compliance for major antihypertensive drug

classes and overall health care costs associated with drug compliance using the Pennsylvania clinical claims data. The authors found that overall compliance for antihypertensive drugs were poor, even though the fact was better for newer drugs. Poor compliance was associated with higher overall health care costs. The authors showed that uncontrolled hypertension would reduce 5.5 work days, and $325 could be saved with appropriate use and compliance to anti-hypertensive drugs.

Goldman et al. (2006) examined the relationship between insurance copayments and drug compliance for 8 therapeutic classes. The authors found that doubled drug copayments would significantly decrease the drug compliance. The overall supplied days of prescriptions were also reduced by 25% for antihypertensives, antidepressants and antidiabetics . Increased drug copayments also resulted in increased emergency room visits and hospital admissions for chronic conditions like diabetes, asthma, etc. Sokol et al. (2005) reached similar conclusions by analyzing 4 chronic conditions: diabetes, hypertension, hypercholesterolemia, and congestive heart failure. The authors found that hospital admission rates were lower for patients with higher medication adherence. For some chronic conditions, better medical adherence would decrease overall medical costs and achieve net saving.

Empirical Studies: Physician workforce and health care utilization

Large geographic disparities in per-capita medical spending have been reported (Dartmouth Atlas of Health Care) in the United States. According to previous research, there is nearly 2 - 3 fold variation of physician supply across the United States (COGME 1998). Regional variation of physician supply is not explained by patient needs (Komaromy et al. 1996; Goodman and Grumbach 2008). Previous literature have shown that higher per-capita physicians did not bring superior patient health outcome with exception of primary care physician services (Kravet et al. 2008; Starfield et al. 2005; Fisher et al. 2003a,b).

Kravet et al. (2008) studied the relationship between the primary care physician supply and health service utilization for metropolitan statistical regions. The authors found higher proportion of primary care physician was associated with lower health care utilization, specifically fewer hospital admissions, emergency department visits, and total surgeries. Higher physician density was associated with higher health care utilization. 1% increase in proportion of primary care physician was associated with 0.65 fewer inpatient admission and 3.83 fewer emergency room visits per 1000 people per year. Starfield et al. (2005) developed county level analysis on the relationship between physician workforce and population health, finding that while higher proportion of primary care physicians was associated with lower mortality rate, higher proportion of specialist was related to higher mortality rate.

Wide variations in health care spending suggest possible inefficiencies and opportunities to reduce costs without sacrificing quality for Medicare patients (Skinner and Fisher 1997; Skinner et al. 2005). Fisher et al (2003a 2003b) examined regional variation of Medicare spending in hospitalized hip fracture, acute myocardial infarction and colorectal cancer patients. The authors showed regions with highest quintile of spending had 60% more medical specialist and 26% less family practitioner. Patients in higher spending regions received 60% more health care services without apparent improvement in quality of care. Particularly, comparing to the lowest quintile patients, highest quintile patients had 1.27 times higher outpatient visits, 2.13 times higher inpatient visits and 2.36 times higher inpatient specialist consultation. Baicker and Chandra (2004) studied the relationship between physician workforce and service quality, finding that states with more specialists have higher costs but lower quality. Sirovich et al. (2006) showed that physicians in high spending regions finding it harder to provide needed services for their patients.

1.3 Contribution Overview

Overall Medical Expenditures

For overall medical expenditures, I find a positive and significant relationship between medical expenditures and health for both objective and subjective health measures. Using the EuroQoL as the health measure, the elasticity of overall medical expenditures on health is 0.26: a 10 % increase in medical expenditures leads to a 2.6% increase in health as measured by the EuroQoL. Using the rating scale, I find very similar results, with an overall elasticity of 0.19. Considering cost-outcome correlation for medical expenditure components, the elasticity of pharmaceutical expenditure on health is 0.18. And the return figure is similar for the prescription utilization measure - number of prescriptions in the past 12 months. A 10% increase in the number of prescriptions will improve the health outcome (EuroQoL) by 2.2%. Moreover, the elasticity of physician services expenditure on health (EuroQoL) is around 0.30.

The most interesting results come from comparing different patterns of the expenditure-health outcome relationships by the type of health measure (e.g. objective vs. subjective) and by age group. Using the EuroQoL, the objective measure, the returns to overall medical expenditure are greatest for the middle-aged group (e.g., 46 to 64 years of age). However, using the subjective rating scale measure, I find that the perceived returns to health are greatest for seniors (e.g., $>$ 64 years of age) cohort. Moreover, the relationship between medical expenditures and health differs quite substantially among senior subjects depending on the health measure considered. In particular, I find no statistically significant relationship between medical expenditures and the objective health measure (e.g., the EuroQoL) for the senior group, but a positive and significant relationship between medical expenditures and self-assessed health status, with an elasticity of 0.30. These results suggest that seniors may gain significant perceived benefit from more health care spending, but the objective benefits to their health

appear to be substantially less. These findings suggest that current health policy initiatives to reduce the Medicare Advantage benefit plan may achieve cost savings without substantively affecting overall objective health outcomes for senior population. Given the strong perceived benefit for medical expenditures among seniors, however, such a reallocation may meet with considerable resistance.

Medical Expenditure Components: Pharmaceutical Expenditure and Physician Services Expenditure

To better understand the source of health benefit for different age groups, I also examine the cost-outcome relationship for medical expenditure components: pharmaceutical expenditure and physician services expenditure. Using objective health measure, middle-age group population has highest return from prescription expenditure, while no statistically significant correlation is found between health benefit and prescription drug expenditures for seniors. The period of this study is before the Medicare Part D plan was implemented. Drug compliance among seniors may have been adversely affected by limited coverage during this period, which could account for this result.

Considering physician service spending, I find higher health returns for senior group than younger groups using subjective health measure. The results suggest that older patients may benefit more from office-based visits, where the type of care is "face-to-face" contact. These findings could inform public policies designed to more closely match specific types of care with those groups likely to benefit the most from them.

This dissertation is proceeded as follows: Chapter II presents the estimation strategy employed to estimate the health returns to overall medical expenditures and medical expenditure components, given the presence of medical expenditures endogeneity. Chapter III seeks to quantify the effects of overall medical expenditures for general population. Age group cost-outcome relationship is also examined to explain the differential health returns to medical

expenditures across age groups. Chapter IV provides cost-outcome analysis focusing on pharmaceutical expenditure. Health Benefit from physician services spending is further examined in Chapter V. Then this dissertation is concluded with summarized results and policy discussions.

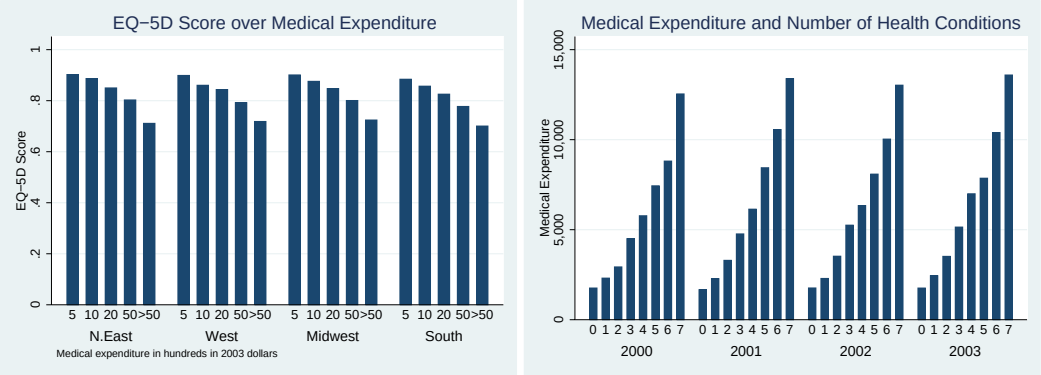
Chapter 2

Estimation Strategy - Instrumental Variable Estimation

While the question of the empirical relationship between medical expenditures and health seems straightforward, the practical challenges are formidable. Health affects medical expenditures, and failure to address this reverse-causation effect can lead to serious underestimates of the effects of medical expenditures on health and even a negative estimated relationship. I use instrumental variables (IV) methods to purge medical expenditures of endogeneity and obtain estimates of the effects of medical expenditure on health outcomes.

Simple ordinary least squares (OLS) estimates of medical expenditures and health yield an inverse relationship, likely reflecting that healthier subjects need less health care. In studying the effects of medical expenditures on health, controlling for the endogeneity of health inputs is essential (Rosenzweig and Schultz 1983). It is intuitively straightforward to recognize that people with better health status should have lower health care spending. Using simple correlations, or standard OLS methods, therefore, one will likely obtain a biased and even a negative relationship between health care spending and health outcomes.

This phenomenon is illustrated in Figure 1A, which shows a negative correlation between medical expenditure and quality of life. Similarly, Figure 1B demonstrates a strong positive



(a) EuroQoL and Med Exp (b) Med Exp and Number of Medical Conds.

Figure 2.1: Endogeneity of Medical Expenditures

relationship between medical expenditures and the number of medical conditions. Moreover, the negative relationship between medical expenditures and quality of life persists in ordinary least squares estimation, when I control for the covariates described in part IV above. Finally Hausman-type tests confirm that the medical expenditure variable is endogenous.

Thus, it is important to control for endogeneity in order to isolate the effects of medical expenditures on health. Instrumental variables (IV) estimation is a commonly-accepted approach in such situations. In the present application, the objective of IV estimation is to obtain variables that are strongly correlated with health spending but which have no direct effect on quality of life. Previous studies suggest that the wide geographic variations in medical expenditures across the United States reflect differences in treatment intensity and practice style (Wennberg et al. 2002, 2009; Skinner et al. 2006; Dartmouth Atlas of Health Care 2008). While such differences in treatment intensity and practice styles should affect medical expenditures, they may not directly affect health outcomes independent of indirect effects working through health expenditures. Hence, variables indicating geographical variations in treatment intensity and practice style have been used as instruments to control for the endogeneity of expenditures in health outcomes analyses (Skinner et al. 2005, Kaestner and Silber 2009,

Stukel et al. 2007, Doyle 2007).

In particular, Skinner et al. (2005)[1] used patients' physician visits during the last 6 months of life to instrument Medicare spending in 1986-2002, finding no significant relationship between per capita Medicare spending and survival rates for hospital referral regions. Kaestner and Silber (2009) found a negative relationship between inpatient spending and inpatient mortality rate in Medicare patients admitted to hospitals for surgery. End-of-life expenditures in hospital referral regions (HRR) were used to instrument for inpatient spending. Stukel et al. (2007) found 16% decreased mortality rate for Medicare AMI patients because of cardiac catheterization, using the regional catheterization rate as an instrumental variable. Doyle (2007) selected county-level medical spending as an instrumental variable for per patient medical costs following heart-related emergencies, finding that higher spending is beneficial for Florida visitors with a heart emergency.

