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An Analysis of ambulatory pediatric Medicaid costs in Montana: A cost function approach

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AN ANALYSIS OF AMBULATORY PEDIATRIC MEDICAID COSTS IN MONTANA

A Cost Function Approach

by

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An Analysis of Ambulatory Pediatric Medicaid Costs in Montana: A Cost Function Approach (102 pages)

Director: Kay Unger

The purpose of this paper is to provide detailed information on the nature of the medical care provided to young children receiving Medicaid in the state of Montana in 1994 and the cost of these services to government agencies. A cost function approach, using the translog functional form, is employed to estimate the costs of providing ambulatory Medicaid services to children from the ages of one to five using data obtained from the Montana/Wyoming Foundation for Medical Care. One output measure (patient visits) and seven broadly defined input categories (hospital outpatient departments, EPSDT providers, clinics, drugs, physicians, labs, and nurse specialists) are used to examine such issues as high and low cost counties, the marginal cost of an additional patient visit, economies of scale, and the substitution of inputs.

The results suggest that counties with significantly lower costs in 1994 than the base county, Beaverhead, were generally sparsely populated and/or had limited access to medical services. The significantly higher costs of one county, Big Horn, seem to be attributable to the high incidence of poverty in that county. There is some evidence that economies of scale exist in the provision of Medicaid services for young children. The results also indicate that many of the above inputs serve as substitutes for one another, including clinics and physicians, physicians and nurse specialists, clinics and nurse specialists, and drugs and labs. Contrary to many previously published studies, no evidence was found to support the hypothesis that young Medicaid patients in Montana substitute high-cost emergency and hospital outpatient services for physician's services.

ACKNOWLEDGMENTS

Looking back over the whole of my academic career, there are a number of people to whom I owe debts of gratitude. The faculty and staff of the Economics Department at The University of Montana have been instrumental in helping me to achieve my academic goals. There are a few people in the department, however, to whom I owe special thanks. Without the guidance of Dr. Kay Unger, I would not have pursued my graduate studies. She convinced me, that tired as I was of school, graduate school should be my next step. She has always been there to lend me assistance, and her kind words of encouragement meant a lot to me. Dr. Douglas Dalenberg, from whom I was lucky enough to have taken an inordinate amount of classes, was always available to patiently listen to all my questions and help me find the answers I needed. He also provided the technical support I needed in order to complete this project. To Becky Hofstad, I owe my thanks for her aid and friendship. Without being asked, she would unselfishly lend me a helping hand when I was particularly busy. She was always there when I needed someone to talk to, and my stint as a teaching assistant was made all the more pleasant because of her friendship. Finally, I would be remiss if I didn't mention my office mate, and friend, Michelle Gall. Having someone else to go through the process with made it all the more bearable. She listened to my problems and provided me with numerous instances of support and assistance. I will miss her.

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CHAPTER 1

INTRODUCTION

Ever since its inception in 1965, the Medicaid program has been subject to criticism and scrutiny. Escalating costs in the first years of the program brought it under attack with claims of inefficient administration, waste, and fraud. Over the years, this program has been modified to contain costs and prevent misuse, while still trying to serve the needs of America's poor. Now, once again, the Medicaid program is under assault. In 1996, the move towards achieving a balanced budget in Washington, as well as the cry for tax reform, tightened budgetary pressures and forced Congress to look for ways to reduce spending. Rapidly rising costs in the health care sector and increasing numbers of Medicaid and Medicare recipients led these programs to become major targets in budgetary reform agendas. States also joined in this movement for Medicaid reform and looked for ways to modify their existing programs.

Any policy aimed at reforming the Medicaid program needs to be built on a solid base of information. This study will provide a base line analysis of young children currently receiving Medicaid in the state of Montana. The results will give policy makers detailed information on the nature of the medical care provided and its cost to government agencies.

Specifically, this study estimates a cost function for ambulatory Medicaid services for children one to five years of age using 1994 data on Montana Medicaid patients. There are three reasons why the analysis has been restricted to children: (1) children are likely to comprise a more homogenous group than adults or senior citizens since self-imposed health problems, such as alcohol abuse or cigarette smoking, are not really a consideration in children, (2) children are the largest group of Medicaid recipients nationwide (50% of Medicaid recipients in 1994 were children), and (3) studies have shown that adequate health care for children is important for preventing poor health later in life. Children under the age of one were excluded from study because health problems encountered in the first year of life differ from those of older children (e.g., mortality is much higher for infants than for other children). School-age children were excluded to keep the data set at a manageable size and because exposure to childhood ailments, as well as peer pressure, may cause the health conditions of school-age children to differ from those of preschool children.[1]

This study will explore the total monthly costs of providing outpatient care in 1994 for young children in Montana, as well as the incremental cost of an additional pediatric ambulatory visit. High-cost and low-cost counties will be pinpointed, and the question of economies of scale in the production of Medicaid services will be examined. Another area of interest is the substitution of inputs in the provision of medical services. Is it possible, for example, to substitute less expensive health care providers for more costly providers? Numerous studies have suggested that Medicaid patients misuse expensive hospital outpatient and emergency room services (see Chapter Three), substituting it for less-expensive physician services. Is this true in Montana? Finally, one can show how changing

[1]The growing use of daycare and preschool programs has increased preschoolers' exposure to childhood ailments; however, since Montana's population is largely rural, it is assumed that for most areas of Montana this assumption is valid.

the price of medical care affects utilization and which types of care contribute most to program costs.

The results obtained by investigating such issues will guide policy makers in their efforts to contain Medicaid costs. If there are economies of scale in the provision of these services, it may be cost effective to increase the provision of services in some areas. It may be that smaller counties, with fewer patients, lack the ability to substitute lower-cost inputs such as nurse specialists[2] for physician services. Information on input substitution would allow policy makers to see how inputs are being used in the provision of Medicaid services and where changes might be made that could lower costs. The input shares can also provide valuable information. Policies to control costs would be most effective if targeted at those inputs that account for the largest share of costs.

Thesis Organization

The remainder of this paper is organized as follows. Chapter Two is a description of the Medicaid program, with sections discussing the Federal program in general and characteristics specific to the Montana Medicaid program. Chapter Three, consisting of four sections, contains a brief review of some of the previous work done in areas pertaining to this study. The first section deals with studies that have looked at the rising costs of the Medicaid program, and the second section reviews other Medicaid-related studies. Research dealing with ambulatory and pediatric care is examined in the third section, and in the final section the use of cost functions in the analysis of medical care is reviewed.

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[2]The term "nurse specialist" includes nurse practitioners and physician's assistants.

Chapter Four outlines the basic model used for the present research, the assumptions inherent in the use of the model, and the functional form used. Chapter Five describes the data used for this study and the specifics of the statistical model. The estimation procedures and the empirical results of the study are discussed in Chapter Six. The final chapter discusses shortcomings of the model and policy implications and provides suggestions for future research.

CHAPTER 2

MEDICAID

The Medicaid Program

Today's Medicaid program is generally perceived as having arisen out of the Johnson administration's War on Poverty and Great Society programs. Even before this era, however, steps were being taken to alleviate some of the burden of medical care expenses for the poor. In 1950 an amendment to the Social Security Act of 1935 provided federal matching funds to assist states in making medical payments to hospitals, physicians, and other providers of medical care who provided services to those on public assistance. By 1960, about forty percent of the states were participating in this program. Federal involvement was further expanded in 1960 with the passage of another amendment, commonly called the Kerr-Mills Act. This amendment increased federal matching funds, required coverage for specific services, and expanded coverage to include the "medically needy"[1] and the elderly who were not receiving cash assistance. By the end of 1965, all states were participating in this program to varying degrees (Davis and Rowland 1991).

The Medicaid program was essentially a replacement for the Kerr-Mills Act. Medicaid was enacted in 1965 as Title XIX of the Social Security Act under P.L.

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[1]The "medically needy" are defined as those persons who meet categorical requirements for Medicaid eligibility and whose income, after medical expenses, is less than the state's "medically needy" income standard.

74-271, the Social Security Amendments of 1965, and was signed into law on July 30, 1965. Federal matching funds were further increased, and states were required to cover everyone eligible for cash assistance, with the option to cover all the medically needy (Davis and Rowland 1991).

The Medicaid program is a joint federal-state program. The states administer the program and provide medical benefits to low-income individuals who meet certain categorical criteria. These are generally people whose economic status is seen as largely beyond their control (dependent children, the aged, and the blind and disabled). The federal government provides matching funds for state payments according to a formula that varies inversely with the state's per capita income. The federal government also requires mandatory coverage for certain groups and services, with the states having discretion to cover other optional groups of individuals and services.

The high incidence of health problems among low income children has been a major motivation behind the Medicaid program. A 1967 study conducted by the Department of Health, Education, and Welfare (HEW) revealed that 20% to 40% of low-income children suffered from one or more chronic conditions, and that only 40% of these conditions were being treated. Another HEW study found that many of the health problems of low-income eighteen-year-olds rejected for Selective Service could have been prevented or corrected if they had received earlier treatment. Thirty-three percent of the detected health problems could have been prevented or corrected if these children had received treatment before age 9 and sixty-two percent if treatment had been received before age 15 (Davis and Schoen 1978). Starfield (1982) found a variety of health problems to be more common among low-income children, such as low birth weight, iron deficiency anemia, lead poisoning, hearing disorders, and functionally poor vision. She also found that low-income children are more likely to be admitted to a hospital, have more restricted activity days, and miss more school due to illness.

Additional research centering on the issue of children's health care helped bring this issue to the attention of Congress. Studies showed that children were more likely to be uninsured than adults, and that Medicaid failed to reach over half of the children in poverty (Burwell and Rymer 1981, Butler et al 1985). Other studies concluded that the absence of health insurance coverage, as well as low incomes, led to lower utilization of health care services, especially preventive care (Davis and Rowland 1983; Freeman et al 1987). A 1981 study by Kleinman, Gold and Makuc, using National Health Interview Survey data for the years 1976 to 1978, found that after adjusting for health status, of those children with fair or poor health, poor children had 47% fewer visits to physicians than children in high-income families. For children in good or excellent health, low-income children had 29% fewer physician visits than high-income children. In 1984 Congress began to respond to the concern over infant mortality and the health problems of low-income children by expanding the coverage available to pregnant women and children. Between 1984 and 1990, Congress amended Medicaid seven times to expand coverage for these individuals.[2]

Eligibility requirements for Medicaid primarily follow those of welfare assistance. States are required to extend medical coverage to all recipients of Aid to Families with Dependent Children (AFDC) and to most of the elderly and disabled who receive Supplemental Security Income (SSI). States are also

[2]For a summary of Medicaid program changes since 1984 see Feder et al (1993).

required to extend coverage to families in which the principal wage earner is unemployed, though such coverage is only required for six months. Pregnant women, whose children will be covered by AFDC when born, are also eligible for Medicaid.

Certain categories of individuals not receiving cash assistance are also covered. These include, but are not limited to, the following: (1) qualified members of families with unemployed parents who do not receive AFDC payments for a full twelve months, but meet other AFDC requirements, (2) work-related transitional Medicaid beneficiaries, (3) poverty level children under age six whose family income does not exceed 133% of the federal poverty level (FPL), and (4) those children between the ages of six and nineteen whose family income does not exceed 100% of the FPL. Mandatory services include, but are not limited to, inpatient hospital services, outpatient hospital services, physician services, laboratory and x-ray services, early and periodic screening, diagnostic, and treatment (EPSDT) services for children under age 21, and medical and surgical dental services. Some of the optional services that states may cover include clinic services, optometrist services and eyeglasses, and prescribed drugs (U.S. Department of Health and Human Services 1993).

Characteristics of the Montana Medicaid Program

Medicaid is a joint federal-state program, with most of the administration left up to the states. The federal government sets minimum eligibility and service standards, giving the states the option of covering other specified groups of individuals and additional services. The characteristics of the Montana Medicaid program outlined here are those concerned with the eligibility of, and services available to, children. These Montana characteristics are fully described in Montana Department of Social and Rehabilitation Services 1994 and U.S. Department of Health and Human Services 1992.

Montana's Medicaid program seems to be neither extremely conservative nor extremely liberal. Montana requires those recipients over the age of 21, not pregnant, and not living in a nursing home to provide co-payments for many services. These co-payments range from $.50 to $2.00 for each service performed during a visit. There is a limit on the maximum co-payment per household set at $200 per year.

All states are required to have EPSDT services. In Montana, this program is called KIDS COUNT. This program provides for periodic health screening as well as immunizations as required. No co-payment is charged for this service.

To date, Congress has mandated coverage of pregnant women and children up to the age of six whose family income does not exceed 133% of the FPL, and poverty level children between the ages of six and nineteen whose family income does not exceed 100% of the FPL. States are given the options of covering pregnant women and infants up to 185% of the FPL, and all children under ages 18-21 who meet state AFDC income standards. Montana has not elected to cover these optional groups. Children under the age of 21 are covered if under institutional or subsidized care or if classified as medically needy. Some of the optional services that Montana covers (with limits) are as follows: podiatrists, optometrists, psychologists, medical social workers, physical therapy, occupational therapy, certain clinic services such as maternal and child health, dental services, and prescription drugs.