I followed this approach and chose local health care resource availability as part of the IV set. It is reasonable to argue that regions with different densities of health care providers have different practice styles, which should also affect expenditure levels. Indeed, as Skinner and Staiger (2009) have argued, different regions may exhibit different health production functions. Cutler (2006) has argued that efficiency in health production varies across regions. The literature is clear that regional variation in medical practice exists in the United States. Given these observations, differences in the availability of health care resources should affect the way medical care is produced and, ultimately, medical expenditures. In contrast, there is little reason to expect variation in the supply of health care providers to have a direct effect on an individual's quality of life. Thus the first instrumental variable selected from the Area Resource File is the number of non-hospital based physicians per thousand subjects in the

[1] Two additional IVs were included in Skinner et al. (2005): the percentage of decedents admitted to the ICU during the last 6 months of life, and Medicare expenditures for AMI patients during 1993-94.

county [2].

Two additional instruments are selected into the IV set which reflect respondents' attitudes toward risk. The selection of risk preference variables is motivated by health investment theory (Dardanoni and Wagstaff 1990, Picone et al. 1998), which predicts that risk averse individuals will spend more on their health. In particular, I include a binary variable equals to 1 if the respondent considers himself to be less likely to engage in risk taking behavior and 0 otherwise, and an indicator variable equals to 1 if the respondent always wears a seatbelt when driving and 0 otherwise. It seems reasonable to argue that risk preference does not directly affect quality of life independent of its effects on medical expenditures.

Table 2.1 summarizes the relationships between attitudes towards risk, health insurance and medical expenditures. Table 2.1 includes information on levels of risk aversion and the percentage of subjects who consider insurance necessary and average medical expenditure for each category. The risk averse category has the highest percentage of individuals who consider health insurance necessary, compared to the risk lover groups. Table 2.2 shows the respondent-reported frequency of wearing seatbelts, attitude towards health insurance and medical expenditure. Individuals who report always wearing seatbelts have the highest percentage of subjects that consider health insurance to be necessary and have higher medical expenditures compared to groups who report less frequently wearing seatbelts, with the exception of subjects who never wear a seatbelt. Subjects who wear seatbelts more regularly are also more likely to believe that it is necessary to have health insurance. Overall, these summary statistics suggest that more risk averse individuals consider health insurance necessary and invest more in their health.

[2]The number of physicians was normalized to the number of non-hospital based physicians per 1,000 population.

Table 2.1: Attitudes toward health risk, health insurance and medical expenditures

	1 Risk dislike	2 Somewhat dislike	3 Risk Neutral	4 Somewhat like	5 Risk lover
Sample N	22,940	13,143	7,768	8,746	2,213
Consider Insurance is Necessary	85%	68%	65%	59%	62%
Variance	0.35	0.47	0.48	0.49	0.49
Medical Expenditure in 2003 $	$4,076	$3,175	$3,343	$2,848	$3,246
Variance	$9,201	$7,269	$7,716	$7,506	$8,088

Table 2.2: Frequency wearing seatbelt, attitudes toward health insurance and medical expenditures

	1 Always	2 Nearly Always	3 Sometimes	4 Seldom	5 Never
Sample N	43,093	5,487	3,480	1,235	1,515
Consider Insurance is Necessary	74%	70%	69%	68%	71%
Variance	0.44	0.46	0.46	0.46	0.45
Medical Expenditure in 2003 $	$3,552	$3,368	$3,234	$3,160	$4,333
Variance	$8,210	$8,879	$6,870	$8,804	$9,977

Chapter 3

Health Returns to Overall Medical Expenditures: Does Age Make A Difference?

3.1 Introduction & Motivation

Previous literature examined relationship between medical expenditures and relatively narrowly defined health outcomes in understanding medical spending efficiency for specific populations (e.g., Medicare Beneficiaries) , severe illnesses (e.g., Heart disease) or spending categories (e.g., inpatient spending). Such evidence, while useful, may not provide an accurate assessment of effects on health generally. With relatively few empirical studies and seemingly contradictory evidence, no consensus conclusion has been reached . Further study is needed to examine the returns of medical expenditure on general population. Generic quality of life measure is of great importance to study as it provides the evaluation of overall health condition considering multi-dimensional aspects of health.

I examine the relationship between overall medical expenditures and health considering both objective and subjective health measures. The EuroQoL (EQ-5D) is the objective health measure. It is a preference based health-related quality of life (HRQoL) measure that includes

both physical and mental health status components and consists of the following domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression (Fleishman 2005; Rabin and de Charro 2001; Dolan 2000; McDowell 2006). The EQ-5D is one of the most widely used general health utility measures. Self-assessed health status based on a rating scale serves as the subjective health measure.

The remainder of this chapter is organized as follows: the next section presents the data and methods. Section III reports estimation results including both OLS and IV analysis. The last section summarizes the results and discusses their policy implications.

3.2 Data & Methods

3.2.1 Data

This study uses data from the Medical Expenditure Panel Survey (MEPS) conducted by Agency for Healthcare Quality and Research (AHRQ). The MEPS database includes detailed information on patients' health care utilization, medical expenditures, health status, insurance coverage and sociodemographic characteristics (Cohen 1997, 2003) [1]. It is representative of the non-institutionalized civilian population in the United States. I use the MEPS Household Consolidated files from 2000-2003, a time period when information on quality of life measures were included in MEPS. In addition, selected variables in the restricted Area Resource File (ARF) from AHRQ were incorporated into this study. The ARF provides information on county-level medical resources across the United States, including the supply of health care providers, health facility information, as well as socioeconomic and environmental information.

[1] I also included home ownership information from the National Health Interview Survey-Family file. According to the design of MEPS survey, sample individuals and families in MEPS are drawn from a prior year subsample of NHIS. Given this survey feature of MEPS, I used linkage file from AHRQ to merge a home ownership variable to the yearly consolidated file.

I excluded individuals under 18 years of age and pregnant women. Respondents who reported a negative health status (worse than death) and zero medical expenditure were also excluded from the sample, leaving 54,810 observations for estimation purposes[2].

Variables

Dependent variables

This chapter included both objective and subjective health indices: the EuroQoL (EQ-5D) (objective) and self-rated (subjective) health status, respectively. The EuroQoL (EQ-5D) is a widely used, general quality of life measure (EuroQoL group (2010)). The EQ-5D represents an individual's health utility score for a given health state. The MEPS included the EQ-5D on surveys from 2000-2003. The survey first queried respondents about their health status along each of the five domains of the EQ-5D: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. For each category, there are three possible levels ranging from 1-3 (1 as the best), and a total of 243 possible health states. Then a time-tradeoff [3] exercise was performed by individuals to assign preference weights for each health status. Incorporating these preference weights for each health state, a cardinal utility score between 1 and 100 was obtained. Self-rated health status, the subjective measure, was based on subjects' responses to a question asking them to rate their health on a scale of 0 (worst) to 100 (best).

[2]I dropped 1,277 cases who reported negative health status values on the EuroQoL. According to the design of the EuroQoL measure, a health status equal to 100 represents perfect health and 0 represents death. Negative values are derived when individuals reveal a preference for "death" over living in other health conditions. How to measure health states worse than death and whether to include them as valid health measures are controversial issues in quality of life assessment (De Charro et al. 2005). Given this uncertainty, and because the health investment model considers individuals whose health states are better than death, I elected to exclude these subjects from this analysis. I also dropped 10,962 subjects who reported having zero medical expenditures. Because these individuals incurred no medical expenditures, it is impossible to determine the health returns to medical expenditures for them.

[3]In the time trade-off exercise, individual respondents express their preferences toward different health conditions. The U.S. population-based preference weighting system for EQ-5D was developed by AHRQ through a series of time trade-off (TTO) exercises and statistical imputations. See: http://www.ahrq.gov/rice/EQ5Dscore.htm

Explanatory variables

The key predictor for health is total medical expenditures per annum per patient. This measure includes individual out-of-pocket expenditures as well as expenditures made by the insurer, if applicable. Other sociodemographic predictors of health include age, gender, race and educational attainment. Socioeconomic predictors include health insurance, employment status, annual family income and home ownership. I also control for preexisting conditions that could affect quality of life. In particular, I control for 15 major chronic diseases and for whether the subject is obese. Regional factors include whether the subject resides in an urban location and Census Region. Year is controlled for using a series of binary indicators, with 2000 serving as the reference year.

All dollar-denominated variables are converted to 2003 dollars. For medical expenditures, I use the Medical Care Component of the Consumer Price Index (CPI). For non-medical items, the general CPI is used.

3.2.2 Methods

The empirical model to be estimated may be written as:

$$ln(MEDEXP) = \alpha_0 + \alpha_1 X + \alpha_2 IV + \varepsilon \tag{3.1}$$

$$ln(EuroQoLorRatescale) = \beta_0 + \beta_1 ln(MEDEXP) + \beta_2 X + \varepsilon \tag{3.2}$$

The first equation examines the determinants of medical expenditures. The vector X represents socioeconomic, demographic, comorbdities, and regional factors affecting both medical expenditures and health. Three instrumental variables are used in the first stage including: risk averse, seatbelt and number of non-hospital based physicians per 1,000 population. Equation (2) uses the predicted value from (1) and the vector X to predict health outcomes. I conduct separate regression analysis for EQ-5D and the self-assessed rating

scale measures. Medical expenditures and both health outcome measures are transformed to natural logarithms to normalize their distributions. Equations (1) and (2) are also estimated separately for three age groups: younger persons (18-45 years of age), middle aged subjects (46 to 64) and seniors (65 and over).

3.3 Results

3.3.1 Summary Statistics

Summary statistics are provided in Table 3.1. The dependent variables include both subjective (rating scale) and objective (EQ-5D) health outcomes. Both health outcome measurements are normalized to lie between 0 and 1. The key explanatory variable of interest, annual medical expenditure, is $3,526 on average.

3.3.2 Ordinary Least Squares Results

Table 3.2 shows the results of ordinary least squares estimation of the association between medical expenditures and our health measures, ignoring the issue of endogeneity. As the table indicates, this relationship is estimated to be negative and significant for each health outcome measure, reflecting endogeneity of the medical expenditure variable.

3.3.3 First-stage Medical Expenditures Equation

Table 3.3 presents the first-stage medical expenditure regression results for the two-stage least squares model. Female and married individuals spend more than males and single individuals, respectively. Minority populations spend significantly less compared to Caucasians. Individuals with a college education have higher medical expenditures compared to those with high school education. Uninsured individuals spend significantly less. All three instrumental variables are highly significant, with risk aversion and wearing a seatbelt significant at

1% level and the physician supply variable significant at 5% level. The number of physicians per 1000 population has a positive effect on medical expenditures. As predicted, people who are more risk averse spend more on medical care.

To test the validity of the instruments and the two-stage least squares estimation approach, I conducted a series of tests for endogeneity of medical expenditures and overidentification of the instrumental variables. The test statistics confirm that the medical expenditure variable is endogenous. I also tested the overidentification restrictions. The resulting Hansen test statistics failed to reject the null hypothesis and the instrumental variable setting in this study passed overidentification test.

3.3.4 Second-stage Results

Table 3.4 provides the second-stage estimates predicting health outcomes. Medical expenditure has a positive and significant effect on both objective and subjective health measurements. The elasticity of health expenditure on health outcome is 0.26 for the objective measure (EQ-5D) and 0.19 for self-rated health scale. The elasticity of 0.26 indicates that a 10% increase in medical expenditures will improve quality of life by 2.6%. Age has a large negative effect on health outcomes. Men have slightly better health status than women. The ethnic minority variables including Hispanic, African American and other racial ethnicities all exhibit a positive relationship to both health measurements. While this pattern seems puzzling, it must be remembered that these race/ethnicity effects are adjusted for differences in medical expenditures. And as the results in Table 3.4 indicate, racial and ethnic minorities have substantially lower medical expenditures than do Caucasians. Unemployed individuals have worse health status. Individuals with relatively low income have lower health status. All chronic disease conditions have significant negative effects on health status.

Do the returns to medical expenditures vary by age group? To investigate this issue, I

repeated the analysis on sub groups stratified into three age groups; less or equal to 45 years of age, 46 to 64 years of age and $>$ 64 years of age (analysis results presented in Table 3.5). I estimated separate two-stage least squares models for each age group and health outcome measure. The results are provided in Table 3.5. Using the EuroQoL, the objective health measure, the elasticity of medical expenditure on health is 0.20 for subjects aged less or equal to 45 ($p < 0.05$); 0.34 for subjects aged 46-64 ($p< 0.01$), and 0.23 for subjects aged greater than 64 (p: ns). Clearly, the effect of medical expenditure on health is much greater for the middle-aged cohort than for either of the other groups. Indeed, I find no statistically significant effect of expenditures on health for older subjects. In contrast, a different pattern emerges using the rating scale, the subjective measure. In this case, all three groups show a positive and highly significant relationship between medical expenditures and health, with the effect strongest for the senior group.

Thus we see that the health returns to medical expenditure vary by age and by whether the health measure is subjective or objective. When an objective measure was used, middle-aged individuals clearly gained more from medical expenditures than older subjects, who showed little benefit. But medical expenditures strongly increased self-assessed health status among senior subjects. These results suggest that while the middle-age group obtained the highest objective health returns to medical expenditures, the senior population may enjoy higher perceived benefits from health care expenditures.

To gain further insight into the high perceived health benefits from medical expenditures among seniors, I obtained the residuals from a regression of the natural logarithm of the rating scale measure on the natural logarithm of the EQ-5D. These residuals provide variations in the rating scale that are independent of EQ-5D, the objective health measure. I then estimated two-stage least squares models for each of the age groups using these residuals as the second-stage outcome measure. The results, summarized in Table 3.6, indicate that medical

expenditures have the strongest associations with the residual measure among seniors, followed by the young cohort. By contrast, medical expenditures are unrelated to the residuals for the middle-aged group. These findings suggest that the source of the positive relationship between the rating scale and medical expenditures among seniors reflects factors that are unrelated to EQ-5D, the general objective measure of health.

Table 3.1: Summary Statistics: Overall Medical Expenditures

	Mean	Std.Dev
Health measures		
Quality of life scale (EuroQoL-EQ-5D)	0.83	0.21
Self health rating scale (RATESCALE)	0.80	0.17
Health expenses in 2003 dollars	$3,526.40	$8,270.72
Age	47.07	17.31
Male	0.42	0.49
Married	0.54	0.50
Race		
White, non-Hispanic	0.68	0.47
African American, non-Hispanic	0.12	0.32
Other races, non-Hispanic	0.04	0.20
Hispanic	0.16	0.37
Years of schooling		
Less than 9 years	0.08	0.28
9-11 years	0.14	0.34
12 years	0.32	0.47
13-15 years	0.22	0.41
16 years or more	0.24	0.43
Health insurance		
Private Non HMO	0.34	0.47
Private HMO	0.29	0.45
Medicaid Non HMO	0.05	0.21
Medicaid HMO	0.04	0.2
Medicare	0.17	0.38
Uninsured	0.11	0.32
Unemployed	0.29	0.46
Annual family income in 2003 dollars	$58,626.33	$47,108.20
House Ownership		
Own	0.68	0.47
Rent	0.27	0.45
Other arrangement	0.05	0.21
US region		
Northeast	0.16	0.37
West	0.23	0.42
Midwest	0.23	0.42
South	0.38	0.48
Living in MSA	0.77	0.42
Body Weight Categories		
Underweight BMI<18.5	0.02	0.13
Normalweight 18.5<=BMI<25	0.36	0.48
Overweight 25<=BMI<30	0.36	0.48

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Summary Statistics – Continued

	Mean	Std.Dev
Obesity 30<=BMI<40	0.23	0.42
Morbidly Obesity BMI>=40	0.04	0.19
Risk Preference Variable		
Adrisk =1 Self considered less likely taking risk	0.66	0.47
Seatbelt=1 if always wearing seat belt	0.79	0.41
Health Resource Variable		
Dr Number per 1000 population	2.27	1.37
Year		
2000	0.17	0.38
2001	0.26	0.44
2002	0.31	0.46
2003	0.26	0.44
Main Disease Categories		
Diabetes	0.08	0.27
Hypertension	0.21	0.41
Lipid metabolism disorders	0.11	0.31
Anxiety disorders	0.07	0.26
Acute myocardial infarction	0.01	0.08
Congestive heart failure	0.01	0.09
Cerebrovascular disease	0.01	0.09
Peripheral vascular disease	0.00	0.05
Atherosclerosis	0.01	0.12
Chronic obstructive pulmonary disease	0.05	0.22
Asthma	0.05	0.21
Osteoarthritis	0.01	0.10
Osteoporosis	0.02	0.14
Affective disorders	0.01	0.10
Migraine	0.06	0.24

Table 3.2: Ordinary Least Squares Analysis

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Health expenses in 2003 dollars,	-0.04	***	-0.03	***
Age, natural logarithm	-0.10	***	-0.06	***
Male	-0.02	***	-0.02	***
Married	0.01	***	0.01	**
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	-0.01	**	0.00	
Other races, non-Hispanic	-0.01		-0.02	***
Hispanic	0.02	***	0.01	**
Years of schooling				
Less than 9 years	-0.07	***	-0.08	***
9-11 years	-0.04	***	-0.03	***
12 years	Reference		Reference	
13-15 years	0.03	***	0.02	***
16 years or more	0.07	***	0.03	***
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	0.00		0.00	
Medicaid Non HMO	-0.17	***	-0.13	***
Medicaid HMO	-0.15	***	-0.10	***
Medicare	-0.01		-0.01	
Uninsured	-0.08	***	-0.05	***
Unemployed	-0.07	***	-0.06	***
Family Income	0.02	***	0.02	***
House Ownership				
Own	Reference		Reference	
Rent	-0.01	***	-0.02	***
Other arrangement	-0.02	*	-0.04	***
US region				
Northeast	Reference		Reference	
West	-0.01	**	-0.01	***
Midwest	0.00		0.00	
South	-0.02	***	-0.01	**
Living in MSA	0.01	***	0.01	**
Body Weight Categories				
Underweight BMI<18.5	-0.08	***	-0.05	***
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	-0.02	***	0.00	
Obesity 30<=BMI<40	-0.05	***	-0.04	***
Morbidly Obesity BMI>=40	-0.15	***	-0.09	***

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OLS – Continued

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Year				
2000	Reference		Reference	
2001	0.02	***	0.03	***
2002	0.03	***	0.04	***
2003	0.03	***	0.04	***
Main Disease Categories				
Diabetes	-0.06	***	-0.08	***
Hypertension	0.00		-0.01	***
Lipid metabolism disorders	0.02	***	0.01	**
Anxiety disorders	-0.13	***	-0.07	***
Acute myocardial infarction	-0.08	**	-0.08	***
Congestive heart failure	-0.15	***	-0.18	***
Cerebrovascular diseasevd	-0.16	***	-0.17	***
Peripheral vascular diseasevd	-0.04		-0.07	**
Atherosclerosis	-0.05	**	-0.06	***
Chronic obstructive pulmonary disease	-0.04	***	-0.05	***
Asthma	-0.07	***	-0.04	***
Osteoarthritis	-0.16	***	-0.06	***
Osteoporosis	-0.06	***	-0.01	
Affective disorders	-0.24	***	-0.15	***
Migraine	-0.08	***	-0.05	***
Constant	0.48	***	0.18	***
R-squared	0.16		0.20	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 3.3: Two-stage Least Squares: First Stage

	Health Expenditures in 2003 $ natural log	
	Coeff.	Sig.
Age, natural logarithm	0.60	***
Male	-0.35	***
Married	0.03	**
Race		
White, non-Hispanic	Reference	
African American, non-Hispanic	-0.30	***
Other races, non-Hispanic	-0.31	***
Hispanic	-0.33	***
Years of schooling		
Less than 9 years	-0.08	***
9-11 years	-0.03	
12 years	Reference	
13-15 years	0.04	**
16 years or more	0.15	***
Health insurance		
Private Non HMO	Reference	
Private HMO	-0.05	***
Medicaid Non HMO	0.49	***
Medicaid HMO	0.27	***
Medicare	0.17	***
Uninsured	-0.55	***
Unemployed	0.21	***
Family Income	0.01	
House ownership		
Own	Reference	
Rent	-0.03	*
Other arrangement	0.00	
US region		
Northeast	Reference	
West	-0.05	**
Midwest	0.04	*
South	0.01	
Living in MSA	0.01	
Body Weight Categories		
Underweight BMI<18.5	0.01	
Normalweight 18.5<=BMI<25	Reference	
Overweight 25<=BMI<30	0.01	
Obesity 30<=BMI<40	0.10	***
Morbidly Obesity BMI>=40	0.20	***

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2sls First Stage – Continued

	Health Expenditures in 2003 $ natural log	
	Coeff.	Sig.
Year		
2000	Reference	
2001	0.11	***
2002	0.10	***
2003	0.11	***
Disease Categories		
Diabetes	0.60	***
Hypertension	0.43	***
Lipid metabolism disorders	0.44	***
Anxiety disorders	0.46	***
Acute myocardial infarction	1.11	***
Congestive heart failure	0.77	***
Cerebrovascular disease	0.79	***
Peripheral vascular disease	0.47	***
Atherosclerosis	0.54	***
Chronic obstructive pulmonary disease	0.27	***
Asthma	0.47	***
Osteoarthritis	0.45	***
Osteoporosis	0.33	***
Affective disorders	0.78	***
Migraine	0.37	***
IV		
MDs per 1000 population	0.12	**
Adrisk	0.05	***
Seatbelt	0.08	***
Constant	4.38	***
R-squared	0.26	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 3.4: Two-stage Least Squares: Second Stage

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Health expenses in 2003 dollars	0.26	***	0.19	***
Age, natural logarithm	-0.28	***	-0.19	***
Male	0.09	***	0.06	***
Married	0.00		0.00	
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	0.07	***	0.06	***
Other races, non-Hispanic	0.08	***	0.04	**
Hispanic	0.12	***	0.08	***
Years of schooling				
Less than 9 years	-0.04	***	-0.06	***
9-11 years	-0.03	***	-0.02	***
12 years	Reference		Reference	
13-15 years	0.02	**	0.01	
16 years or more	0.02		-0.01	
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	0.02	***	0.01	*
Medicaid Non HMO	-0.31	***	-0.23	***
Medicaid HMO	-0.23	***	-0.16	***
Medicare	-0.06	***	-0.04	***
Uninsured	0.10	**	0.07	***
Unemployed	-0.14	***	-0.10	***
Family income	0.02	***	0.01	***
House Ownership				
Own	Reference		Reference	
Rent	-0.01		-0.01	*
Other arrangement	-0.02		-0.03	***
US region				
Northeast	Reference		Reference	
West	0.00		0.00	
Midwest	-0.01		-0.01	
South	-0.02	**	-0.01	
Living in MSA	0.01		0.00	
Body Weight Categories				
Underweight BMI<18.5	-0.08	***	-0.05	***
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	-0.02	***	-0.01	
Obesity 30<=BMI<40	-0.08	***	-0.06	***
Morbidly Obesity BMI>=40	-0.20	***	-0.13	***