In an effort to control costs, in January 1993 Montana implemented a primary care case management program called PASSPORT TO HEALTH (PASSPORT). In counties where there are enough health care providers willing to participate, most Medicaid recipients must enroll in this program. Enrollees choose, or are assigned, a primary care provider who must approve services provided by other medical providers before Medicaid will pay for these services. Twenty-four of Montana's 56 counties were involved in this program by the end of 1994, including Broadwater, Carbon, Cascade, Custer, Daniels, Dawson, Deer Lodge, Flathead, Gallatin, Hill, Jefferson, Lake, Lewis and Clark, Missoula, Park, Powell, Ravalli, Richland, Roosevelt, Sheridan, Silver Bow, Stillwater, Sweet Grass, and Yellowstone counties.[3] As of June 30, 1993, there were 13,000 enrollees in the PASSPORT program.[4] In 1993, total enrollment in the Montana Medicaid program was 89,000 persons (U.S. Department of Health and Human Services 1993).

[3]By 1996, all counties in Montana, with the exception of Fergus and Lewistown, were participating in the PASSPORT program.
[4]An evaluation of the PASSPORT program was not undertaken at the time of this study.

CHAPTER 3

LITERATURE REVIEW

This chapter will review existing research on Medicaid costs, access to care and other Medicaid policy issues, children's health care, and the use of cost functions in analyzing health care issues.

Medicaid Costs

Much of the criticism aimed at Medicaid since its inception in 1965 has centered on the rapidly rising costs of the program. Feder et al (1993) investigated some of the causes of the rapid increase in Medicaid costs from 1988 to 1991. During that period, Medicaid expenditures grew from $51.6 billion to $88.6 billion. Feder et al found that 34.1% of the Medicaid expenditure growth during that time could be attributed to expansions in enrollment, 31% to general medical price inflation,[1] and 28.4 % to increases in expenditures per beneficiary above inflation.[2]

Enrollment growth was found to be due to federal legislation mandating expansion in the coverage for pregnant women, children, and low-income elderly

[1]Health spending increased 13.2% in 1991 and 14% in 1992. Price increases for inpatient hospital services and nursing homes contributed the most to cost increases, 8% and 7.8% respectively. This reflects the fact that these services account for more than half of total Medicaid expenditures, even though average annual price growth was slower than for most other medical services. Prescription drugs had the highest rate of price growth (9.4%), but contributed the least to cost increases because of their small share in Medicaid expenditures. Ambulatory care accounted for 4.5% of expenditure increases (Feder et al 1993).

[2]Sources of this cost factor include greater demand for services, higher provider payments, and increased efforts by the states to obtain more matching federal funds.

individuals, as well as increased enrollment of traditional recipients caused by the economic recession of the period. During this time, enrollment in Medicaid grew from 22.2 million beneficiaries in 1988 to 27 million in 1991. These 4.8 million new enrollees consisted of 2.6 million newly covered women and children who became eligible because of the new federal mandates, 1.4 million traditional recipients, 200,000 elderly, and 600,000 disabled enrollees. The costs of care, however, are disproportionately attributable to long-term care for young disabled and elderly beneficiaries. According to Families USA 1995, dependent children under the age of 21 made up 50% of the beneficiaries but accounted for only 15% of the total expenditures in 1994. On the other hand, the elderly made up 12% of Medicaid beneficiaries but accounted for 28% of the costs, while the blind and disabled comprised 15% of recipients and accounted for 31% of the costs. Disproportionate Share Hospitals (DSH)[3] accounted for 12% of Medicaid costs (see Figure 1).

In a similar study Wade and Berg (1995) found that increased Medicaid enrollment, Federal and State Medicaid policy changes, and the prevalence of AIDS all were significantly related to Medicaid expenditure growth for the period 1984 to 1992. They used cross-sectional time series data from 49 states and the District of Columbia to analyze the growth in Medicaid expenditures for this period. Using two stage least squares (2SLS) and fixed-state effects, Wade and Berg estimated separate models for adults, children, the blind and disabled, and the elderly. Medicaid enrollment was treated as an endogenous variable

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[3]Disproportionate Share Hospitals are hospitals that serve a higher than average number of Medicaid and other low-income patients. These hospitals are reimbursed differently than other hospitals.

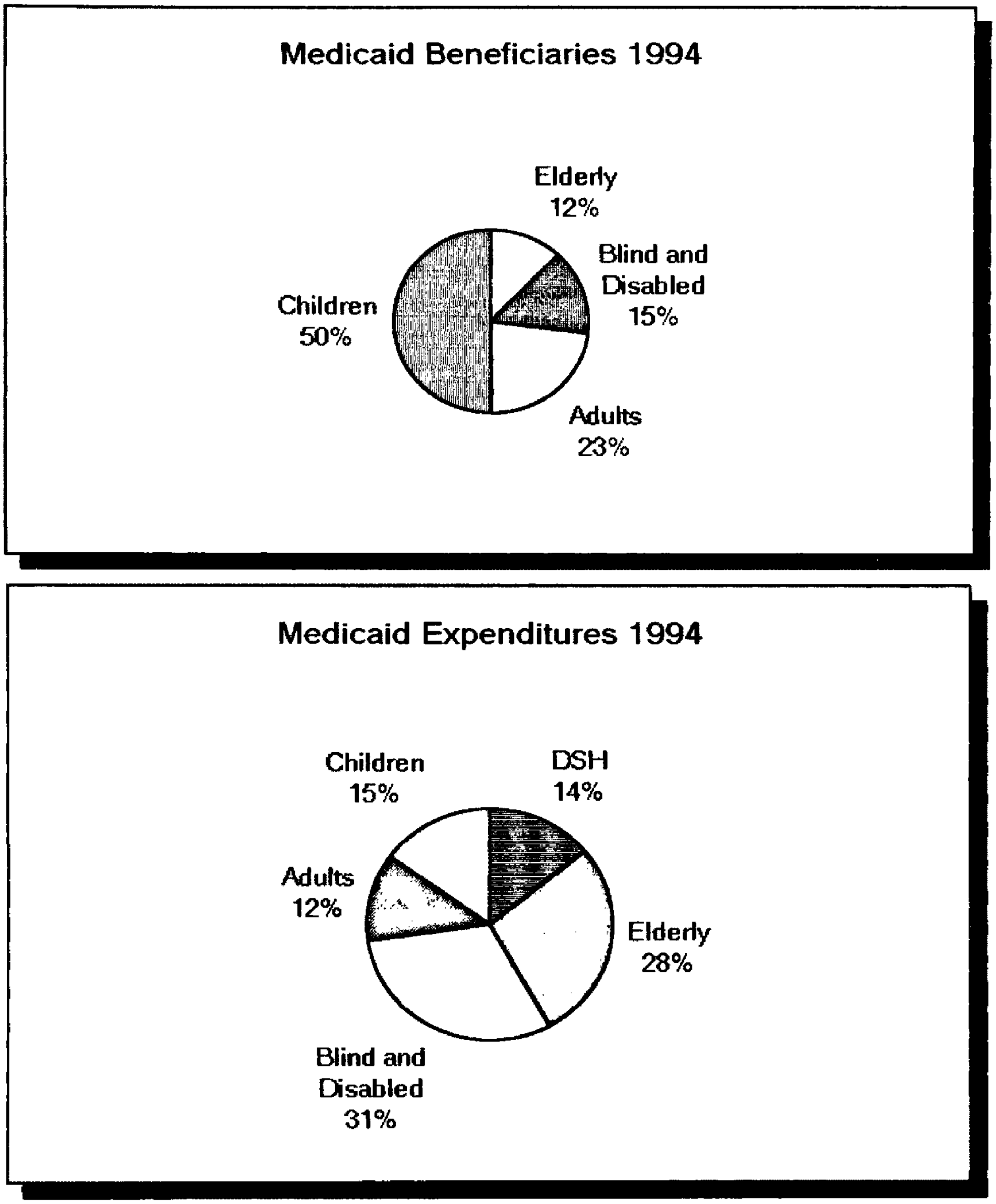

Figure 1. Percent of recipients and expenditures by type
Source: Families USA, 1995.

(simultaneously determined with expenditure levels). They found the estimated coefficients to be consistent with other studies indicating that adults are more expensive than children, and that the elderly, blind and disabled are significantly more expensive than other groups of individuals. Such results may suggest that the "cheapest" way of improving health care might well be to improve the health care of children.

Other Medicaid-related Studies

Many studies of Medicaid have analyzed physician participation, patient utilization, access to care, and other issues involving the effects of reimbursement policies on the utilization and costs of Medicaid services. Though individuals enrolled in Medicaid may obtain ambulatory care from physician's offices, clinics, or hospital outpatient clinics, not all health care providers will accept Medicaid patients. In *Medicaid and Pediatric Primary Care,* Perloff et al (1987) studied the Medicaid participation decisions of pediatricians. Using a survey of 800 office-based, non-federal pediatricians, they examined three different decisions regarding Medicaid at both the individual pediatrician and the state level for the years 1978 and 1983. The decisions included whether to accept or not accept Medicaid patients (PARTICIPATION), the proportion of a physician's practice devoted to Medicaid patients (EXTENT), and whether acceptance was limited or all Medicaid recipients were accepted (FULL). Independent variables included personal characteristics of the physician, service characteristics such as per capita income and the physician/population ratio, and policy variables such as the ratio of Medicaid to normal fees (reimbursement), the amount of time between billing and reimbursement, and the Revised Medicaid Program Index (RMPI).[4]

The results showed that participating physicians were more likely to be older and less likely to be board certified than non-participants. Neither per capita income nor size of the Medicaid population affected the participation decision, but the physician/population ratio did have a significant negative association with this decision. Lower Medicaid reimbursement rates and less favorable policies also affected the participation decision.

When looking at EXTENT, all the policy variables were significantly related to the percentage of Medicaid patients seen. The time lag between billing and reimbursement was negatively associated with EXTENT, while the RMPI and reimbursement rate were both positively associated with EXTENT. It was also found that the higher the Medicaid eligible population, the greater the extent of participation, and that the higher the physician/population ratio, the lower the extent. Concerning the decision about whether to limit acceptance of Medicaid patients or accept all patients, both the reimbursement rate and RMPI were found to be positively and significantly correlated to FULL.

Adams (1995) examined a 1986 change in Medicaid fees for selected obstetricians and pediatricians in Tennessee that was aimed explicitly at increasing physician participation. She examined two related issues in this study: Whether an increase in Medicaid physician fees was associated with increased utilization by enrollees, and whether there was an association between increased physician participation and service use. Monthly county panel data using

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[4]This is an index consisting of reimbursement procedures, number of optional services, service limitations, and other kinds of program characteristics.

Medicaid Tape-to-Tape data for 1985 to 1988 were used to examine visits per enrollee, physician participation, and caseloads.[5]

Adams found that a 10% increase in the relative fee index of Medicaid fees to Medicare fees was associated with a 2.5% increase in the number of participating physicians and a 1% increase in caseload. Urban and rural counties were affected differently; a 10% increase in the relative fee index was associated with a 3.5% increase in the number of participating physicians in urban counties, but only a 2.5% increase in rural counties.

The number of enrollees/population was positively related to all three dependent variables (enrollee visits, physician participation, and caseload) with a 10% increase in this ratio being associated with increases of 5%, 9%, and 5%, respectively. Again differences were observed between rural and urban areas with a 10% increase in enrollment/population being associated with an increase in the number of participating physicians in urban counties by 11%, but only 2% in rural areas. Adams concluded by noting that higher payments to providers were more strongly correlated to the participation decision than to service utilization.

Several studies examined the utilization of hospital outpatient[6] services by Medicaid patients. Kleinman (1981), for example, found that the poor were 11% more likely to use hospital outpatient services (rather than a physician's office) than the non-poor. In their study of emergency room misuse Nelson et al (1979)

[5]Panel data is a type of pooled data "in which the same cross-sectional unit is surveyed over time." (Gujarati 1988)

[6]For the purposes of this study, unless otherwise stated, the term "hospital outpatient" is used to refer to the provision of medical services in a hospital outpatient department or an emergency room. The provider codes in the original data file utilized for this study does not differentiate between these two types of services. Most authors cited in the literature review do not differentiate between these services either. Clinics refer to free-standing clinics not associated with a hospital. Physician care refers to care obtained through a private physician's office.

concluded that Medicaid patients had a greater tendency than non-Medicaid patients to use emergency room facilities inappropriately, with 64% of unnecessary visits attributed to Medicaid patients.

Fossett, Choi, and Peterson (1991) examined the relationship between hospital outpatient services, office-based physician services, and Medicaid physician fees. Data used in the study includes county level Medicaid claims data for the State of Illinois for 1985. Maximum likelihood estimation using Linear Structural Relations (LISREL)[7] was employed to estimate a system of equations consisting of three endogenous variables (sites of care), and five exogenous variables (Medicaid demand variables, provider supply, and prevailing primary physician charges). Since hospital outpatient departments, physician's offices, and clinics may be substitutes for each other, the levels of care for two of the sites were used as independent variables in the equations explaining use for the remaining site. Fossett et al concluded that hospital outpatient care and physician primary care are not substitutes, but rather that the relationship between outpatient care and physician care was positive and significant. They also found little evidence that fees influenced patient utilization. For rural Medicaid patients, hospital outpatient care was found to be a major source of care. These patients were found to travel to hospital outpatient departments outside of their home county to obtain care. Fossett et al suggested that this could be attributable to a lack of specialty services in their home counties,

[7]LISREL is a "path analysis technique that estimates the relationships between variables simultaneously rather than estimating separate equations for each dependent variable." (Fossett et al 1991)

especially for elderly SSI clients with chronic health problems whom Fossett et al felt constituted a large percentage of the rural Medicaid population.