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2sls Second Stage – Continued

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Year				
2000	Reference		Reference	
2001	-0.01		0.01	
2002	0.00		0.02	**
2003	-0.01		0.02	*
Disease Categories				
Diabetes	-0.24	***	-0.21	***
Hypertension	-0.13	***	-0.11	***
Lipid metabolism disorders	-0.11	***	-0.09	***
Anxiety disorders	-0.27	***	-0.17	***
Acute myocardial infarction	-0.42	***	-0.32	***
Congestive heart failure	-0.39	***	-0.35	***
Cerebrovascular disease	-0.40	***	-0.35	***
Peripheral vascular disease	-0.18	***	-0.18	***
Atherosclerosis	-0.22	***	-0.18	***
Chronic obstructive pulmonary disease	-0.13	***	-0.11	***
Asthma	-0.22	***	-0.15	***
Osteoarthritis	-0.29	***	-0.16	***
Osteoporosis	-0.16	***	-0.08	***
Affective disorders	-0.48	***	-0.32	***
Migraine	-0.19	***	-0.13	***
Constant	-0.86	***	-0.79	***

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 3.5: Age Group Results

	Two-stage Least squares			
	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Health expenses in 2003 dollars				
Entire sample	0.26	***	0.19	***
By age group				
Less than or equal to 45 years old	0.20	**	0.25	***
Between 46 and 64	0.34	***	0.14	**
Greater than 64 years old	0.23		0.30	**

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Explanatory variables also include gender, marital status, races, years of schooling, health insurance, employment status, house ownership status, annual family income in natural logarithm, US region, living in MSA, body weight, survey year and current diseases (diabetes, hypertension, hyperlipidemia, acute myocardial infarction, congestive heart failure, cardiovascular disease, peripheral vascular disease, atherosclerosis, chronic obstructive pulmonary disease, asthma, osteoarthritis, osteoporosis, anxiety disease, affective disorder, and migraine).

Table 3.6: Selected Coefficients Using Two-stage Least Squares by Age Groups for Residual Model

	Two-tage Least squares Residual (lnratescale=lnEuroQoL+residual)	
	Coeff.	Sig.
Health expenses in 2003 dollars		
Entire sample	0.11	***
By age group		
Less than or equal to 45 years old	0.13	**
Between 46 and 64	0.02	
Greater than 64 years old	0.22	**

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Explanatory variables also include gender, marital status, races, years of schooling, health insurance, employment status, house ownership status, annual family income in natural logarithm, US region, living in MSA, body weight, survey year and current diseases (diabetes, hypertension, hyperlipidemia, acute myocardial infarction, congestive heart failure, cardiovascular disease, peripheral vascular disease, atherosclerosis, chronic obstructive pulmonary disease, asthma, osteoarthritis, osteoporosis, anxiety disease, affective disorder, and migraine).

Endogeneity Tests and Tests Of Instruments

After estimating the two-stage least squares regression models, I conducted a series of tests to establish endogeneity of the medical expenditure variable and test the validity of the instruments. First, I tested the endogeneity of the medical expenditure variable. I used the STATA 10 command of ivreg2 with ”endog” option, finding that the test statistics chi-square p value equals to 0.00. The test result thus rejects the null hypothesis of exogeneity and I conclude that medical expenditure is endogenous[4].

The first stage equation is over-identified and the F value for the instruments is 13.68. Previously, first stage F$>$10 is used as a conservative rule of thumb in determining weak instrumental variable of first stage equation in 2sls analysis (Staiger and Stock 1997). Later on, new methods were introduced to evaluate the efficiency of the instrumental variables by measuring the relative bias of 2sls coefficients comparing to the bias of OLS regression (Stock and Yogo 2002). According to the their standards, in 3 instrumental variables case, to yield relative bias less than 5%, the Cragg-Donald Wald F statistics (Cragg and Donald 1993) needs to be be greater than 13.91, and the statistics in the regressions are 18.84, which are greater than the critical value. The resulting Hansen J statistic tests the hypothesis that the first stage equation is over-identified. The Hansen J test chi-square p value is 0.87 in the EQ-5D regression and 0.17 in the rating scale regression, each of which fails to reject the hypothesis of overidentification.

[4]The relative IV tests results are read from STATA command ”ivreg2” with ”ffirst” options. ”gmm2s robust” option was added to the regressions to obtain the two-step feasible efficient GMM estimator. Hansen J test examines the overidentification of all instrument variables in the first stage. The original hypothesis is: the first stage equation is over-identified. The chi-square p value is 0.87 for EQ-5D regression and 0.17 for ratescale regression, failed to reject the hypothesis that first stage equation is over-identified (Reference: (Baum 2006; Wooldridge 2002; Greene 2003)).

3.4 Discussion

This chapter is an empirical attempt to test the health investment model and provide estimates of the value of medical expenditures using broader health measures than found in prior studies. Using a nationally representative database, I explored the returns to medical expenditures considering both subjective and objective general measures of health. The objective measure, the EQ-5D, incorporates multi-dimensional health domains. The subjective health outcome - a self-assessed rating scale– reflects individuals' perceptions of their overall health status.

By applying the two-stage least squares technique with valid instrumental variables, I was able to estimate the elasticity of medical expenditure on health outcome for a general population. I also performed further analysis on different age groups, which led to some intriguing results. In particular, while the middle-age group cohort enjoys the highest returns to medical care expenditures in terms of improving objective health, seniors have the highest return on medical expense for the subjective measure of health. This suggests that, among seniors, there may be considerable perceived health benefits from medical expenditures that do not correspond to actual gains in health. An alternative possibility is that there are additional real health benefits to medical expenditures among seniors that are not captured by EQ-5D. It is not clear, however, what these additional benefits might be and why they are apparent among seniors but not among the middle-aged cohort.

The age-specific variation in the returns to medical expenditures has potentially important implications for the optimal allocation of scarce health care resources. If seniors achieve less objective health benefit from medical expenditures than do other age cohorts, this suggests that resources should be directed away from this group and toward groups where medical investment will yield greater health gains. However, given the large perceived health benefits from medical expenditures, older individuals and their advocates may be quite resistant to any

such changes. Moreover, even if such a reallocation would improve efficiency, considerations of equity are also quite important in prioritizing health care expenditures.

This study represents a first step in quantifying the effects of medical expenditures on general measures of health. In the following chapters, I investigate how these relationships differ by alternative types of health care expenditures, such as pharmaceutical expenditures and physician services spending. Such efforts will shed light on inefficiencies in the allocation of health care resources and disparities in the benefits from medical investments.

Chapter 4

Health Benefit from Pharmaceutical Expenditure/Utilization for General Population

4.1 Introduction & Motivation

Starting from 2010, health care system is going through a transition period as a result of newly passed health care reform bill (Health Care Reconciliation Bill: H.R. 4872). A very important element of the Health Care Reform Bill is to close the coverage gap in Medicare Part D prescription drug plan - better known as "donut hole". Previously the Medicare beneficiaries are responsible for 100% of drug cost when total drug costs reach $2830. After the yearly out-of-pocket costs reach $4550, the beneficiaries will be eligible for catastrophic coverage and only pay a small coinsurance or copayment[1]. In 2010, the Medicare beneficiaries who hit the "donut hole" can receive a rebate of $250. During the phase-out period of

[1]The Medicare beneficiaries pays first $310 of drug cost as deductible, then the Medicare Part D drug plan takes place and within the total drug cost range of $310-$2830, the beneficiaries pays the copayment or coinsurance according to the plan. When the total drug cost goes beyond $2830, Medicare beneficiaries are responsible for 100% of drug costs until the out-of- pocket spending reaches $4550. After that, the coverage gap ends and the beneficiaries only pay a small coinsurance or a small copayment. Reference to Centers for Medicare and Medicaid Services website: http://www.cms.gov/partnerships/downloads/11240-P.pdf.

2010−2020, Medicare Part D beneficiaries are going to receive 50% of manufacture discount on brand-name drugs, and the government subsidy will also progressively increase to 25% in 2020. In the next 10 years, the cost shared by consumers will be decreased to 25% of prescription drug cost (CMS: Health Reform for American Seniors).

There are two aspects of potential benefits from prescriptions drugs: direct health benefit and indirect cost saving by affecting the use of other medical services. When prescription drugs are complements with other medical services, increased drug utilization will increase the use of other medical services. However, when prescription drug is substitute to other medical services, increase use of prescription drugs will prevent or treat diseases, and avoid the need of other costly medical services, such as hospitalization and emergency visits. Many previous studies supported the direct benefit of pharmaceutical drugs on longevity (Cremieux et al. 2005; Frech and Miller 2004; Lichtenberg 2004) as well as cost saving on non-drug medical expenditures (Sokol et al. 2005, Shang and Goldman 2007, Cutler et al. 2007, Stuart et al. 2009).

Understanding how prescription drug expenditure affects health outcome is essential for resource allocation in health care services. Given the current environment of health care reform, further evidence on the health returns to prescription drug is both timely and policy-relevant, as it assists policy maker developing market driven solutions. Previous literature provided profound evidence in understanding benefits of pharmaceutical innovation and cost off-setting effect on other non-drug medical services. I will estimate returns to pharmaceutical expenditure in broader scope for general population using national level data.

This chapter provides an empirical assessment of the relationship between prescription drug expenditures/utilization (number of prescriptions) and health-related quality of life. I use objective (EuroQoL) measures of health. The conceptual start point for this study is Grossman's classic model of health investment. I employ two-stage least squares estimation

techniques to address the endogeneity of individual prescription drug expenditures (e.g., that sicker people spend more).

The remainder of this chapter is organized as follows: section II presents the data and methods. Section III reports estimation results including both OLS and IV analysis. The last section summarizes the result and discusses their policy implications.

4.2 Data & Methods

4.2.1 Sample & Variables

Dependent variables

EuroQoL (EQ-5D) is the health outcome variable used in this analysis. The EuroQoL is a widely used, general quality of life measure (EuroQol Group (EQ-5D) 2010). The MEPS included the EQ-5D on surveys from 2000-2003. I excluded individuals under 18 years of age and pregnant women. Respondents who reported a negative health status (worse than death), zero prescription drug expenditures and more than 50 prescriptions per annum were also excluded from the sample, leaving 40987 observations for estimation purposes.

Explanatory variables

The key predictor for health is total pharmaceutical expenditures per annum per patient. This measure includes individual out-of-pocket expenditures as well as expenditures made by the insurer, if applicable. Other sociodemographic predictors of health include age, gender, race and educational attainment. Socioeconomic predictors include health insurance, employment status, annual family income and home ownership. I also controlled for preexisting conditions that could affect quality of life. In particular, I control for 15 major chronic diseases and for whether the subject is obese. Regional factors include whether the subject resides in an urban location and Census Region. Year is controlled for using a series of binary indicators, with 2000 serving as the reference year.

All dollar-denominated variables are converted to 2003 dollars. For pharmaceutical expenditures, I use the Medical Care Component of the Consumer Price Index (CPI). For non-medical items, the general CPI is used.

4.2.2 Methods

$$ln(RXEXPorNumberofPrescriptions) = \alpha_0 + \alpha_1 X + \alpha_2 IV + \varepsilon \quad (4.1)$$

$$ln(EuroQoL) = \beta_0 + \beta_1 ln(RXEXPorNumberofPrescriptions) + \beta_2 X + \varepsilon \quad (4.2)$$

The first equation examines the determinants of pharmaceutical expenditures or utilization. The vector X represents socioeconomic, demographic, comorbidities, and regional factors affecting both pharmaceutical expenditures and health. The instrumental variables include risk averse variable, seatbelt variable and number of family physicians per 1,000 population. Equation (2) uses the predicted value from (1) and the vector X to predict health outcomes. Pharmaceutical expenditures and health outcome measures were transformed to natural logarithms to normalize their distributions. Equations (1) and (2) are also estimated separately for three age groups: younger persons (18-45 years of age), middle aged subjects (46 to 64) and seniors (65 and over).

4.3 Results

First-stage Prescription Drug Expenditure Equation

Descriptive Statistics

Summary statistics are provided in Table 4.1. The dependent is objective (EQ-5D) health outcome measure. The health outcome measure was normalized to lie between 0 and 1. The key explanatory variable of interest, the average annual prescription drug expenditure is $656 for our sample. In the second regression, the average number of prescriptions is 11.

Ordinary Least Squares Results

Table 4.2 shows the results of ordinary least squares estimation of the association between prescription drug expenditures/number of prescriptions and our health measures, ignoring the issue of endogeneity. As the table indicates, this relationship is estimated to be negative and significant for both prescription drug expenditure and utilization (number of prescriptions) measures, reflecting endogeneity of the prescription drug expenditure and utilization variables.

Two-stage Least squares: First Stage

Table 4.3 presents the first-stage prescription drug expenditure regression results for the two-stage least squares model. Male spend less than female and married people spend less than single individuals. Minorities spend less on prescription drugs. People with college or higher education level have more prescription drug expenditure. Uninsured individuals spend significantly less. All chronic conditions have positive effect on prescription drug expenditures.

The first - stage prescription drug utilization regression results is presented in Table 4.3. Similar with pharmaceutical expenditure results, male and married people have fewer prescriptions. Minorities have fewer prescriptions comparing to Caucasian. Individuals with education higher than college level have more prescriptions and uninsured people have fewer prescriptions. The chronic conditions are associated with more prescriptions.

For expenditure regression, all three instrumental variables have significant effects on prescription drug expenditure. The natural log form of number of family physician per 1,000 population has a positive effect on prescription drug expenditures. As predicted, people who are more risk averse spend more on prescription drugs. For drug utilization regression, risk averse individuals have more prescriptions. People living in regions with higher per capita

family physician have more prescription drug expenditure. Seatbelt variable is does not show significant effect on number of prescriptions.

To test the validity of the instruments and the two-stage least squares estimation approach, I conducted a series of tests for endogeneity of prescription drug expenditures and overidentification of the instrumental variables. The test statistics confirm that the prescription drug expenditure variable is endogenous and the first stage equation is over-identified. The resulting Hansen test statistics failed to reject the null hypothesis and the instrumental variable setting in this chapter passed overidentification test.

Two-stage Least Squares: Second-stage Results

Table 4.4 shows the second-stage estimates predicting health outcome. Both Prescription drug expenditure and number of prescriptions have positive and significant effect on health-related quality of life measure. The elasticity of health expenditure on health outcome is 0.18 for prescription drug expenditure and 0.22 for number of prescriptions. The elasticity of 0.18 indicates that a 10% increase in prescription drug expenditures will improve quality of life by 1.8%.

Age has a large negative effect on health outcomes. Men have slightly better health status than women. The ethnic minority variables including Hispanic, African American and other racial ethnicities all exhibit a positive relationship in both regressions. While this pattern seems puzzling, it must be remembered that these race/ethnicity effects are adjusted for differences in prescription drug expenditures. And as the results in Table 4.3 indicate, racial and ethnic minorities have substantially lower prescription drug expenditures than do Caucasians.

Those who received college education have better health outcomes compared to individuals with a high school education. Individuals with relatively low income have lower health outcomes. All chronic disease conditions have significant negative effects on health

outcomes.

Do the returns to prescription drug expenditures vary by age group? To investigate this issue, I repeated the analysis on sub groups stratified into three age groups: $<$ 46 years of age, 46 to 64 years of age and $>$ 64 years of age. I estimated separate two-stage least squares models for each age group and health outcome measure.

The results are provided in Table 4.5. Using the EuroQoL, the objective health measure, the elasticity of prescription drug expenditure on health is 0.17 for subjects aged $<$ 46 ($p <$ 0.01); 0.20 for subjects aged 46-64 ($p < 0.05$), and 0.02 for subjects aged greater than 64 (p: ns). In prescription drug utilization regression, the elasticity of number of prescriptions on health is 0.27 for subjects aged $<$46 ($p < 0.01$); 0.32 for 46-64 group ($p<0.05$); -0.29 for individuals older than 64(p:ns).

Thus we see that the health returns to prescription drug expenditure and utilization vary by age. For both prescription drug expenditure and utilization measures, neither the prescription drug expenditure nor the number of prescriptions has significant effect on objective health measure for senior age group in the analysis. These results suggest that there are other factors affecting the senior group from obtaining beneficial returns from prescription drug expenditure and utilization. Considering the period of data used in the analysis, one possibility is the poor compliance of prescriptions due to the financial burdens. The investigation period is 2000-2003, when the Medicare Part D plan has not yet been introduced and the prescription coverage for senior individuals was very limited. It is very possible that without much coverage for prescription drugs, senior individuals have poorer drug compliance and the effects of the drugs are affected without appropriate compliance.

Table 4.1: Summary Statistics: Pharmaceutical Expenditure

	Mean	Std.Dev
Health measures - EuroQoL	0.82	0.20
RX expenses in 2003 dollars	$656.21	$930.91
Number of Rx Prescriptions	11.69	11.70
Age	47.78	17.34
Male	0.40	0.49
Married	0.55	0.50
Race		
White, non-Hispanic	0.69	0.46
African American, non-Hispanic	0.12	0.32
Other races, non-Hispanic	0.04	0.19
Hispanic	0.15	0.36
Years of schooling		
Less than 9 years	0.08	0.28
9-11 years	0.13	0.34
12 years	0.32	0.47
13-15 years	0.22	0.41
16 years or more	0.24	0.43
Health insurance		
Private Non HMO	0.34	0.47
Private HMO	0.29	0.45
Medicaid Non HMO	0.04	0.21
Medicaid HMO	0.04	0.20
Medicare	0.18	0.39
Uninsured	0.10	0.31
Unemployed	0.30	0.46
Annual family income in 2003 dollars	$58705.25	$47033.88
House Ownership		
Own	0.69	0.46
Rent	0.27	0.44
Other arrangement	0.04	0.21
US region		
Northeast	0.16	0.37
West	0.23	0.42
Midwest	0.23	0.42
South	0.38	0.49
Living in MSA	0.77	0.42
Body Weight Categories		
Underweight BMI<18.5	0.02	0.13
Normalweight 18.5<=BMI<25	0.35	0.48
Overweight 25<=BMI<30	0.36	0.48
Obesity 30<=BMI<40	0.24	0.43

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Summary Statistics – Continued

	Mean	Std.Dev
Morbidly Obesity BMI>=40	0.04	0.19
Risk Preference Variable		
Adrisk =1 self considered less likely taking risk	0.67	0.47
Seatbelt=1 if always wearing seat belt	0.79	0.41
Health Resource Variable		
Number of family physician per 1000 population	0.25	0.14
Year		
2000	0.17	0.38
2001	0.27	0.44
2002	0.30	0.46
2003	0.26	0.44
Main Disease Categories		
Diabetes	0.08	0.27
Hypertension	0.23	0.42
Lipid metabolism disorders	0.12	0.32
Anxiety disorders	0.08	0.27
Acute myocardial infarction	0.01	0.08
Congestive heart failure	0.00	0.07
Cerebrovascular disease	0.01	0.09
Peripheral vascular disease	0.00	0.05
Atherosclerosis	0.01	0.11
Chronic obstructive pulmonary disease	0.06	0.23
Asthma	0.05	0.22
Osteoarthritis	0.01	0.10
Osteoporosis	0.02	0.15
Affective disorders	0.01	0.11
Migraine	0.07	0.25

Table 4.2: Ordinary Least Squares Analysis

	Dependent Variable – ln(EuroQoL)			
	ln(RXEXP)		ln(RXNUM)	
	Coeff.	Sig.	Coeff.	Sig.
RxExp or RxNum	-0.03	***	-0.05	***
Age, natural logarithm	-0.11	***	-0.11	***
Male	-0.01	***	-0.02	***
Married	0.01	***	0.01	***
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	-0.02	**	-0.02	**
Other races, non-Hispanic	-0.01		-0.01	
Hispanic	0.01	*	0.01	*
Years of schooling				
Less than 9 years	-0.06	***	-0.06	***
9-11 years	-0.04	***	-0.04	***
12 years	Reference		Reference	
13-15 years	0.03	***	0.03	***
16 years or more	0.07	***	0.07	***
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	0.01		0.01	
Medicaid Non HMO	-0.16	***	-0.15	**
Medicaid HMO	-0.14	***	-0.13	**
Medicare	-0.01		0.00	
Uninsured	-0.07	***	-0.07	***
Unemployed	-0.07	***	-0.07	***
Family Income	0.02	***	0.02	***
House Ownership				
Own	Reference		Reference	
Rent	-0.02	***	-0.02	***
Other arrangement	-0.02	**	-0.03	**
US region				
Northeast	Reference		Reference	
West	-0.02	***	-0.02	***
Midwest	-0.01		-0.01	
South	-0.02	***	-0.01	***
Living in MSA	0.01		0.01	
Body Weight Categories				
Underweight BMI<18.5	-0.09	***	-0.09	***
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	-0.02	***	-0.02	***
Obesity 30<=BMI<40	-0.06	***	-0.05	***