Cohen (1989) also looked at the substitution of hospital outpatient care for physician care by Medicaid recipients. He used ordinary least squares (OLS) regression to examine the effect of physician reimbursement policies, as well as utilization control policies, on utilization patterns and expenditures. Data for the years 1980-1984 were obtained from HCFA 2082, an annual report submitted by the states to the Health Care Financing Administration (HCFA). With respect to expenditures, Cohen's results indicated that higher physician fee ratios (Medicaid reimbursement/Medicare reimbursement) were positively associated with spending for physician services per Medicaid recipient, with elasticities ranging from 0.60 to 0.80. Cohen also found evidence that physician fee ratios affected physician participation in the Medicaid program. In the short run, lower physician fee ratios were associated with a reduction in access to care, although the elasticity (0.25) was smaller in magnitude than that for expenditures. Regarding substitution of hospital outpatient care for physician services, Cohen found the hospital outpatient regressions to indicate that when physician fee ratios were low more hospital outpatient care was utilized. The results indicated that a 1 percent decrease in the physician fee ratio was associated with a 0.34 percent increase in the number of hospital outpatient recipients. This is an indication that attempts to cut costs by lowering reimbursements to physicians may have the unintended effect of increasing use of higher cost facilities.

Miller (1988) examined the role of substitutes in Medicaid acute care services within the context of policy analysis. He asserted that the amount of medical service rendered and the cost of that service are outcomes of the medical care market. The purpose of his study was to explain the amount of medical care service provided to those on Medicaid and to highlight the impact of substitutes or complements in care on policy outcomes. He employed a model where the quantity of medical services provided was a function of the supply of medical services, the demand for medical services, market conditions, policy decisions, and substitutable or complementary services (other sites of care). Miller utilized four interrelated acute care services as his dependent variables: inpatient, physician, hospital outpatient, and clinic services, with the state as the unit of analysis. Data were obtained from a number of sources including HCFA 2082 State Medicaid Data tapes and American Hospital Association (AHA) hospital statistics. Using fifty cross-sectional observations (49 states and the District of Columbia)[8] for the years 1982 to 1984 and 2SLS, a system of four simultaneous equations was estimated, one for type of acute care service.[9]

Miller concluded that physician, hospital outpatient, and clinic services all complemented inpatient services, and that hospital outpatient and physician care served as substitutes. The supply of physicians was found to have a significant, positive association with the number of inpatient, physician, and hospital outpatient recipients. The medical care price index (MCPI), which was used as a market condition variable, had a significant, negative association with the number of physician care recipients. The demand variables (AFDC recipients, SSI recipients, and population below the poverty line minus AFDC recipients) were significantly correlated with the number of inpatient, physician and hospital

[8]Arizona was dropped because it began a fully capitated Medicaid program during this time.
[9]2SLS is used to estimate this system of equations since the other three service settings appear as determinants in each equation.

outpatient recipients, though not always in the expected direction. The number of AFDC enrollees was positively related to the number of hospital care recipients, while the number of persons below the Federal Poverty Level (FPL), when significant, was always negatively correlated with the number of hospital recipients.[10] The correlation between the policy variables and the number of Medicaid recipients in all three areas was weak.[11] Miller believed that this was due to the inadequacy of using recipients as the dependent variable. For future research purposes, Miller suggested that the dependent variables be inpatient days and patient visits.

In a review of the research done on limiting prescription usage by Medicaid patients over the past twenty years, Soumerai et al (1993) concluded that drug reimbursement caps and modest cost sharing can reduce the use of both essential and less important drugs among the Medicaid population, but they warned that severe reimbursement caps can have serious unintended effects. Such caps can cause substitution effects which may lead to increased health expenditures in other areas. Soumerai et al (1994) examined the effect of a three-prescription monthly limit (cap) on the use of psychotropic drugs by noninstitutionalized Medicaid patients with schizophrenia. They found that though the cap resulted in immediate reductions in the use of antipsychotic drugs, antidepressants and lithium, it also resulted in coincident increases of one to two

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[10]Miller postulates that this was due to the poor nature of this variable as a proxy for demand. Relatively poor states may be reluctant to have liberal policies covering the medically needy because of the high program costs.

[11]These policy variables included: (1) four indicators of eligibility that measured the number of groups beyond those mandated by the federal government that a state includes in its Medicaid program, (2) two indicators of services offered that looked at mandatory service restrictions and optional services which were not provided, and (3) two "administrative" indicators (percentage of expenditures going to program administration and the federal matching share).

visits per patient per month in visits to Community Mental Health Centers and sharp increases in the use of emergency and hospital services. They concluded that the estimated average increase in mental health care per patient ($1,530) exceeded the drug cost savings by a factor of 17.

It has been found, however, that prior authorization (mandatory advance approval for use of expensive medications) has been successful in lowering drug costs without the adverse effects of increasing the use of medical services in other areas. Smalley et al (1995) found that a prior-authorization requirement in Tennessee on the use of nonsteroidal antiinflammatory drugs by Medicaid patients resulted in a decrease in expenditures of 53% and estimated savings of $12.8 million over a two year period. They found no concomitant increase in medical expenditures for other medical care.

These Medicaid studies all emphasize the care that must be taken when attempting to reform Medicaid policy. Attempts to cut costs in one area may have unintended consequences such as reducing physician participation and access to care, or causing substitution effects which instead of lowering costs may actually end up raising them.

Ambulatory and Pediatric Care

Research in ambulatory and pediatric care is also pertinent to the present study. Altman and Socholitzky (1981) reviewed the literature on the costs of ambulatory care in alternative settings, such as hospital-based outpatient departments, physician's offices, and free-standing clinics. They found that the literature supported the hypothesis that physicians' offices are the least costly deliverers of ambulatory care, followed by free-standing clinics, with the hospital outpatient setting being the most costly. Upon reviewing the relevant literature, they found that cost differences are generally attributable to the following factors: (1) the accounting system used, (2) the patient mix, (3) the site of care, (4) whether a teaching program was involved, (5) the availability of ancillary departments, (6) economies of scale, and (7) efficiency or productivity. Altman and Socholitzky also cite a number of studies indicating that hospital outpatient clinics see more Medicaid patients than do other sites (e.g., Thacker et al 1978, Cugliani 1978) and that hospital outpatient clinics treat a higher number of low income patients.

Pediatric care utilization by children from ages one through five was examined in a 1978 study by Colle and Grossman. Dichotomous logit estimation was used to estimate the probability of physician contact within the year prior to the study and the probability of obtaining a preventive physical examination during that year.[12] Ordinary least squares was used to analyze the number of office visits to physicians in private practice and the average quality of visits.[13] The data came from a 1971 health survey conducted by the Center for Health Administration Studies and the National Opinion Research Center of the University of Chicago. Colle and Grossman's study indicated that family income had a significant association with utilization. Children from families with annual incomes under $6,000 were less likely than those with incomes above $6,000 to

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[12]Logit is a type of binary choice model, which assumes a logistic cumulative distribution of the error term. More information can be found by consulting econometric texts such as Gujariti 1988 or Greene 1993.

[13]Though Colle and Grossman do not explicitly state what they mean by "quality", they state quality differences among physicians can be traced to differences in education and training. This dependent variable is estimated from mean office prices of five types of physicians, with the assumption that higher prices mean higher quality.

have had an ambulatory contact and a preventive physician visit in the year prior to the study. Family income was also positively and significantly correlated to the demand for visits and the quality of visits, with the income elasticity of visits equal to 0.38 and that of quality being 0.03. The Medicaid dummy had a large, significant negative association with the quality of visits, and the dummy for receipt of welfare income was positively and significantly associated with the use and prevention equations. Mothers' schooling was significant in all but the quality equations, and was found to be positively related to use, prevention and quality, but negatively correlated to the number of visits.

The effect of insurance on medical care utilization by children was examined by Currie and Thomas (1995). Data from the Child-Mother Module of the National Longitudinal Surveys of Youth were used to compare the medical care utilization of children with private insurance, those on Medicaid, and those with no insurance coverage. A conditional demand function for child medical care that included child-specific fixed effects was estimated. The results of the study indicated that children without any insurance coverage were least likely to report having had a check up in the last year, and children on Medicaid were most likely to have had a check up. They also found that white children with insurance (either private or Medicaid) were significantly more likely to have visited a doctor for an illness than those without any coverage. For black children the number of visits for illness was unrelated to insurance coverage.

In a 1983 study, Kasper and Wilson examined the effects of income and education level on the use of prescribed medications. Their analysis indicated that children from poor and less educated families had a lower likelihood of receiving a prescription than did similar aged children from higher-income families. This difference was attributed to lower use of physician services by poor children, rather than differences in physician treatment patterns.

Kasper (1987) outlined several important factors, other than financing, that affect health care use. Barriers to entry such as long queues for services, long travel times, and lack of access to certain sites of care all may hinder a person's ability to obtain medical care. Another important factor affecting the use of medical services is whether an individual has a usual or regular source of care.[14] Kasper used data from the National Medical Care Use and Expenditure Survey to estimate several models analyzing the importance of a usual source of care on medical use and expenditures for children under the age of six. Logistic regression was used when the dependent variable was dichotomous (whether the source of care was a physician's office or hospital outpatient department, whether a physician was seen during the year, and whether there was a preventive care visit during the year). OLS was used when the dependent variable was continuous (the number of office visits, and the number of preventive visits).

Kasper found that most children reported a physician's office as their usual source of care, but the results varied significantly by income and residence. Poor children were less likely to report a physician's office as their usual source of care and were more likely to be without a usual source of care (12% as compared to 6% for higher income children). One third of urban poor children reported hospital outpatient department (OPD) or emergency room (ER) as their regular

[14]A study by Rundall and Wheeler (1979) found that the presence or absence of a usual source of care was more important than income in determining use of preventive services among a sample of adults.

source of care, and being poor was negatively related to having a physician's office as the usual source of care.

Children with no usual source of care were 5% less likely to see a physician compared to those listing a physician's office as their usual source of care. Children with no usual source of care were also found to have fewer physician visits and preventive visits than those children with a physician's office as their usual source of care. The expenditure data indicated that average expenditures were higher for poor children whose regular source of care is an OPD or ER, but who identified no specific caregiver (both in comparison to higher income children using OPD/ER as their usual source of care and having no specific caregiver, and to those children listing a physician's office as their usual source of care). No difference in average expenditures was found between those children with a physician's office as the usual source of care and those with OPD or ER as the usual source of care if a specific caregiver was listed.

The above research highlights several issues that are relevant to the present study. First, these studies indicate the overuse of high-cost sites of care, such as hospital outpatient departments and emergency rooms, by the poor. Second, low-income children and children with no insurance coverage are less likely than high-income children or those covered by insurance to seek medical care. The importance of health care in childhood in preventing poor health outcomes in later life has been well documented. Programs that seek to control Medicaid costs must take into account not only ways in which current costs can be cut, such as substituting less expensive care for high-cost care, but also the effect of preventive and early childhood care in curtailing future costs.

Use of Cost Functions in the Study of Medical Care

Cost functions have predominantly been used in health care research to analyze hospital costs and efficiency. Several basic approaches and a number of functional forms have been used to estimate hospital cost functions. Many of these studies have dealt with the multi-product nature of hospital output. Lave and Lave (1970) used a two-step procedure in their estimation process. In order to allow the cost function to differ among hospitals, the first step estimated the relationship between average cost, utilization, size, and time for each hospital, after which a search was conducted for the causes of the variations among hospitals. The causes of variation were investigated by regressing the coefficient on the time variable, from the first step, on a number of hospital characteristics which Lave and Lave felt would affect costs, including size of the hospital, location and teaching status, as well as the hospital's average cost and utilization rate from the first time period. The final step in their analysis was an estimation of a single cost function using pooled data for all the hospitals, based on the assumption that all hospitals have the same cost function. These results were then compared to those for the individual hospitals.

Lave and Lave used a Cobb-Douglas functional form to account for the L-shaped average cost functions found in many hospital studies. The data consisted of 14 semi-annual observations for each of 74 western Pennsylvania hospitals for 1961 to 1967. The observations were obtained from Comparative Financial and Statistic Information, a report created by Blue Cross of Western Pennsylvania. Regarding cost variations, the regression results indicated that hospitals with high initial average costs tended to have relatively low rates of cost increase, and large hospitals had relatively large rates of increase. When examining the results for the pooled data, they found: (1) the rate of increase in costs rose over time, (2) the short-run cost curve was L-shaped, and (3) marginal cost represented a large percentage of average cost (40-65%).[15] No significant evidence of economies of scale was found.