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OLS – Continued

	Dependent Variable – ln(EuroQoL)			
	ln(RXEXP)		ln(RXNUM)	
	Coeff.	Sig.	Coeff.	Sig.
Morbidly Obesity BMI>=40	-0.14	***	-0.14	***
Year				
2000	Reference		Reference	
2001	0.02	***	0.02	***
2002	0.03	***	0.03	***
2003	0.03	***	0.03	***
Main Disease Categories				
Diabetes	-0.03	**	-0.02	*
Hypertension	0.03	***	0.04	***
Lipid metabolism disorders	0.04	***	0.03	***
Anxiety disorders	-0.10	***	-0.10	***
Acute myocardial infarction	-0.06	*	-0.05	
Congestive heart failure	-0.09	**	-0.07	*
Cerebrovascular disease	-0.11	***	-0.11	***
Peripheral vascular disease	-0.05		-0.04	
Atherosclerosis	-0.05	**	-0.04	*
Chronic obstructive pulmonary disease	-0.02		-0.01	
Asthma	-0.03	***	-0.03	***
Osteoarthritis	-0.17	***	-0.17	***
Osteoporosis	-0.03	*	-0.03	
Affective disorders	-0.23	***	-0.23	***
Migraine	-0.07	***	-0.07	***
Constant	0.36	***	0.27	***
R-squared	0.12		0.12	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 4.3: Two-stage Least Squares: First Stage

	ln(RXEXP)		ln(RXNUM)	
	natural log			
	Coeff.	Sig.	Coeff.	Sig.
Age, natural logarithm	0.87	***	0.61	***
Male	-0.28	***	-0.29	***
Married	-0.05	***	-0.04	***
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	-0.39	***	-0.24	***
Other races, non-Hispanic	-0.25	***	-0.16	***
Hispanic	-0.35	***	-0.25	***
Years of schooling				
Less than 9 years	-0.05	*	0.00	
9-11 years	-0.03		0.01	
12 years	Reference		Reference	
13-15 years	0.03		0.01	
16 years or more	0.11	***	0.04	***
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	-0.02		0.00	
Medicaid Non HMO	0.26	***	0.25	***
Medicaid HMO	0.09	*	0.15	***
Medicare	0.00		0.04	**
Uninsured	-0.39	***	-0.23	***
Unemployed	0.17	***	0.12	***
Family Income	0.01		-0.01	
House Ownership				
Own	Reference		Reference	
Rent	-0.04	*	-0.02	
Other arrangement	-0.01		-0.03	
US region				
Northeast	Reference		Reference	
West	-0.10	***	-0.05	***
Midwest	0.03		0.06	***
South	0.13	***	0.12	***
Living in MSA	-0.03	*	-0.04	***
Body Weight Categories				
Underweight BMI<18.5	0.02		0.04	
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	0.01		-0.01	
Obesity 30<=BMI<40	0.09	***	0.08	***
Morbidly Obesity BMI>=40	0.12	***	0.18	***

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2sls First Stage – Continued

	ln(RXEXP) natural log		ln(RXNUM)	
	Coeff.	Sig.	Coeff.	Sig.
Year				
2000	Reference		Reference	
2001	0.18	***	0.05	***
2002	0.17	***	0.06	***
2003	0.24	***	0.05	***
Main Disease Categories				
Diabetes	0.83	***	0.65	***
Hypertension	0.69	***	0.61	***
Lipid metabolism disorders	0.69	***	0.38	***
Anxiety disorders	0.55	***	0.40	***
Acute myocardial infarction	0.44	***	0.46	***
Congestive heart failure	0.36	***	0.45	***
Cerebrovascular disease	0.47	***	0.36	***
Peripheral vascular disease	0.22	*	0.16	*
Atherosclerosis	0.32	***	0.30	***
Chronic obstructive pulmonary disease	0.25	***	0.22	***
Asthma	0.73	***	0.56	***
Osteoarthritis	0.33	***	0.28	***
Osteoporosis	0.42	***	0.30	***
Affective disorders	0.90	***	0.58	***
Migraine	0.37	***	0.30	***
Adrisk	0.10	***	0.08	***
Seatbelt	0.05	***	0.02	
log(Family MD per 1000 popu)	0.03	*	0.02	**
Constant	1.70	***	-0.71	***
R-squared	0.30		0.33	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 4.4: Two-stage Least Squares: Second Stage

	ln(EuroQoL)			
	ln(RXEXP)		ln(RXNUM)	
	Coeff.	Sig.	Coeff.	Sig.
RxExp and RxNum	0.18	***	0.22	***
Age, natural logarithm	-0.30	***	-0.27	***
Male	0.05	***	0.06	***
Married	0.02	***	0.02	***
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	0.06	***	0.05	***
Other races, non-Hispanic	0.04	**	0.03	**
Hispanic	0.09	***	0.08	***
Years of schooling				
Less than 9 years	-0.05	***	-0.06	***
9-11 years	-0.03	***	-0.04	***
12 years	Reference		Reference	
13-15 years	0.02	***	0.02	***
16 years or more	0.04	***	0.05	***
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	0.01		0.01	
Medicaid Non HMO	-0.21	***	-0.22	***
Medicaid HMO	-0.16	***	-0.17	***
Medicare	0.00		-0.01	
Uninsured	0.02		0.00	
Unemployed	-0.10	***	-0.10	***
Family income	0.02	***	0.03	***
House Ownership				
Own	Reference		Reference	
Rent	-0.01		-0.01	
Other arrangement	-0.02		-0.02	
US region				
Northeast	Reference		Reference	
West	0.00		0.00	
Midwest	-0.02	*	-0.02	***
South	-0.04	***	-0.05	***
Living in MSA	0.01	**	0.02	**
Body Weight Categories				
Underweight BMI<18.5	-0.10	***	-0.11	***
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	-0.02	***	-0.02	***
Obesity 30<=BMI<40	-0.07	***	-0.07	***

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2sls Second Stage – Continued

	ln(EuroQoL)			
	ln(RXEXP)		ln(RXNUM)	
	Coeff.	Sig.	Coeff.	Sig.
Morbidly Obesity BMI>=40	-0.17	***	-0.17	***
Year				
2000	Reference		Reference	
2001	-0.02		0.01	
2002	-0.01		0.01	
2003	-0.02		0.02	*
Disease Categories				
Diabetes	-0.20	***	-0.19	***
Hypertension	-0.12	***	-0.13	***
Lipid metabolism disorders	-0.11	***	-0.07	***
Anxiety disorders	-0.22	***	-0.21	***
Acute myocardial infarction	-0.16	***	-0.18	***
Congestive heart failure	-0.16	***	-0.20	***
Cerebrovascular disease	-0.21	***	-0.21	***
Peripheral vascular disease	-0.09		-0.08	
Atherosclerosis	-0.12	***	-0.13	***
Chronic obstructive pulmonary disease	-0.07	***	-0.07	***
Asthma	-0.19	***	-0.18	***
Osteoarthritis	-0.24	***	-0.24	***
Osteoporosis	-0.12	***	-0.11	***
Affective disorders	-0.41	***	-0.38	***
Migraine	-0.15	***	-0.15	***
Constant	0.00		0.46	***

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 4.5: Age Group Results

	Two Stage Least Squares EuroQoL as Dependent Variable			
	ln(RXEXP)		ln(RXNUM)	
	Coeff.	Sig.	Coeff.	Sig.
Entire sample	0.18	***	0.22	***
By age group				
Less than or equal to 45 years old	0.17	***	0.27	***
Between 46 and 64	0.20	**	0.32	**
Greater than 64 years old	0.02		-0.29	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Explanatory variables also include gender, marital status, races, years of schooling, health insurance, employment status, house ownership status, annual family income in natural logarithm, US region, living in MSA, body weight, survey year and current diseases (diabetes, hypertension, hyperlipidemia, acute myocardial infarction, congestive heart failure, cardiovascular disease, peripheral vascular disease, atherosclerosis, chronic obstructive pulmonary disease, asthma, osteoarthritis, osteoporosis, anxiety disease, affective disorder, and migraine).

Endogeneity Tests and Tests Of Instruments

After estimating the two-stage least squares regression models, I conducted a series of tests to establish endogeneity of the prescription drug expenditure/utilization (# of prescriptions) variables and test the validity of the instruments. The first stage equation is over-identified and the F value for the instruments is 16.39 for drug expenditure equation and 22.81 for # of prescription regression. Early on, first stage F$>$10 is used as a conservative rule of thumb in determining overidentification feature of first-stage equation in 2sls analysis (Staiger and Stock 1997). Later on, new methods were introduced to evaluate the efficiency of the instrumental variables by measuring the relative bias of 2sls coefficients comparing to the bias of OLS regression (Stock and Yogo 2002). According to the their standards, in 3 instrumental variables case, to yield relative bias less than 5%, the Cragg-Donald Wald F statistics (Cragg and Donald 1993) has to be greater than 13.91, and the statistics in both of the regressions are greater than the critical value. In addition, I performed an overidentification test of the instruments. The resulting Hansen J test statistic tests the hypothesis that the first stage is over-identified. The Hansen J test chi-square p value is 0.31 in the Rx expenditure equation and 0.07 in the utilization (number of prescriptions) regression, each of which fails to reject the hypothesis of overidentification.

4.4 Discussion

This chapter is an empirical attempt to test the health investment model and provide estimates of the value of prescription drug expenditures using more broader health measures than found in prior studies. Using a nationally representative database, I explored the returns to prescription drug expenditures and utilization using the objective measure, the EQ-5D, incorporates multi-dimensional health domains.

By applying the two-stage least squares technique with valid instrumental variables, I was able to estimate the elasticity of prescription drug expenditure/utilization on health outcome for a general population. I also performed further analysis on different age groups, which led to some intriguing results. In particular, while the middle-age group and younger population gains returns to prescription drug expenditures in terms of improving objective health, I found no statistical significant benefit on health outcome for senior group. This suggests that, among seniors, there may be related factors that affect the effectiveness of prescription drug usage and make the drug use do not correspond to actual gains in health. One of the possible explanations is the study period is 2000-2003, where Medicare Part D prescription drug coverage is not implemented. Because of limited coverage on prescription drug use, it may have discouraged the compliance of prescriptions, which can drastically affect the significance of prescription drug effectiveness. An alternative possibility is that there are additional real health benefits to prescription drug expenditures among seniors that are not captured by EQ-5D. It is not clear, however, what these additional benefits might be and why they are apparent among seniors but not among the middle-aged cohort.

The age-specific variation in the returns to prescription drug expenditures has potentially important implications for the optimal allocation of scarce health care resources. If seniors achieve less objective health benefit from prescription drug than do other age cohorts, this suggests that resources should be directed away from this group and toward groups where

medical investment will yield greater health gains. However, if the ineffective prescription drugs usage is caused by the inconsistency of compliance to prescription drugs, then the policies need to be implemented to relieve the financial burden for senior population. Current policy reform will close the long existed ”donut hole” for Medicare population, which I expect will greatly improve the access and compliance with prescription drugs.

Chapter 5

Health Returns to Physician Services Expenditure across Age Groups

5.1 Introduction & Motivation

Medical spending on physician and clinical services counted for about 22% of overall health spending in 2008. With baby boomer population coming into Medicare program, public spending on physician services is projected to accelerate during next decade (Truffer et al. 2010). Although wide geographic variations in Medicare spending have been reported (Dartmouth Atlas of Health Care 2008), there is no strong evidence that greater expenditures lead to better health outcomes. According to previous research, there is nearly 2 - 3 fold variation of physician supply across the United States (COGME 1998). Regional variation of physician supply is not explained by patient needs (Komaromy et al. 1996; Goodman and Grumbach 2008). Previous literature have shown that higher per-capita physicians did not bring superior patient health outcome with exception of primary care physician services (Kravet et al. 2008; Starfield et al. 2005; Fisher et al. 2003a,b).

It would be helpful to know what the actual health returns per dollar of physician expenditure are and how this relationship varies by demographic factors such as age. Studying

the health returns to physician expenditure by age is particularly pertinent, given the changing demographics in the United States toward an older population. The percentage of the population aged 65 and older has risen steadily from 8.1% in 1950 to 12.4% by 2000. It is projected to reach 20.6% of the total population by 2050 (Shrestha 2006). An aging population poses critical challenges to the health care system since older persons typically develop more medical conditions and demand more care.

This chapter sought to examine the physicians office visits expenditure - health outcome relationship adjusting for the endogeneity of the expenditure variables (e.g., individuals with more problematic medical conditions have higher physician office visits expenditure). I consider both subjective and objective health outcome measures. Cost-outcome correlation are also studied across age groups aiming to explore the benefit source for different age groups over medical expenditure components.

The remainder of this paper is organized as follows: Section II briefly reports the data sources and variables. Section III presents estimation results including both OLS and IV analysis. The last section summarizes the results and their policy implications.

5.2 Data and Method

5.2.1 Sample & Variables

Dependent variables This study included both objective and subjective health indices: the EuroQoL (EQ-5D) (objective) and self-rated (subjective) health status, respectively.

Explanatory variables The key predictor for health is physician services expenditures per annum per patient. This measure includes individual out-of-pocket expenditures as well as expenditures made by the insurer, if applicable. Other sociodemographic predictors of health include age, gender, race and educational attainment. Socioeconomic predictors include health insurance, employment status, annual family income and home ownership. I also

controlled for preexisting conditions that could affect quality of life. In particular, I control for 15 major chronic diseases and for whether the subject is obese. Regional factors include whether the subject resides in an urban location and Census Region. Year is controlled for using a series of binary indicators, with 2000 serving as the reference year[1].

All dollar-denominated variables are converted to 2003 dollars. For physician services expenditures, I use the Medical Care Component of the Consumer Price Index (CPI). For non-medical items, the general CPI is used.

5.2.2 Methods

The empirical model to be estimated may be written as:

$$ln(DrServEXP) = \alpha_0 + \alpha_1 X + \alpha_2 IV + \varepsilon \tag{5.1}$$

$$ln(EuroQoLorRatescale) = \beta_0 + \beta_1 ln(DrServEXP) + \beta_2 X + \varepsilon \tag{5.2}$$

The first equation examines the determinants of physician services expenditures. The vector X represents socioeconomic, demographic, comorbdities, and regional factors affecting both physician office-based visit expenditures and health. In this analysis, IV set include seatbelt and number of physicians per 1,000 population[2]. Equation (2) uses the predicted value from (1) and the vector X to predict health outcomes. I conducted separate regression analyses for EQ-5D and the self-assessed rating scale measures. Physician expenditures and both health outcome measures were transformed to natural logarithms to normalize their distributions.

[1] I excluded individuals under 18 years of age and pregnant women. Respondents who reported a negative health status (worse than death), zero physician services expenditures and more than 40 dr's office visits per annum were also excluded from the sample, leaving 43543 observations for estimation purposes.

[2] The risk averse variable used as IV in previous analysis is dropped from this analysis, as it does not show significant effect on physician services expenditure.

5.3 Results

Descriptive Statistics

Summary statistics are provided in Table 5.1. The dependent variables include both subjective (rating scale) and objective (EQ-5D) health outcomes. Both health outcome measures were normalized to lie between 0 and 1. The key explanatory variable of interest, annual physician expenditure, is $746 on average.

Ordinary Least Squares Results

Table 5.2 shows the results of ordinary least squares estimation of the association between physician services expenditure and the health measures, ignoring the issue of endogeneity. As the table indicates, this relationship is estimated to be negative and significant for each health outcome measure, reflecting endogeneity of the physician services expenditure variable.

First-stage Physician Services Expenditure Equation

Table 5.3 presents the first-stage physician expenditure regression results for the two-stage least squares model. Spending on physician services is positively associated with age. Female and married individuals spend more than males and single individuals, respectively. Minority populations spend significantly less compared to Caucasians. Individuals with college education spend more on doctor visits. Uninsured individuals spend significantly less.

Both instrumental variables are significant: seatbelt variable at 1%, log(number of MDs) at 5% significant level. The number of physicians per 1,000 population has a positive effect on physician services expenditures. As predicted, people who are more risk averse have higher physician services expenditure. To test the validity of the instruments and the two-stage least squares estimation approach, I conducted a series of tests for endogeneity of physician services expenditures and overidentification of the instrumental variables. The test statistics

confirm that the physician expenditure variable is endogenous and the first-stage equation is over-identified. I also tested the overidentification test of instrumental variables. The resulting Hansen test statistics failed to reject the null hypothesis and the instrumental variable setting in this chapter passed over identification test.

Second-stage Results

Table 5.4 shows the second-stage estimates predicting health outcomes. Physician expenditure has a positive and significant effect on both objective and subjective health measurements. The elasticity of physician expenditure on health outcome is 0.31 for the objective measure (EQ-5D) and 0.28 for self-rated health scale. The elasticity of 0.31 indicates that a 10% increase in physician services expenditures will improve quality of life by 3.1%. Age has a large negative effect on health outcomes. Men have slightly better health status than women. The ethnic minority variables including Hispanic, African American and other racial ethnicities all exhibit a positive relationship to objective measurement. While this pattern seems puzzling, it must be remembered that these race/ethnicity effects are adjust for differences in physician expenditures. And as the results in Table 5.3 indicate, racial and ethnic minorities have substantially lower physician expenditures than do Caucasians.

Those who reported own a house have better health outcomes comparing to individuals reported renting a house or with other house arrangements. Individuals with relatively higher family income have better health outcomes. All chronic disease conditions have significant negative effects on health outcomes.

Do the returns to medical expenditures vary by age group? To investigate this issue, I estimated separate two-stage least squares models for each age group and health outcome measure. The results are presented in Table 5.5. Using the EuroQoL, the objective health measure, the elasticity of medical expenditure on health is 0.43 for middle age group ($p < 0.10$).

However, I find no statistically significant effect of expenditures on health for younger or older subjects. In contrast, a different pattern emerges using the rating scale, the subjective measure. In this case, both middle-age group and senior group show a positive and highly significant relationship between physician services expenditures and health, with the effect strongest for the senior group.

The first-stage equation is over-identified and the F value for the instruments is 10.96. Previously, first stage F$>$10 is used as a conservative rule of thumb in determining overidentification restriction of first-stage equation in 2sls analysis (Staiger and Stock 1997). Later on, new methods were introduced to evaluate the efficiency of the instrumental variables by measuring the relative bias of 2sls coefficients comparing to the bias of OLS regression (Stock and Yogo 2002). According to the their standards, in 2 instrumental variables case, to yield relative bias less than 15%, the Cragg-Donald Wald F statistics (Cragg and Donald 1993) needs to be be greater than 11.59, and the statistics in the regressions are 14.70, which are greater than the critical value. In addition, I performed an overidentification test of the instruments. The resulting Hansen J statistic tests the hypothesis that the first stage is overidentified. The Hansen J test chi-square p value is 0.63 in the EQ-5D regression and 0.32 in the rating scale regression, each of which fails to reject the hypothesis of overidentification.

Table 5.1: Summary Statistics: Physician Services Expenditure

	Mean	Std.Dev
Health measures		
Quality of life scale (EuroQoL-EQ-5D)	0.81	0.21
Self health rating scale (RATESCALE)	0.79	0.17
Dr Services Exp in 2003 dollars	$746.28	$1637.21
Age	48.76	17.5
Male	0.40	0.49
Married	0.55	0.50
Race		
White, non-Hispanic	0.69	0.46
African American, non-Hispanic	0.12	0.32
Other races, non-Hispanic	0.04	0.20
Hispanic	0.15	0.36
Years of schooling		
Less than 9 years	0.09	0.28
9-11 years	0.13	0.34
12 years	0.32	0.47
13-15 years	0.22	0.41
16 years or more	0.24	0.43
Health insurance		
Private Non HMO	0.33	0.47
Private HMO	0.29	0.45
Medicaid Non HMO	0.05	0.22
Medicaid HMO	0.04	0.20
Medicare	0.20	0.40
Uninsured	0.09	0.28
Unemployed	0.32	0.47
Annual family income in 2003 dollars	$58644.06	$47247.1
House Ownership		
Own	0.69	0.46
Rent	0.26	0.44
Other arrangement	0.04	0.20
US region		
Northeast	0.17	0.37
West	0.23	0.42
Midwest	0.23	0.42
South	0.38	0.48
Living in MSA	0.77	0.42
Body Weight Categories		
Underweight BMI<18.5	0.02	0.13
Normalweight 18.5<=BMI<25	0.35	0.48
Overweight 25<=BMI<30	0.36	0.48

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Summary Statistics – Continued

	Mean	Std.Dev
Obesity 30<=BMI<40	0.24	0.43
Morbidly Obesity BMI>=40	0.04	0.19
Risk Preference Variable		
Seatbelt=1 if always wearing seat belt	0.80	0.40
Health Resource Variable		
Dr Number per 1000 population	2.74	1.90
Year		
2000	0.17	0.38
2001	0.26	0.44
2002	0.31	0.46
2003	0.26	0.44
Main Disease Categories		
Diabetes	0.09	0.29
Hypertension	0.25	0.43
Lipid metabolism disorders	0.13	0.34
Anxiety disorders	0.08	0.28
Acute myocardial infarction	0.01	0.09
Congestive heart failure	0.01	0.09
Cerebrovascular disease	0.01	0.10
Peripheral vascular disease	0.00	0.05
Atherosclerosis	0.02	0.13
Chronic obstructive pulmonary disease	0.06	0.24
Asthma	0.05	0.22
Osteoarthritis	0.01	0.11
Osteoporosis	0.02	0.16
Affective disorders	0.01	0.11
Migraine	0.07	0.25

Table 5.2: Ordinary Least Squares Analysis

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Dr Services expenses in 2003 dollars, natural logarithm	-0.04	***	-0.02	***
Age, natural logarithm	-0.11	***	-0.06	***
Male	-0.02	***	-0.02	***
Married	0.01	***	0.01	**
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	-0.02	*	0.00	
Other races, non-Hispanic	0.00		-0.03	***
Hispanic	0.03	***	0.01	***
Years of schooling				
Less than 9 years	-0.07	***	-0.08	***
9-11 years	-0.05	***	-0.03	***
12 years	Reference		Reference	
13-15 years	0.03	***	0.02	***
16 years or more	0.07	***	0.03	***
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	0.00		0.00	
Medicaid Non HMO	-0.18	***	-0.13	***
Medicaid HMO	-0.17	***	-0.11	***
Medicare	0.00		-0.01	
Uninsured	-0.08	***	-0.05	***
Unemployed	-0.08	***	-0.06	***
Family Income	0.02	***	0.02	***
House Ownership				
Own	Reference		Reference	
Rent	-0.02	***	-0.02	***
Other arrangement	-0.02		-0.04	***
US region				
Northeast	Reference		Reference	
West	-0.01	*	-0.01	***
Midwest	-0.01		0.00	
South	-0.02	***	-0.01	**
Living in MSA	0.02	***	0.01	***
Body Weight Categories				
Underweight BMI<18.5	-0.10	***	-0.06	***
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	-0.02	***	0.00	
Obesity 30<=BMI<40	-0.05	***	-0.04	***