Using a different approach, Conrad and Strauss (1983) estimated a translog joint cost function using three output measures (non-Medicare, Medicare, and child inpatient days) and four inputs (general services, nursing services, ancillary services, and capital). Their data came from audited Medicare cost reports submitted by 114 North Carolina hospitals to North Carolina Blue Cross and Blue Shield for the fiscal year 1978. The results of Conrad and Strauss's study indicated that North Carolina hospitals exhibited constant returns to scale (CRTS) during fiscal year 1978. Nursing and ancillary services were found to be complements for capital, while general labor services and capital were found to be substitutes. Results also indicated that the marginal cost of a child-patient day was substantially higher than the marginal cost of non-Medicare or Medicare days for adults. They concluded that the rapid increase in hospital costs was largely due to the complementary nature of nurses and other highly skilled labor with respect to capital. The introduction of new capital-intensive technologies had led to a high demand for these highly paid groups of laborers, and, subsequently, higher costs for hospitals.

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[15]Lave and Lave state that it is widely believed that an empty hospital bed costs about 75 percent as much as a full one, which means that the cost of providing services for an additional patient (marginal cost) is a small percentage of average cost.

Cowing and Holtman (1983) used a multi-product translog cost function to estimate a short-term total variable cost function for a sample of 138 short-term general care hospitals in New York for the year 1975. They used five different output measures (ER, medical-surgical care, pediatric, maternity, and other inpatient care) and six inputs (nurses, auxiliary labor, professional labor, administrative labor, general labor, and capital). Limited evidence of economies of scope for pediatric care and other inpatient care was found, along with limited evidence of diseconomies of scope with respect to emergency services and other inpatient care. Evidence of economies of scale was found, and the short-run marginal cost curve was found to be L-shaped. Regarding the substitution of inputs, Cowing and Holtman found nurses and professional workers to be strong substitutes for one another, as well as nurses and general workers, nurses and administrative workers, and professional and administrative labor. Other results indicated over-investment in capacity and equipment and lower costs for proprietary hospitals as opposed to non-profit hospitals. The coefficient on the teaching status dummy variable was not significantly associated with costs when the type of hospital was also included in the regression; however, it had a significant, positive association with costs when the type of hospital was excluded, indicating these variables may be collinear.

Grannemann, Brown, and Pauly (1986) used a multi-product cost function to investigate marginal and average incremental costs, economies of scale, and economies of scope.[16] Cross-sectional data on 867 hospitals obtained from AHA

[16]Incremental cost is defined as the difference between the cost of producing all outputs (at some specified levels) and the cost of producing all of these outputs except the one being examined.

survey data, the 1982 Hospital Ambulatory Care Survey[17], and other sources were used in this study. Grannemann et al maintained that the advantage of their study over similar studies stemmed from three important advances. First, they used separate measures of hospital outpatient services (Emergency Room, Outpatient Departments, Physical Therapy, Home Care, and Family Planning). Second, they employed a two-dimensional measure of inpatient services (inpatient days and discharges) to account for differences in average length of stay (ALOS). Finally, they utilized a flexible functional form with second and third order terms on major outputs and interaction terms. However, because they were not interested in substitutability of inputs, their functional form did not include interactions between input prices and output measures. OLS was used to estimate the equations.

Grannemann et al stated that interpretation of the results was difficult because of the functional form used. The study did find, however, that Medicaid inpatient days were more costly than Medicare inpatient days. They also found that hospitals controlled by local and state governments had costs that were about 8% higher than other non-profit hospitals. Contrary to Cowing and Holtman's results, Grannemann et al found that for-profit hospitals had costs about 15% higher than non-profit hospitals. Teaching and research hospitals were found to have costs about 15% higher than other hospitals. Nursing wages and per capita income were both found to be positively related to costs.

When looking at the cost of outpatient care, emergency rooms were found to have different cost structures than other outpatient departments, with

[17]This survey was developed jointly by Mathematica Policy Research Inc. and the AHA.

significantly higher average and marginal costs in emergency rooms. Diseconomies of scope with respect to emergency rooms and inpatient care were also found as well as economies of scale for emergency departments. It was observed that in most cases the marginal cost of hospital-provided ambulatory care was high, but for some small hospitals the price was comparable to physician-provided ambulatory care.[18]

In another study using a multi-output cost function, Carey and Stefos (1992) employed the concept of incremental cost to isolate hospital outpatient costs. They did not use a standard functional form, such as the Cobb-Douglas or translog, but rather chose to use a functional form that they felt incorporated many of the factors which influence hospital costs. To take into account a U-shaped average and marginal cost curve, their functional form included second and third order terms for number of discharges, number of outpatient visits, and ALOS. Other exogenous factors were included in the model that they believed had an effect on costs, such as service category, teaching status, population size, and ownership.

The data used in the Carey and Stefos study came from the AHA's Annual Survey of Hospitals and the HCFA's Hospital Cost Reporting Information System for the years 1984 though 1988. For their dependent variable, Carey and Stefos used the logarithm of total cost minus the logarithm of the wage index to impose the assumption of linear homogeneity in input prices. Using OLS and weighted least squares (WLS), they found no evidence of economies of scope. As for the costs of outpatient care, outpatient costs were not found to differ substantially

[18]Size was measured by volume of discharges, with small hospitals having less than 3,000 discharges annually.

from inpatient costs, despite the large differences in the utilization and revenue patterns. Though the number of outpatient visits rose 28% for the period in question, the overall average incremental cost of an outpatient visit fell from 2.3% of the average inpatient cost to 1.7%.

Another approach to the estimation of hospital cost functions stems from the assumption of cost minimization. Some researchers feel that assuming cost minimization where it may not be applicable leads to inaccurate estimates of factor substitution measures. Eakin and Kniesner (1988) claim that a non-minimum cost function should be applied to hospital cost analysis because it makes cost minimization a testable hypothesis rather than an assumption. It also allows researchers to look at the question of efficiency.

Eakin and Kniesner use a "hybrid" translog function to estimate individual hospital's shadow total costs.[19] Data from a cross section of 331 hospitals in the United States during the years 1975 and 1976, obtained from the AHA's Annual Survey of Hospitals, was used in their study. Four categories of output (general medicine, obstetrics and gynecology, weighted surgery, and outpatient visits) and four inputs (labor, physician, materials, and capital) were used in estimation. The cost function, along with the share equations, was estimated using Zellner's seemingly unrelated regression (SUR). They found an overemployment of capital and an underemployment of physicians, as well as an allocative inefficiency of approximately four to five percent of the total observed cost, depending upon the specification. In general, they found that the following pairs of inputs were substitutes: capital and labor, capital and physicians, labor and physicians, and

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[19]Eakin and Kniesner's "hybrid" function is "a translog function modified to handle zero output levels by replacing the natural log of an output with the actual output."

labor and materials. Unlike Cowing and Holtman (1983), Eakin and Kniesner found increasing marginal costs over the relevant range for all four output measures. They ascribed the differences in results between the two studies to population measures (Eakin and Kniesner used national data while Cowing and Holtman only looked at the state of New York) and different output measures. Eakin and Kniesner also found overall diseconomies of scale in the production of hospital care, with individual hospitals displaying mixed results. They concluded that the assumption of cost minimization does not change the sign of the elasticity of substitution measures, and that if one is mainly interested in output concepts (marginal costs, scale and scope economies) there is no real need to use a non-minimum cost function.[20]

Efficiency in the hospital industry has also been measured using frontier cost functions.[21] Zuckerman et al (1994) used this approach to look at the efficiency of a sample of 1,600 short-term non-federal hospitals for the years 1986 and 1987, using data from the Medicare Hospital Cost Report Information System and the AHA Annual Survey. A translog functional form and the frontier subroutine in LIMDEP were used for estimation. They concluded that inefficiency accounts for 13.6% of total hospital costs. They found this to be robust with respect to model specification and different approaches for pooling the data. Hospital occupancy rates were found to be negatively related to inefficiency with a 10% increase in

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[20]Other studies using non-minimum cost functions have found them to be important. See Toda 1976, Atkinson and Halvorsen 1984, Parker 1994, and Bhattacharyya et al 1995.

[21]In this approach, a minimum technically feasible total cost function is used as a reference point for comparing individual cost functions. In Zuckerman et al (1994) hospital inefficiency is defined to be "the difference between the actual total cost and the minimum feasible total cost of producing some given set of outputs at a given level of quality." To obtain a more accurate estimation, they include variables to control for case mix, number of hospital outputs, severity of illness, and quality of care.

the occupancy rate associated with a 2% decrease in inefficiency. Those hospitals paying higher salaries were also found to be more inefficient than hospitals with relatively low salaries. Finally, Zuckerman et al found that profit rates were significantly higher among relatively less inefficient hospitals.

CHAPTER 4

MODEL

General Framework

When analyzing the health care sector of the economy, the ultimate output is health itself. A production function for health includes numerous inputs thought to affect the health of individuals, such as medical care, nutrition, genetic endowment, housing quality, and others. This production of health leads to a derived demand for inputs such as medical care. On the supply side of the equation, health can be seen as an intermediate output. Since health care, or medical services, are much easier to quantify than health itself, much of the economic analysis of the health care sector has concerned itself with the demand and supply of medical services. The production of medical services is accomplished with a number of broad categories of inputs such as capital (hospital beds, equipment), medical care providers (private physicians, outpatient departments, clinics, nurse specialists), and medical supplies (drugs, labs, x-rays).

With the use of duality theory, the technology represented by a firm's production function can be described in alternative ways, such as a profit function or a cost function, which also incorporate the concept of optimization. A major advantage of using a cost function over a production function is that input demands can be derived by simple differentiation, using Shepherd's lemma. In addition, a cost function allows efficiency issues to be addressed, unlike a production function that deals only with technology.

In analyzing the production costs of pediatric ambulatory Medicaid services in Montana, these costs are hypothesized to be a function of the quantity of Medicaid services provided and the prices of a number of broadly defined inputs. For the purposes of this study it is assumed that inputs are being employed at their cost-minimizing levels, given the prevailing factor prices and output level. Therefore, it is appropriate to estimate a long-run cost function, which is defined as:

$$C = G(Y, p', A)$$

where C is minimum total costs, Y is output, p' is a vector of J variable input prices, and A is a vector of county characteristics that are thought to affect the costs of medical service.

Though cost-minimizing behavior has been questioned both in cases of hospitals and physicians, there is no apparent reason to assume that this hypothesis does not hold for the provision of Medicaid services.[22] Inasmuch as Medicaid providers are in general compensated at a lower than market rate for Medicaid services, the rent-seeking behavior implicit in non-cost minimization is less likely to occur in the provision of Medicaid care than in the case of fee-for-service markets. Cost minimization is also consistent with many non-profit theories of behavior, as well as for profit-maximization in competitive markets. In addition, political pressures to cut the costs of providing medical services to

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[22]See Eakin and Kniesner 1988 and Eakin 1993 for discussions on the use of non-minimum cost functions.

Medicaid recipients have led to the implementation of cost-saving practices such as case management programs and hospital admission reviews. Moreover, even if this assumption does not hold, Eakin and Kniesner (1988) found that the use of a non-minimum cost function in their study of hospital costs had only a minor impact on the estimates of output concepts such as marginal cost and scale and scope economies, as well as limited effect on the signs of substitution measures.

A cost function model also assumes that output is exogenous.[23] Again, this does not seem to be an unreasonable assumption since the production of Medicaid services is inherently dependent on Medicaid recipients' demand for medical care, as well as Medicaid regulations. It is also assumed that input prices are exogenous (this assumption will be discussed further in Chapter Five).

For the solution to a cost minimization problem to exist, the cost function must satisfy a number of regularity conditions. These conditions are (Morrison 1993):

(i) $C(.)$ is a nonnegative function ($C(Y, p') \geq 0$);

(ii) $C(.)$ is (positively) linearly homogeneous in input prices for any fixed output level ($C(Y, tp') \equiv tC(Y, p')$ for $t > 0$);

(iii) $C(.)$ is increasing in prices ($C(Y, p_1) > C(Y, p_0)$ if $p_1 > p_0$, or $\partial C / \partial p_j > 0$);

(iv) $C(.)$ is a concave function of p' (informally, $\partial^2 C / \partial p_j^2 \leq 0$);

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[23]Endogenous variables are those variables whose values are determined within the model. Exogenous variables are those variables whose values are determined outside of the model and which are used to explain the endogenous variables.

(v) $C(.)$ is continuous in p' and continuous from below in Y; and

(vi) $C(.)$ is nondecreasing in Y for fixed p'

$(C(Y^0, p') \leq C(Y^1, p')$ for $Y^0 \leq Y^1$, or $\partial C / \partial Y > 0)$.

These regularity conditions can be explained quite easily in non-mathematical terms. The first condition states that costs must be positive. The second implies that if all prices increase by a particular proportion, then minimum total cost must increase by the same proportion. The implication of the third condition is that as prices increase, then costs must also increase. The fourth condition implies that as input prices increase, costs will increase, but at a decreasing rate. This decreasing rate occurs because as input prices increase some substitution with lower-cost inputs will occur. Divisibility of inputs is implied with condition five, which is necessary for differentiation, and condition six ensures that marginal cost will also be positive.