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OLS – Continued

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Morbidly Obesity BMI>=40	-0.15	***	-0.09	***
Year				
2000	Reference		Reference	
2001	0.02	***	0.03	***
2002	0.03	***	0.04	***
2003	0.03	***	0.04	***
Main Disease Categories				
Diabetes	-0.07	***	-0.08	***
Hypertension	-0.01	*	-0.02	***
Lipid metabolism disorders	0.01	*	0.00	
Anxiety disorders	-0.14	***	-0.07	***
Acute myocardial infarction	-0.10	***	-0.09	***
Congestive heart failure	-0.16	***	-0.19	***
Cerebrovascular disease	-0.18	***	-0.19	***
Peripheral vascular disease	-0.04		-0.06	**
Atherosclerosis	-0.06	*	-0.07	***
Chronic obstructive pulmonary disease	-0.04	***	-0.05	***
Asthma	-0.08	***	-0.05	***
Osteoarthritis	-0.16	***	-0.06	***
Osteoporosis	-0.07	***	-0.01	
Affective disorders	-0.25	***	-0.16	***
Migraine	-0.09	***	-0.05	***
Constant	0.42	***	0.15	***
R-squared	0.15		0.20	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 5.3: Two-stage Least Squares: First Stage

	Physician Services Expenditures in 2003 $ natural log	
	Coeff.	Sig.
Age, natural logarithm	0.37	***
Male	-0.20	***
Married	0.07	***
Race		
White, non-Hispanic	Reference	
African American, non-Hispanic	-0.19	***
Other races, non-Hispanic	-0.11	***
Hispanic	-0.20	***
Years of schooling		
Less than 9 years	-0.16	***
9-11 years	-0.06	***
12 years	Reference	
13-15 years	0.02	
16 years or more	0.13	***
Health insurance		
Private Non HMO	Reference	
Private HMO	-0.08	***
Medicaid Non HMO	0.27	***
Medicaid HMO	0.15	***
Medicare	0.16	***
Uninsured	-0.34	***
Unemployed	0.18	***
Family Income	0.01	
House ownership		
Own	Reference	
Rent	0.00	
Other arrangement	0.07	*
US region		
Northeast	Reference	
West	0.09	***
Midwest	0.05	**
South	0.00	
Living in MSA	0.03	*
Body Weight Categories		
Underweight BMI<18.5	-0.04	
Normalweight 18.5<=BMI<25	Reference	
Overweight 25<=BMI<30	0.03	**
Obesity 30<=BMI<40	0.10	***
Morbidly Obesity BMI>=40	0.13	***

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2sls First Stage – Continued

	Physician Services Expenditures in 2003 $ natural log	
	Coeff.	Sig.
Year		
2000	Reference	
2001	0.05	***
2002	-0.01	
2003	-0.03	
Disease Categories		
Diabetes	0.33	***
Hypertension	0.12	***
Lipid metabolism disorders	0.14	***
Anxiety disorders	0.28	***
Acute myocardial infarction	0.48	***
Congestive heart failure	0.25	***
Cerebrovascular disease	0.29	***
Peripheral vascular disease	0.31	***
Atherosclerosis	0.38	***
Chronic obstructive pulmonary disease	0.14	***
Asthma	0.23	***
Osteoarthritis	0.32	***
Osteoporosis	0.23	***
Affective disorders	0.40	***
Migraine	0.22	***
IV		
Seatbelt	0.07	***
log(# of drs per 1000 popu)	0.03	**
Constant	3.97	***
R-squared	0.12	

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 5.4: Two-stage Least Squares: Second Stage

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
lndrexp	0.31	***	0.28	***
Age, natural logarithm	-0.25	***	-0.18	***
Male	0.06	***	0.05	***
Married	-0.01		-0.02	**
Race				
White, non-Hispanic	Reference		Reference	
African American, non-Hispanic	0.05	**	0.06	***
Other races, non-Hispanic	0.03	*	0.01	
Hispanic	0.09	***	0.07	***
Years of schooling				
Less than 9 years	-0.01		-0.04	**
9-11 years	-0.03	*	-0.01	
12 years	Reference		Reference	
13-15 years	0.02	***	0.01	
16 years or more	0.02		-0.01	
Health insurance				
Private Non HMO	Reference		Reference	
Private HMO	0.03	***	0.02	***
Medicaid Non HMO	-0.27	***	-0.21	***
Medicaid HMO	-0.22	***	-0.16	***
Medicare	-0.06	***	-0.06	***
Uninsured	0.04		0.05	*
Unemployed	-0.15	***	-0.12	***
Family Income	0.02	***	0.01	***
House Ownership				
Own	Reference		Reference	
Rent	-0.02	**	-0.02	***
Other arrangement	-0.04	**	-0.06	***
US region				
Northeast	Reference		Reference	
West	-0.04	***	-0.04	***
Midwest	-0.02	*	-0.01	
South	-0.02	**	-0.01	
Living in MSA	0.00		-0.01	
Body Weight Categories				
Underweight BMI<18.5	-0.08	***	-0.05	**
Normalweight 18.5<=BMI<25	Reference		Reference	
Overweight 25<=BMI<30	-0.03	***	-0.01	
Obesity 30<=BMI<40	-0.09	***	-0.07	***
Morbidly Obesity BMI>=40	-0.19	***	-0.12	***

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2sls Second Stage – Continued

	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Year				
2000	Reference		Reference	
2001	0.00		0.02	**
2002	0.03	***	0.04	***
2003	0.03	***	0.05	***
Main Disease Categories				
Diabetes	-0.19	***	-0.18	***
Hypertension	-0.06	***	-0.06	***
Lipid metabolism disorders	-0.03	**	-0.04	***
Anxiety disorders	-0.24	***	-0.16	***
Acute myocardial infarction	-0.27	***	-0.23	***
Congestive heart failure	-0.25	***	-0.26	***
Cerebrovascular disease	-0.28	***	-0.28	***
Peripheral vascular disease	-0.15	**	-0.16	***
Atherosclerosis	-0.19	***	-0.18	***
Chronic obstructive pulmonary disease	-0.09	***	-0.09	***
Asthma	-0.16	***	-0.12	***
Osteoarthritis	-0.27	***	-0.16	***
Osteoporosis	-0.15	***	-0.08	***
Affective disorders	-0.39	***	-0.28	***
Migraine	-0.17	***	-0.12	***
Constant	-0.98	**	-1.06	***

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Table 5.5: Age Group Results

	Two-stage Least Squares			
	ln(EuroQoL)		ln(Ratescale)	
	Coeff.	Sig.	Coeff.	Sig.
Dr Serv Exp 2003 dollars				
Entire sample	0.31	***	0.28	***
By age group				
Less than or equal to 45 years old	0.01		0.06	
46 to 64 years old	0.43	*	0.30	*
Greater than 64 years old	0.66		0.63	*

*** : Significant at the 1% level, **: Significant at the 5%, *: Significant at the 10% level.

Explanatory variables also include gender, marital status, races, years of schooling, health insurance, employment status, house ownership status, annual family income in natural logarithm, US region, living in MSA, body weight, survey year and current diseases (diabetes, hypertension, hyperlipidemia, acute myocardial infarction, congestive heart failure, cardiovascular disease, peripheral vascular disease, atherosclerosis, chronic obstructive pulmonary disease, asthma, osteoarthritis, osteoporosis, anxiety disease, affective disorder, and migraine).

5.4 Discussion

This chapter is an empirical attempt to test the health investment model and provide estimates of the value of physician services expenditures using broader health measures than found in prior studies. Using a nationally representative database, I explored the returns to physician expenditures considering both subjective and objective general measures of health. The objective measure, the EQ-5D, incorporates multi-dimensional health domains. The subjective health outcome - a self-assessed rating scale– reflects individuals' perceptions of their overall health status.

By applying the two-stage least squares technique with valid instrumental variables, I was able to estimate the elasticity of physician expenditure on health outcome for a general population. The results suggest that the elasticity of physician services expenditure on health is around 0.30, captured by EuroQoL measure. I also performed further analysis on different age groups, which led to some intriguing results. In particular, while the middle-age group population gains the highest returns to physician services expenditures in terms of improving objective health, seniors yield the highest return on physician services expense for the subjective measure of health.

Thus we see that the health returns to physician services expenditure vary by age and by whether the health measure is subjective or objective. When an objective measure was used, middle-aged individuals gained highest health benefit from medical expenditures. However, physician services expenditure strongly increased self-assessed health status among senior subjects. These results suggest that while the middle-age group gained health benefit captured by objective health returns , the senior population may enjoy higher perceived benefits from physician services expenditures.

Chapter 6

Conclusion

Economic literature has captured health as a special form of human capital, with medical care as important elements of input. Given the assumption that age depreciation increases with age, implications have been derived that demand for health will decrease and medical expenditures will increase with age. Empirical studies showed seemingly contradictory evidences. While the cost-effectiveness has been justified for increased medical spending due to technology advancement, there is large geographical disparities considering per-capita medical expenditures across the United States. This study aims to quantitatively investigate the relationship between medical expenditures, medial expenditure components and health outcome measures for general population. Two-stage least squares technics are used to control for endogeneity issue (eg., sick people spend more).

In the first step of examining relationship between overall medical expenditure and health outcome issue, I find that the patterns of cost-outcome correlations vary across age groups. It also depends on the type of health measure I use (objective health measure: Health Related Quality of Life - EQ-5D or subjective health measure: ratescale). Using the objective measure, the returns to medical expenditure are greatest for the middle-aged group (46 to 64 years of age). However, using the subjective measure, I find that the perceived returns to

health are greatest for seniors ($>$ 64 years of age). If objective health measures provide better evidence of actual gains in health, these findings suggest that reallocation of spending from seniors towards middle-aged cohorts can improve overall health without affecting expenditures. Given the strong perceived benefit for medical expenditures among seniors, however, such a reallocation may meet with considerable resistance. As a result, it is very important to further examine the cost-outcome correlation for medical expenditure components to better understand the health benefit source for different age groups.

Health Benefit to pharmaceutical expenditure and physician office visits expenditure is also studied using similar methodology. I find that the elasticity of prescription drug utilization (number of prescriptions) is 0.22, which means one more prescription is associated with about a 2% increase in health. However, the returns to prescription drug expenditures and utilization differ by age group. Using the objective measure, the overall returns to pharmaceutical expenditure/utilization are greater for the younger population (18 to 45 years of age) and middle-aged group (46 to 64 years of age). In contrast, there is no statistically significant health benefit from prescription drug expenditures for seniors ($>$ 64 years of age). The period of this study was before the Medicare Part D plan was implemented. Drug compliance among seniors may have been adversely affected by limited coverage during this period, which could account for this result.

The last chapter examines the health benefits from medical expenditure on physician services. I empirically estimate the health returns to physician services spending considering both objective health-related quality of life measure (EuroQoL) and self-rated health scales. I find the elasticity of physician service spending on health is approximately 30% using EuroQoL measure. I further examine the returns to expenditure on physician services vary across age groups. The results show that senior group gain highest returns when using subjective health measure. The results suggest that senior patients may have higher perceived health

benefit from office-based visits, where the type of care is “face-to-face” contact. These findings could inform public policies designed to more closely match specific types of care with those groups likely to benefit the most from them.

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