The Translog Cost Function

Many different functional forms have been used in the analysis of production costs. One functional form commonly used is the Cobb-Douglas cost function. The major shortcomings of this form are that the factor shares are constant and the elasticity of substitution is limited to unity. Since one of the goals of this study is to examine substitutions among inputs, a more flexible functional form is needed for analysis. The functional form chosen for this study is the translog cost function which may be written as:[24]

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[24]The majority of the information on translog cost functions was obtained from Chung 1994.

$$\ln C = \ln \alpha_0 + \alpha_y \ln Y + \sum_i \alpha_i \ln p_i + \tfrac{1}{2}\beta_{YY}(\ln Y)^2$$

$$\tfrac{1}{2}\sum_i \sum_j \beta_{ij} \ln p_i \ln p_j$$

$$+\sum_i \beta_{iY} \ln Y \ln p_i \qquad (i \neq j; i, j = 1, \ldots, n)$$

where C is the long run total production costs, Y is output, and p_i is the price of input i. The above function is homothetic if $\beta_{iy} = 0$ for all i and the regularity conditions of linear homogeneity in input prices, given Y, as well as symmetry $(\beta_{ij} = \beta_{ji})$, are imposed by the following restrictions:

$$\sum_i \alpha_i = 1, \quad \text{and} \quad \sum_i \beta_{ij} = \sum_i \beta_{ji} = \sum_i \beta_{iY} = 0$$

Further restrictions may be imposed, depending on the assumptions made about the underlying technology. The function is linearly homogeneous in output if in addition to the above restrictions $\beta_{YY} = 0$, and $\alpha_Y = 1$.

The translog cost function can be estimated directly using OLS but gains in estimation efficiency can be realized by estimating the cost function along with the cost share equations. The share equations can be obtained by differentiating the translog cost function with respect to $\ln p_i$. This derivation of the share equations makes use of Shephard's lemma which states that the optimal, cost-minimizing demand for input i can be found by simply differentiating the cost function with respect to p_i. The share equations can be derived as follows:

$$\frac{\partial \ln C}{\partial \ln p_i} = \frac{\partial \ln C}{\partial C} \cdot \frac{\partial C}{\partial p_i} \cdot \frac{\partial p_i}{\partial \ln p_i} = \frac{1}{C} \cdot X_i \cdot p_i = \frac{p_i X_i}{C} = S_i,$$

where $\sum_{i=1}^{n} p_i X_i = C$. It then follows that $\sum_{i=1}^{n} S_i = 1$. For the translog function outlined above, these share equations can be written as:

$$S_i = \frac{\partial \ln C}{\partial \ln p_i} = \alpha_i + \sum_{j=1}^{n} \beta_{ij} \ln p_j + \beta_{iY} \ln Y.$$

In order for the system of share equations to meet these criteria, the same restrictions as for linear homogeneity and symmetry must be imposed, which are:

$$\sum_i \alpha_i = 1, \qquad \text{and} \quad \sum_j \beta_{ij} = \sum_i \beta_{ji} = \sum_i \beta_{iY} = 0$$

The input demand functions for the translog can be found through the use of Shephard's lemma, as stated above. In terms of the share equations, these functions can be derived as follows:

$$X_i = \frac{\partial C}{\partial p_i} = \frac{\partial C}{\partial \ln C} \cdot \frac{\partial \ln C}{\partial \ln p_i} \cdot \frac{\partial \ln p_i}{\partial p_i} = \frac{C}{p_i} . S_i$$

which for the translog cost function can be written as:

$$X_i = \frac{\partial C}{\partial p_i} = \frac{C}{p_i}\left(\alpha_i + \sum_{j=1}^{n} \beta_{ij} \ln p_j + \beta_{iY} \ln Y \right)$$

The marginal cost can be computed as follows:

$$MC = \frac{\partial C}{\partial Y} = \frac{\partial C}{\partial \ln C} \cdot \frac{\partial \ln C}{\partial \ln Y} \cdot \frac{\partial \ln Y}{\partial Y} = \frac{C}{Y} \cdot \frac{\partial \ln C}{\partial \ln Y} = \frac{C}{Y} . \varepsilon_{CY},$$

which for the translog becomes:

$$MC = \frac{C}{Y}(\alpha_Y + \beta_{YY} \ln Y)$$

The effects of changes in input prices on factor demands can be found through the Allen-Uzawa partial elasticities of substitution (σ_{ij}) and the price elasticities of demand. The Allen-Uzawa partial elasticities of substitution are defined as follows:

$$\sigma_{ij} = \frac{C.C_{ij}}{C_i.C_j} \qquad (i \neq j),$$

$$\sigma_{ii} = \frac{C.C_{ii}}{C_i.C_i}$$

$$\text{where } C_i = \frac{\partial C}{\partial p_i}, \quad C_{ii} = \frac{\partial^2 C}{\partial p_i^{\ 2}}, \quad \text{and} \quad C_{ij} = \frac{\partial^2 C}{\partial p_i \partial p_j}$$

Written in terms of shares and equation parameters, these formulas for the translog cost function are as follows:

$$\sigma_{ij} = \frac{S_i.S_j + \beta_{ij}}{S_i.S_j} = 1 + \frac{\beta_{ij}}{S_i.S_j} \qquad (i \neq j)$$

$$\sigma_{ii} = \frac{S_i^2 - S_i + \beta_{ii}}{S_i^2}$$

If the value of σ_{ij} calculated from the estimated value of β_{ij} is greater than zero, the two inputs are substitutes. If it is less than zero, they are complements.

The own- and cross-price elasticities of input demand can be calculated easily from the estimated shares and the elasticities of substitution given the following formulas:

$$\varepsilon_{ii} = \frac{\partial X_i}{\partial p_i} . \frac{p_i}{X_i} = \sigma_{ii} . S_i$$

$$\varepsilon_{ij} = \frac{\partial X_i}{\partial p_j} . \frac{p_j}{X_i} = \sigma_{ij} . S_j \qquad (i \neq j)$$

$$\varepsilon_{ji} = \frac{\partial X_j}{\partial p_i} . \frac{p_i}{X_j} = \sigma_{ij} . S_i \qquad (i \neq j)$$

Though $\sigma_{ij} = \sigma_{ji,}$ $\varepsilon_{ij} \neq \varepsilon_{ji}$. The elasticity of substitution (σ_{ij}) is a measure of the substitutability of inputs in the production process when output is held constant, and it is symmetric with regard to inputs. The cross price elasticities, however, also take into account the costs of the inputs and their contributions to total costs. Since the cost shares of different inputs are unlikely to be equal, the cross-price elasticities are not symmetric.

CHAPTER 5

DATA AND EMPIRICAL SPECIFICATION

Data

The data for this study came on two computer tapes that were obtained from the Montana/Wyoming Foundation for Medical Care located in Helena, Montana. The entire data file contains information on individual reimbursements to all Montana providers of Medicaid services for the year 1994. The following information is included in this data file for each observation (billable event): provider of the medical service (PROV), type of provider (PROVTP), first date of service (FDATE), last date of service (LDATE), patient number (PATIENT), birthdate of the patient (BIRTH) as well as the sex (SEX) and race (RACE) of the patient, county where service was provided (CTY), reimbursement (REIMB), diagnosis codes (DIAG1 - DIAG5),[1] admission date (ADMDATE), drug code (DRUG), quantity of the drug prescribed (DRUGQT), and number of days for which the drug was prescribed (DAYS).

The necessary information for this study was culled from the main data file with the use of Statistical Package for the Social Sciences - Version 6.1 (SPSS). Observations on children from the ages of one to five were retrieved along with the variables of interest. These variables were PROV, PROVTP, FDATE, CTY,

[1]Diagnoses were coded using the International Classification of Diseases, ninth revision (ICD-9) codes.

REIMB, PATIENT, BIRTH, DRUG, and DRUGQT.[2] This retrieval process had to be carried out in sections because of the large number of observations. The data were then cleaned up by removing observations with computer errors and erroneous entries. This resulted in 23 data files containing a total of 181,800 observations and six variables (those listed above, minus DRUG and DRUGQT).

The data from these 23 files were then aggregated by month for each of Montana's 56 counties. This process resulted in the creation of new variables including total reimbursements, the number of monthly visits, the number of providers by type, the number of prescriptions, reimbursements by provider type, and input prices. The variables included in the aggregated data file and selected descriptive statistics are listed in Table 7 in the appendix, along with a description of the variables in Table 8. This data file consists of 650 observations, and 25 variables.

Information on the population to which this data pertains, namely demographic characteristics of 1994 Montana Medicaid recipients, was unavailable at the time of this writing. However, some general information on the Montana population at large may be of interest. In 1990 the population of Montana was 799,065 persons, which amounted to approximately five and one-half persons per square mile. Of these 799,065 persons, approximately 92.5% were classified as white, 0.30% as black, 0.6% as American Indian, Eskimo, or Aleut, and 0.53% as Asian or Pacific Islander. There were 1,263 non-Federal active physicians, or approximately 158 per 100,000 resident population. There

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[2]The variables DRUG and DRUGQT were used to identify and delete erroneous entries. A number of the observations for drugs had the wrong type of drug code and/or too large of numbers in the DRUGQT variable. These observations were deleted from the data file after consulting with Tim Stratton, Professor of Pharmacy Practice at The University of Montana.

were also 53 hospitals consisting of a total of 4,386 hospital beds, or 542 hospital beds per 100,000 resident population. The medium household income in 1990 was $22,988, and the per capita income was $11,213. In 1990, 25,691 households, or 12% of all families, had incomes below the poverty level. The number of persons below the poverty level totalled 124,853, or 16.1% of the population. For children under 18 years of age, 19.9% were living below the poverty level. Finally, children under the age of five accounted for 7.4% of the population (U.S. Bureau of the Census 1994).

Empirical Specification

This study of Medicaid costs for one to five year-olds in Montana assumes that the production of Medicaid services is accomplished through the use of a number of broadly defined inputs, namely medical care providers, drugs, and lab and x-ray services. A long-run total cost function is estimated that is a function of output and seven input prices. The equation estimated is written as:

$$TC(Y, p', X) = \log TC = \ln \alpha_0 + \alpha_y \ln Y + \sum_i \alpha_i \ln p_i'$$

$$+ \tfrac{1}{2}\beta_{YY}(\ln Y)^2 + \tfrac{1}{2}\sum_i \sum_j \beta_{ij} \ln p_i' \ln p_j'$$

$$+ \sum_i \beta_{iY} \ln Y \ln p_i'$$

$$+\sum_{k=1}^{N}\delta_k A_k$$

$$(i \neq j; i, j = 1, \ldots, 7; k = 2, \ldots 56)$$

where TC is total pediatric ambulatory Medicaid costs for one to five year-olds; Y is output measured in patient visits; $p_i^{'}$ is a set of seven variable input prices for providers of outpatient hospital services, EPSDT providers, clinics, drugs, physicians, labs, and nurse specialists; and A is a set of county characteristics thought to affect costs. The regression variables are described in Table 1, and the means and standard deviations are shown in Table 2.

The following restrictions are imposed on this cost function to ensure (1) that the cost function is homothetic and linearly homogeneous in input prices, (2) that the symmetry condition holds, and (3) that the cost shares add up to one.

$$\sum_i \alpha_i = 1, \quad \sum_i \beta_{ij} = \sum_i \beta_{ji} = \sum_i \beta_{iY} = 0, \quad \text{and} \quad \beta_{iY} = 0 \text{ for all } i.$$

The restrictions $\beta_{YY} = 0$, and $\alpha_Y = 1$, which restrict the cost function to be linearly homogenous in output, were not imposed in order to examine the issue of economies of scale.

Total costs are measured as the sum of the reimbursements for the seven input categories per county per month. It is assumed that these reimbursements are representative of the total costs of providing ambulatory pediatric care including labor, capital, and the opportunity costs of the care providers.

Output is measured in patient visits per county month, which is believed to be a more satisfactory measure of services provided than simply using the

Table 1. Description of Regression Variables

NAME	DESCRIPTION
LC	Log of the sum of reimbursements/cty/month
LMV	Log of the number of patient visits/cty/month
LPD	Log of the price of drugs†
LPO	Log of the price of outpatient hospital departments‡
LPE	Log of the price of EPSDT providers
LPK	Log of the price of clinics
LPP	Log of the price of physicians
LPL	Log of the price of medical laboratories
LPN	Log of the price of nurse specialists.
DUM1 - DUM56	County dummy variables

† Price of drugs = sum of Medicaid reimbursements for drugs per county month ÷ the number of prescriptions per county month.
‡ Prices of other inputs are figures as follows: Price of input = sum of Medicaid reimbursements for the provider type ÷ number of providers of that type.

Table 2. Means and St. Deviation of Independent Regression Variables

VARIABLE	MEAN	STANDARD DEVIATION
LMV	3.8544	1.9120
LPO	-7.8900	4.5511
LPE	-4.5777	6.6898
LPK	-2.1741	7.2201
LPD	2.0623	2.7232
LPP	4.0809	2.7316
LPL	-5.9929	5.6402
LPN	-2.8145	6.8894

number of patients per county month. Reinhardt (1972), in his estimates of production functions for physician services, used patient visits as his explanatory variable, and Miller (1988) postulates that the number of patient visits would be a better measure of output than the number of patients, which he was forced to use because of lack of data. For the purpose of this study, a patient visit is defined to be all ambulatory care services obtained by an individual on a single day. If a patient went to a physician, had lab work done, and received a prescription all on the same day, that is counted as one patient visit. Patient visits are assumed to be exogenous since output is dependent on the patient's need for medical service.

It must be emphasized that the cost function used in this study is not a "typical" cost function like the hospital cost functions discussed in the literature review, though it is similar in some ways. One similarity between this cost function and a standard hospital cost function is in the measurement of output. Typically, hospitals measure output in patient days. This output measure encompasses a wide variety of inpatient hospital services provided to patients on a daily basis. In the present study, the output measurement is patient visits. This output measure, as defined above, can be viewed as child treatment days. This output measure also encompasses a wide variety of services, as does patient days, but the services provided are Medicaid ambulatory care services rather than inpatient services.

The primary difference between the cost function used in this study and the hospital cost functions mentioned above lies in how the input prices are measured. The input prices in the hospital cost functions generally consist of several labor input prices along with some measure of the price of the capital assumed to be used in the provision of hospital services. The labor input prices in the hospital cost functions are typically an index of wages for a composite of various types of workers. For example, the input price for the category "ancillary services" is an index of the average wages paid to a composite of hospital personnel such as lab technicians, respiratory technicians, and so on. The price for capital is usually a proxy that is felt to reflect the prices of equipment, supplies, and the building itself. It is important to note that the input prices in the hospital cost function are exogenous as required for a cost function. These input prices are determined in markets outside the control of the hospitals.

The cost function used in the present study also uses an index for input prices, but it is a different kind of index. Rather than an index for wages or the price of capital, this cost function uses an index for the prices of several types of providers of pediatric ambulatory Medicaid services. For instance, the price of a physician is defined to be a composite of the prices of the inputs that go into the provision of physician's services such as the doctor, the nurses, the office workers, and the buildings and equipment. Therefore, while similar to the hospital cost function in that an index is used to measure input prices, the input prices are not wages and capital prices as in the hospital cost functions. Instead, the input prices are proxies for the prices of broad categories of medical care providers which are felt to reflect the prices of the labor and capital that go into the provision of these services.

These proxies for input prices are measured in one of two ways. For drugs, the input prices are calculated by taking the total reimbursements per county month divided by the number of prescriptions per county month. This yields an average input price for prescriptions. This input price for prescriptions is, therefore, similar to the input prices used in hospital cost functions.

The rest of the input prices, however, are calculated differently and are measured in different units than those in the hospital cost functions. In a hospital cost function, as mentioned above, labor input prices are generally measured as average wage rates. These prices are measured as wages (in dollars) per unit of labor. In this study, however, the input prices (with the exception of prescriptions) are calculated by summing the Medicaid reimbursements for each type of care separately, and then dividing each sum by the number of providers of that type for each county month. The resulting price is the price of each input per county month, measured not as wages (in dollars) per unit of labor but as expenditures (in dollars) per active Medicaid provider. For example, the sum of the reimbursements for doctors for each county month divided by the number of doctors in the county receiving Medicaid reimbursements that month results in twelve monthly input prices for doctors per county.

It is important to note that this input price is not the same as the average wage of a doctor. Doctors providing Medicaid services are not necessarily the same population as doctors who choose not to treat Medicaid patients. As mentioned in the literature review, doctors participating in the Medicaid program are more likely to be older and less likely to be board certified than non-participants (Perloff et al 1987). Also, since doctors are reimbursed for Medicaid services at a lower than market rate, the average wage of physicians who treat large numbers of Medicaid patients will most likely be lower than the average wage of doctors primarily treating fee-for-service patients.

The way in which these prices are calculated leads to another difference between these input prices and the prices in the standard cost function. As mentioned above, the wages and prices of capital for the hospital cost functions are determined in outside markets. If there is an increase in the supply of nurses in a given area, this would lower the wages paid to nurses and would affect the costs of hospitals. This change in wages, however, is not controlled by the hospitals themselves; therefore, wages are exogeneous. In the present study, an influx of nurses into the Montana Medicaid system would not affect the reimbursement rate since that rate is determined by the state. It would, however, still affect the price of nurses since the denominator of the price equation would go up. As with the hospital cost function, the prices paid to nurses would go down as the result of outside influences, so the prices can still be seen as exogenous.

Differences in county characteristics that are thought to affect costs are controlled for by using a fixed effects model. Fifty-five county dummy variables are included in the estimation with the omitted variable being Beaverhead County.[3] A significant positive (negative) coefficient on a county dummy indicates higher (lower) costs for providing ambulatory Medicaid services in that county as compared to Beaverhead County. A system of seven equations, including the cost function and six of the seven share equations, is estimated using Zellner's seemingly unrelated regression technique.

It is difficult to make any assumptions about which counties are more likely to have higher costs of providing Medicaid services than others. Studies, such as

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[3]The choice of Beaverhead County as the base case is completely arbitrary.

Fossett et al (1991), have found that hospital outpatient care comprised a major source of care in rural areas, which could cause the smaller counties in Montana to have higher costs. On the other hand, it is reasonably assumed that counties with a large number of low-income persons will have higher costs, as will counties where Medicaid recipients have greater access to care, both of which may occur in larger counties. It can also be reasonably assumed that counties participating in the PASSPORT program should have lower costs.

Regarding input substitution, it is hypothesized that hospital outpatient departments and doctors will not be substitutes because of the impact of the PASSPORT program. Hospital outpatient care is strictly monitored by the primary care physician in these counties. Inasmuch as a prescription requires a doctor to write it and lab work must be ordered by a physician, physicians and drugs, and physicians and labs, are expected to be complements. The following inputs are expected to be substitutes: physicians and nurse specialists, physicians and clinics, and nurse specialists and clinics. Any of these providers is eligible to be a primary care provider under the PASSPORT program, and so they can be substituted for one another in the provision of medical care. No other hypotheses are made regarding parameter estimates.

CHAPTER 6

EMPIRICAL RESULTS

The results of the cost function estimation for this study are shown in Table 3. The majority of the parameter estimates seem plausible, with reasonable magnitudes and signs. When evaluated at the means of the data, the marginal cost of a patient visit is positive, with a value of $5.42. As required, costs are increasing in prices ($\partial C/\partial p_j > 0$) when evaluated at the data means. This can be shown by examining the cost shares. As stated before, $\partial C/\partial p_j = X_j$ (by Shephard's lemma) and $X_j = C/p_j\,(S_j)$. Therefore, $X_j > 0$ if and only if $S_j > 0$, given that $p_j > 0$ and $C > 0$. As can be seen in Table 4, all the estimated cost shares are positive when evaluated at the means of the data.

The restrictions imposed on the translog cost function ensure that it is linearly homogenous in input prices, and the translog specification guarantees that the function is continuous. A sufficient condition for concavity is that the bordered Hessian matrix of first and second order partial derivatives (with respect to input prices) is negative definite. In order for this to occur, the principal minors of the bordered Hessian must alternate in sign. The concavity condition held at the means of the data (see Appendix A).

Table 3. Translog cost function parameter estimates

VARIABLE	PARAMETER	ESTIMATE	T-VALUE
LMV (Monthly visits)	α_y	-0.1409	-1.63
LPO (Hospital outpatient)	α_1	0.1546	15.04**
LPE (EPSDT)	α_2	0.1671	21.69**
LPK (Clinics)	α_3	0.0534	7.93**
LPD (Drugs)	α_4	0.3165	25.20**
LPP (Physicians)	α_5	0.1877	13.44**
LPL (Labs)	α_6	0.0167	4.17**
LPN (Nurse specialists)	α_7	0.1041	12.72**
LMV × LMV	β_{YY}	0.0831	3.64**
LPO × LPO	β_{11}	0.0080	7.57**
LPE × LPE	β_{22}	0.0128	15.64**
LPK × LPK	β_{33}	0.0075	16.11**
LPD × LPD	β_{44}	0.0450	24.45**
LPP × LPP	β_{55}	0.0723	41.14**
LPL × LPL	β_{66}	0.0018	6.63**
LPN × LPN	β_{77}	0.0092	12.92**
LPO × LPE	β_{12}	0.0035	6.36**
LPO × LPK	β_{13}	-0.0010	-2.01*
LPO × LPD	β_{14}	0.0040	3.57**
LPO × LPP	β_{15}	-0.0150	-13.71**
LPO × LPL	β_{16}	-0.0011	-3.44**
LPO × LPN	β_{17}	0.0015	2.68**
LPE × LPK	β_{23}	-0.0006	-1.89*
LPE × LPD	β_{24}	-0.0066	-7.26**
LPE × LPP	β_{25}	-0.0097	-10.92**
LPE × LPL	β_{26}	0.0004	1.63
LPE × LPN	β_{27}	0.0002	0.44

TABLE 3 (continued)

VARIABLE	PARAMETER	ESTIMATES	T-VALUE
LPK × LPD	β_{34}	-0.0025	-3.67**
LPK × LPP	β_{35}	-0.0021	-2.88**
LPK × LPL	β_{36}	-0.0004	-2.14*
LPK × LPN	β_{37}	-0.0009	-2.69**
LPD × LPP	β_{45}	-0.0376	-31.45**
LPD × LPL	β_{46}	0.0016	3.82**
LPD × LPN	β_{47}	-0.0040	-4.97**
LPP × LPL	β_{56}	-0.0022	-4.91**
LPP × LPN	β_{57}	-0.0059	-6.80**
LPL × LPN	β_{67}	-0.0001	-0.26
Constant	α_0	5.8161	21.26**
R-Squared	0.8872		
Durbin-Watson	2.1984		

Note: Dependent variable = Log of costs; model includes county-specific fixed effects. Coefficients for the county dummies are not included in this table. For information on county cost differentials see Table 5.
* Significant at the 0.05 level.
** Significant at the 0.01 level.

Table 4. Estimated factor shares evaluated at data means

INPUT	FACTOR SHARE
Hospital outpatient Departments	0.01727
EPSDT Providers	0.03551
Clinics	0.04200
Drugs	0.24696
Physicians	0.62338
Labs	0.00407
Nurse specialists	0.03081

Unlike the Cobb-Douglas cost function, the translog specification is not globally concave, and ideally it should be checked for concavity at each observation. The other regularity conditions mentioned above, with the exception of linear homogeneity and continuity, should also be checked at each observation. This was not done for this study, however, so the results may be unreliable when evaluating observations outside the proximity of the data means.

This model was also tested for signs of multicollinearity, heteroskedasticity, and autocorrelation. The simple correlations were examined, as well as the auxiliary r-squareds, to check for the presence of multicollinearity. There was evidence of multicollinearity with respect to the output measure, LMV, and the input prices. All the first order coefficients on the input prices are statistically significant at the 1% level, but the coefficient on LMV is not statistically different from zero. This could be due to the multicollinearity.

Examination of the plots of the residuals against the independent variables showed some evidence of heteroskedasticity. The large number of variables in this model made testing for heteroskedasticity difficult, so the test results produced by SHAZAM - Version 7 (1993) were relied upon. These tests rejected a hypothesis of no heteroskedasticity.[1] Though the tests indicate the presence of heteroskedasticity, the results that are reported in this paper have not corrected for it. The large number of variables in the model and the system estimation made correction difficult; however, several simpler models, which were corrected

[1]The Breusch-Pagan-Godfrey test gave a value of 190.7 with 92 degrees of freedom. The Glesjer Test gave a result of 236.04 with 92 degrees of freedom. These results can be compared with a chi-square critical value of 79.08.

for heteroskedasticity, were also estimated.[2] Changes in the significance of the variables rarely occurred, and when it did occur, the change was almost always in the direction of making an insignificant parameter significant. Since most of the variables in the current model are already significant, it is assumed that not much accuracy is lost by the failure to correct for this problem.

The data was also checked for the presence of outliers and influential observations. One influential observation was found. Upon investigation, this observation was found to be an erroneous entry; therefore, it was eliminated from the data file.

The one puzzling result is the Durbin-Watson statistic that, with a value of 2.1984, fell in the inconclusive region for negative autocorrelation. Autocorrelation is usually a problem found with time-series' data, not cross-sectional data. The most likely cause of the high Durbin-Watson statistic is a misspecification error. It may also indicate a type of spatial autocorrelation, caused by patients crossing county borders to obtain medical care. If patients in a small county are crossing the border to a larger neighboring county to obtain medical care, then the errors could be inversely correlated.

A partial F-test was done to determine whether it was necessary to include the county dummy variables in the model. The results allowed a rejection of the null hypothesis that all the county dummies are equal to zero;[3] therefore, they were included in the model. Twenty-one of Montana's fifty-six counties have total costs that are significantly different from the base case of Beaverhead County.

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[2] A Cobb-Douglas cost function was ran, as well as the translog model without the share equations. Both were corrected for heteroskedasticity using White's correction.
[3] F=2.96, and F-critical=1.32 with 55 and 557 degrees of freedom.

Only one county, Big Horn, has total costs that are significantly greater than the base case. The coefficient on the dummy variable for Big Horn County implies a cost increase of 71.6% over Beaverhead County.[4] The most likely reason for the high costs of providing care in Big Horn county is the high incidence of poverty. Per capita income in Big Horn County was the lowest of all counties in Montana in 1990, only $7,148. Big Horn County also had the highest percentage of children living below the poverty level in 1990, 43.1%.

Twenty of Montana's counties have statistically significant lower total costs than Beaverhead County at the 0.05 level. Most of this difference seems to be explained by the low populations of these counties, along with the lack of available medical services. Seven of the twenty counties have no doctor, and fourteen have populations under 5,000. The two counties that do not seem to fit this pattern are Silver Bow and Yellowstone, which have coefficients on the county dummies indicating costs that are 83.7% and 73.6% lower than Beaverhead County, respectively. However, the lower costs in these counties might be explained by their participation in the PASSPORT Program, though the lack of significantly lower costs in the other PASSPORT counties is puzzling. Table 5 lists the counties with statistically significant cost differentials with respect to the base county, along with some demographic characteristics of the counties. A map of these counties is shown in Figure 2.

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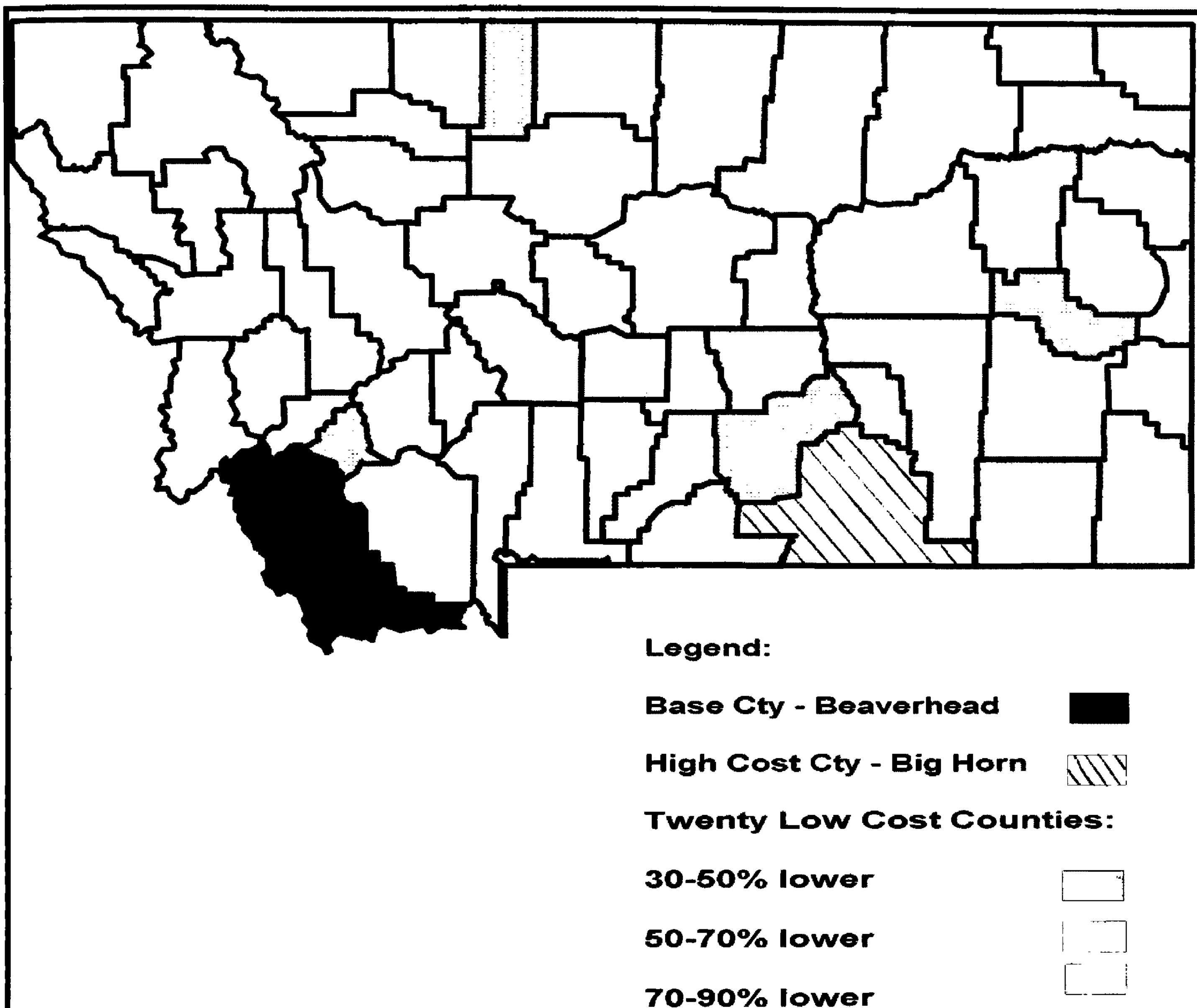
[4]Using the device suggested by Halvorsen and Palmquist (in Gujarati (1988)), the coefficients of the dummy variables are estimated by [exp(b)-1]*100, where b is the estimated coefficient from the regression.

Table 5. High and low cost Montana counties

Differences in characteristics

COUNTY	% CHANGE IN COST†	POPULATION	PER CAPITA INCOME	% CHILDREN BELOW FPL	DRS‡	PTH§
Beaverhead	N/A	8,603	10,376	21.5	131	No
McCone	-39.6	2,099	9,347	21.8	44	No
Rosebud	-39.7	10,592	10,415	25.0	57	No
Wheatland	-40.5	2,264	8,656	25.0	89	No
Blaine	-42.4	6,777	8,290	35.2	59	No
Powder River	-43.9	2,050	12,722	25.0	0	No
Meagher	-45.6	1,813	9,201	19.3	0	No
Carbon	-49.0	8,253	10,727	19.6	87	Yes
Musselshell	-49.5	4,103	8,941	27.7	49	No
Judith Basin	-50.1	2,251	12,060	16.2	0	No
Garfield	-58.2	1,428	9,843	23.3	0	No
Sheridan	-59.9	4,490	10,001	21.5	42	No
Daniels	-60.6	2,128	9,963	17.2	44	No
Carter	-65.4	1,489	10,670	36.9	0	No
Treasure	-65.5	884	10,244	20.7	0	No
Golden Valley	-65.7	897	8,505	29.7	0	No
Madison	-66.2	6,070	10,718	25.2	117	No
Yellowstone	-73.6	118,063	12,416	14.9	231	Yes
Liberty	-76.4	2,255	10,544	18.3	174	No
Prairie	-77.3	1,297	8,497	12.9	145	No
Silver Bow	-83.7	34,128	11,364	19.2	197	Yes
Big Horn	71.6	11,661	7,148	43.1	88	No

Note: All demographic figures are for 1990 and were obtained from the 1994 County and City Data Book.
† Percentage change in cost as compared to the base case county (Beaverhead County). All cost differences listed in this table were statistically significant at the 0.05 level.
‡ Doctors per 100,000 resident population.
§ Participating in the Passport to Health Program for more than six months in 1994.



Note: This map highlights those counties which had significantly higher or lower costs than the base county, Beaverhead (the dummy variables for these counties were statistically significant at the 0.05 level).

Figure 2. High and low cost Montana counties

As mentioned above, the marginal cost of a pediatric ambulatory Medicaid visit in Montana is estimated to be $5.42 at the data means. This figure seems rather low. The average cost of a visit, also evaluated at the means of the data, is $30.20. This is an indication of economies of scale as marginal cost is below average cost. The concept of economies of scale can be further analyzed by examining the output cost elasticity. At the means of the data, the output cost elasticity equals 0.18, which implies that if output is increased by 1%, costs would increase by 0.18%. A value less than one is an indication of economies of scale. These results indicate that economies of scale are present in the provision of Medicaid services for one to five year-olds in Montana, and that gains in efficiency may be obtained by having patients in areas with relatively low numbers of monthly visits travel to areas where the costs of providing Medicaid service may be lower. (Further discussion of this issue can be found in Chapter Seven in the section on policy implications.)

The factor cost share estimates in Table 4 indicate that, as expected, physician services are responsible for the largest share of the costs of providing ambulatory Medicaid services (62.3%) for children from the ages of one to five in Montana. Drugs account for the next largest share, 24.7%. Together, these two inputs account for 87% of the costs of providing care, calculated at the means of the data. These results suggest that programs aimed at cutting Medicaid costs would be most effective if aimed at physician services or prescription use. These results also indicate that outpatient hospital services and laboratory services do not account for a very large share of total costs (together they account for 2.1%) and that unnecessary use of these services is not the cause of increased

Medicaid costs. For the entire Medicaid population nationwide, the factor shares for ambulatory care in 1993 were: physician - 27%, drugs - 29%, other practitioners - 4%, clinics - 13%, outpatient hospital - 23%, and labs - 4%.

Turning now to input concepts, estimations of the own- and cross-price elasticities of demand are shown in Table 6. Estimates of the Allen-Uzawa partial elasticities of substitution (σ_{ij}) are given in Table 9 in the appendix. All of the own-price elasticities are of the correct sign, indicating that demand for the inputs falls as their prices rise. As would be expected, all of the own-price elasticities are inelastic, indicating an unresponsiveness of the quantity of these inputs demanded to changes in their price. The demand for physicians is the most inelastic, with a 10% increase in the price of physicians implying a 2.6% decrease in the quantity demanded. The least inelastic demand is for clinics, with a 10% increase in the price of clinics implying a 7.8% decrease in the demand for clinics.

An examination of the cross-price elasticities of demand indicates that the following pairs of inputs are complements: hospital outpatient departments and clinics, hospital outpatient departments and physicians, hospital outpatient departments and labs, and clinics and labs. The rest of the input pairs are substitutes. Some of these results warrant further discussion.

Table 6. Estimates of elasticities of demand

ε_{OO}	-0.5196
ε_{EE}	-0.6040
ε_{KK}	-0.7794
ε_{DD}	-0.5708
ε_{PP}	-0.2606
ε_{LL}	-0.5539
ε_{NN}	-0.6706
ε_{OE}	0.2381
ε_{EO}	0.1158
ε_{OK}	-0.0159
ε_{KO}	-0.0065
ε_{OD}	0.4786
ε_{DO}	0.0335
ε_{OP}	-0.2449
ε_{PO}	-0.0068
ε_{OL}	-0.0596
ε_{LO}	-0.2528
ε_{ON}	0.1176
ε_{NO}	0.0659
ε_{EK}	0.0251
ε_{KE}	0.0212
ε_{ED}	0.0611
ε_{DE}	0.0088
ε_{EP}	0.3502
ε_{PE}	0.0199
ε_{EL}	0.0153
ε_{LE}	0.1337
ε_{EN}	0.0364
ε_{NE}	0.0420
ε_{KD}	0.1874
ε_{DK}	0.0319

Table 6 (Continued)

ε_{KP}	0.5734
ε_{PK}	0.0386
ε_{KL}	-0.0055
ε_{LK}	-0.0562
ε_{KN}	0.0094
ε_{NK}	0.0128
ε_{DP}	0.4711
ε_{PD}	0.1866
ε_{DL}	0.0105
ε_{LD}	0.6399
ε_{DN}	0.0146
ε_{ND}	0.1171
ε_{PL}	0.0005
ε_{LP}	0.0831
ε_{PN}	0.0213
ε_{NP}	0.4316
ε_{LN}	0.0062
ε_{NL}	0.0008

The finding that hospital outpatient departments and physicians are complements rather than substitutes differs from that of many other studies which have found that Medicaid patients tend to substitute more expensive hospital outpatient care for physician's services. This study indicates that in Montana a 10% increase in the price of physicians leads to a 2.4% decrease in the use of hospital outpatient services. This finding, however, was not unexpected because of the presence of a managed care program in Montana, which serves to curtail the use of hospital outpatient services unless a referral has been obtained by the primary care provider. The same holds true for the finding that hospital outpatient departments and clinics are complements. Hospital outpatient and nurse specialists, however, are found to be substitutes. The reason for this is unclear. It could be that the use of nurse specialists is more prevalent in counties with fewer doctors. Residents in these counties would be unlikely to be enrolled in the PASSPORT program; therefore, more substitution could occur between input providers. An examination of the data, however, does not seem to support this hypothesis.

The results for the cross-price elasticities involving drugs are unexpected. It was believed that drugs would serve as complements to physicians, clinics, hospital outpatient departments, and nurse specialists, but the results are antipodal to this. The cross-price elasticity for physicians and drugs indicates that if the price of physicians increases by 10%, the quantity of drugs demanded increases by 4.7%. One explanation for this probably lies in the way that the price of physicians was calculated. Since the price of physicians was calculated by taking the total reimbursements for physicians per county month divided by the number of physicians per month, the price can increase either because of a relative increase in reimbursement or a relative decrease in the number of physicians. If the reimbursement for physicians is increasing, then either more patients are being seen or patients are being treated more intensively. In either case, this would most likely lead to an increase in the number of prescriptions. If this were the case, drugs would be acting more like a complement than a substitute, even though the regression results indicate substitution among the two inputs. This reasoning would also apply to why drugs are also found to be substitutes for clinics, hospital outpatient departments, and nurse specialists.

Another possible explanation for why drugs and care providers are found to be substitutes is the possibility that care providers may be more intensively prescribing medications for Medicaid patients in lieu of follow-up visits. Due to the lower than market Medicaid reimbursement rates, these care providers (physician's, clinics, hospital outpatient departments, and nurse specialists) may feel that it is a more cost effective use of their time to spend as little time as possible treating their Medicaid patients in order to allow more time for fee-for-service patients. Further research examining differences in prescription usage between Medicaid and non-Medicaid patients is needed to ascertain whether this is indeed the case.

Clinics and physicians, clinics and nurse specialists, clinics and EPSDT providers, physicians and nurse specialists, physicians and EPSDT providers, and nurse specialists and EPSDT providers are all found to be substitutes. These results seem reasonable as all of these provider types are eligible to be primary care providers under the PASSPORT program. Likewise, in counties not participating in the PASSPORT program these providers could be readily substituted for each other in most instances. EPSDT services are provided by the patient's doctor as well as clinics, nurse specialists, dentists, and other health care providers. This category of provider was included in the model because it was billed for separately.

One last interesting result is the substitutability of drugs and labs. The estimate of the cross-price elasticity shows that an increase of 10% in the price of drugs is related to a 6.4% increase in the quantity demanded of labs. This suggests that when the price of drugs increases more diagnostic work may be done before a costly prescription is written.

CHAPTER 7

CONCLUSION

Shortcomings of the Model

The results of this study should be interpreted with care for a number of reasons. As indicated in Chapter Five, the model was not corrected for heteroskedasticity. Although this does not bias the parameter estimates, it does affect the t-values. It is possible that some of the parameter estimates that are statistically significant could become insignificant if this problem was corrected. The model also showed some evidence of negative spatial autocorrelation that was not corrected for in the estimation procedure. Again, though this does not bias the parameter estimates, the standard errors are affected. However, with negative autocorrelation, the standard errors tend to be too high, resulting in t-values that are too low. Since most of the important variables in this model were significant, this may not present a serious problem.

Another concern with the results is the low value for marginal cost ($5.42), and the negative coefficient on the first order output term (LMV). Though this coefficient was not statistically different from zero, the high degree of multicollinearity between it and the other independent variables indicates that the t-value for this parameter estimate may be too low, in which case this parameter could be statistically significant. This negative value allows the marginal cost to be negative when evaluated at levels of output below 5.44 visits per month, which is the case for 93 of the 650 observations. The marginal cost and economies of scale results, therefore, may not be reliable, especially when evaluated at very low levels of output.

Another shortcoming of the model is the failure to check for adherence to the regularity conditions at all observations. If the model fails to comply with these conditions for a majority of the observations, then the results have little meaning when modelling cost behavior outside the immediate vicinity of the data means. The reader should bear in mind, therefore, that the results stated in this paper can only be interpreted locally, not globally. Cost concepts that are valid for small changes in output or input prices at the approximation points may not be valid indicators of the consequences of large incremental changes.

The method of calculating input prices is uncommon. Rather than using actual input prices, proxies were used. The method of computing these prices is explained in the Empirical Specification section of Chapter Four. As was discussed in Chapter Five, this method may lead to inputs that are actually complements being judged as substitutes, and vice versa.

Policy Implications

When assessing the policy implications of this study, care must be taken to account for the multiple objectives of health care provision. Policies designed to increase efficiency and cut costs may have unintended results. They may end up hindering the attainment of other, perhaps more important, considerations. A major concern over the Medicaid program has been its rapidly increasing costs. One must keep in mind, however, that the major goal of Medicaid is to provide health care for individuals who otherwise could not afford it. Policies designed to cut costs may make this goal much harder to achieve. Lower fee reimbursements for physicians have been associated with lower physician participation in the Medicaid program, and, hence, less access to medical care for Medicaid recipients. Low costs may mean lower quality care or the provision of fewer services. In Montana, seven of the twenty counties with significantly lower costs of providing ambulatory Medicaid services to young children had no doctor at all.[1] The increasing costs of providing Medicaid services have been shown to be caused by increasing numbers of recipients, the provision of more services, and the high rate of inflation in the medical care industry. Cutting costs by decreasing necessary services or tightening eligibility requirements does not fit in with the goal of providing adequate medical services for the poor.

With this in mind, the cost implications of this study will be discussed. First, there is evidence of economies of scale in the provision of ambulatory Medicaid services for children aged one to five. This indicates that costs could be decreased by concentrating the provision of these services in areas where demand is the greatest. It must be kept in mind, however, that it is not necessarily efficiency gains that society seeks in the provision of medical services. Though studies have found economies of scale in the provision of hospital services (see Granneman et al 1986, Cowing and Holtman 1983), having fewer large hospitals that capture these economies of scale may not be in people's best interests. One of the goals of health care is to make it readily accessible. Fewer large hospitals and emergency rooms force patients to travel for longer distances to obtain care. In many cases, especially in emergency situations, this is not an adequate solution. The same holds true for the provision

[1] Lower as compared to the base county of Beaverhead.

of other medical services. Big does not necessarily mean better. A major problem in the provision of medical services in rural areas is lack of access to care providers; making persons who live in rural areas travel long distances to obtain care is not a solution to this problem. What these areas need are more health care providers, regardless of the fact that the costs of providing such services will be higher than obtaining care in larger areas.

Other methods of cutting costs suggested by the results of this study would better serve the multiple goals of the Medicaid program. The cross-price elasticities suggest that the provider types, with the exception of hospital outpatient departments, serve as substitutes for one another. It should be possible, therefore, to cut costs by substituting physicians with lower cost service providers, such as nurse specialists, whenever practical. Experiments undertaken by the U.S. Air Force during the 1970s, in which they substituted paramedic care for physician care in a number of their clinics, have been analyzed in numerous studies. These studies indicate that the quality of care was high, the costs were low, and patients were happy with the service they received. (Phelps 1992)

As stated above, the factor shares suggest that policies aimed at physicians and prescription drugs would be likely to have the most impact on costs. According to the results of this study, increasing the reimbursement rate paid to a physician, while holding the number of providers constant, would increase the price of the provider. This increase in price would decrease the use of these providers in the provision of Medicaid services and increase the use of substitute services. This would, however, not decrease costs since all of the inputs in this study were found to have inelastic demand, implying that the percentage decrease in quantity demanded would be less than the percentage increase in price. This means that as reimbursement rates go up, so do total costs. Lowering the reimbursement rate would have the opposite effect and would tend to lower costs (as well as physician participation).

It is doubtful that the number of providers would remain constant if the reimbursement rate were changed. As mentioned, studies show that changes in reimbursement rates affect physician participation in the Medicaid program; therefore, if reimbursement rates went up, the number of participating physicians would most likely increase, and the effect on price would be uncertain. Again, as with the case of economies of scale, care must be taken when attempting to apply these results to the provision of medical services. Programs that attempt to cut the costs of physician services may serve to decrease physician participation in Medicaid, exacerbating the problem of Medicaid patients' access to care.

Care must also be taken when attempting to curtail the costs of prescriptions. Prescription drugs are the fastest growing cost segment of health care; however, attempts to limit drug use may have unintended consequences. Though prior authorization programs have been shown to reduce drug costs without a concomitant increase in medical use in other areas (Smalley et al), other limits on drug use may have unintended consequences. It has been shown that caps or limits on prescription usage can increase the use of other medical services, thereby negating the cost savings (Soumerai et al 1993, 1994). These studies make clear that policies to restrict drug use must be chosen carefully in order to mitigate the effect on other health care costs.

The factor cost shares also indicate hospital outpatient departments and labs are responsible for a very small percentage (2%) of all costs. This would seem to imply that further policies aimed at limiting these services would have a negligible impact on costs.

There are also some indications in this study that the PASSPORT program is helping to cut the costs of providing Medicaid services to children. Though numerous other studies have found that Medicaid patients substitute more expensive hospital outpatient care for physician services, this does not seem to be the case in Montana, probably due to the PASSPORT program. Recipients enrolled in PASSPORT cannot obtain hospital outpatient services without a referral from their primary care physician. Also, three of the counties with significantly lower total costs of providing care (as compared to Beaverhead County) participate in the PASSPORT program. Two of these counties, Silver Bow and Yellowstone, have relatively high populations and a large number of health care providers so that their lower costs cannot be attributed to low populations or lack of access to care.

Conclusion

The aim of this study was to provide information on the costs of providing ambulatory Medicaid services to Montana children from the ages of one to five and possible ways to reduce these medical costs. Further work in this area could serve to provide more, and perhaps more reliable, information. The regularity conditions should be checked for all observations to provide more dependable results that could be used to model the behavior of costs over a wider range of observations. Data encompassing a number of years could be used to assess changes in costs over time, particularly before and after the implementation of the PASSPORT program. Accurate statistics on the number of recipients enrolled in the PASSPORT program in each county could also be added to the model to assess the impact of this program on costs.

In closing, though economics can help us find ways to achieve certain goals in the most cost effective manner, it cannot make decisions on which goals are most important. Though cutting Medicaid costs is one goal of the politicians in Washington, as well as Helena, providing adequate medical care for all individuals at the lowest possible cost is another goal of our society. Big Horn County, the one county with statistically significant higher total costs than the base county, is also the county with the lowest per capita income and the largest percentage of children living under the poverty level. Policies aimed at decreasing the extent of poverty, and thereby indirectly decreasing the number of Medicaid recipients, would seem to be one of the best ways of cutting Medicaid costs.

The present study also highlights the fact that health care for children is remarkably inexpensive. The cost of an additional child treatment day was estimated to be $5.42. This is a pittance. Other studies have also found that children are much more inexpensive to treat than adults or the aged and blind (Wade and Berg 1995). Further confirmation for the low costs of providing care for children is found by looking at Medicaid statistics. Though children made up 50% of Medicaid recipients in 1994, they accounted for only 15% of total expenditures on Medicaid.

This evidence leads to a very important conclusion. The most cost effective way of reducing Medicaid costs for the entire Medicaid system is to increase the provision of medical treatment for children. Preventive and early care of childhood illnesses has been shown to markedly improve the health outcomes of individuals later in life. Small increases in the amount of money spent on children's' health care now is likely to pay large dividends in the future by reducing the amount of high cost medical services needed later on. Not only will the costs of medical care decrease, but society will also benefit in other ways such as increased worker productivity and reduced pain and suffering. Providing adequate health care for all individuals, the primary goal of the Medicaid system as well as the health care system in general, cannot be achieved by short-term, short-sighted plans to cut health care costs. This goal can only be achieved by policy makers and the public putting aside short-term considerations for long-term solutions.

APPENDIX A

Table 7. Selected descriptive statistics -- Aggregate data file

VARIABLE	MEAN	STANDARD DEVIATION	MAXIMUM	SUM†
COST	6,867.06	12,495.29	69,908.90	4,463,586
MVISITS	227.34	444.96	2,517.00	147,772
NO_OUT	.09	.32	2.00	N/A
NO_EPSDT	.48	.87	7.00	N/A
NO_CLIN	.79	.98	5.00	N/A
NO_DRUGS	77.15	135.82	838.00	N/A
NO_PHYS	20.92	25.86	126.00	N/A
NO_LABS	.38	.77	4.00	N/A
NO_NUR	.91	1.31	8.00	N/A
OUT	462.22	2,379.66	26,185.50	300,444
EPSDT	176.61	573.55	4.776.47	114,623
CLINIC	456.32	1,612.57	16,049.77	296,610
DRUG	1,295.44	2,400.16	17,649.42	842,037
PHYS	4,271.67	7,572.31	51,874.74	2,776,590
LAB	39.31	146.82	1,707.60	25,552
NUR	165.19	387.91	3,402.18	107,374
P_ER	395.67	2,054.75	26,185.00	N/A
P_EPSDT	115.67	355.51	3,066.07	N/A
P_KLIN	253.98	920.99	8,943.23	N/A
P_DRUG	16.00	16.96	357.96	N/A

Table 7 (continued)

VARIABLE	MEAN	STANDARD DEVIATION	MAXIMUM	SUM†
P_PHYS	131.28	125.73	1,996.41	N/A
P_LAB	21.83	75.20	853.80	N/A
P_NUR	71.79	140.75	1,089.89	N\A

Note: All variables were aggregated by county month. Minimums are not included as they all had zero values except for COST and MVISITS, which were 5.41 and 1, respectively.
† Only the sums for the reimbursements and monthly visits are included in this table. The sums of the input quantities are not included because of the way they were calculated. The number of providers was calculated each month by counting the number of different providers of each type. Summing these amounts would amount to counting each provider more than once.

Table 8. Description of Variables -- Aggregate Data File

VARIABLE	DESCRIPTION
COST	Total reimbursements
MVISITS	Number of patient visits
NO_OUT	Number of hospital outpatient departments
NO_EPSDT	Number of EPSDT providers
NO_CLIN	Number of clinics
NO_DRUGS	Number of prescriptions
NO_PHYS	Number of physicians
NO_LABS	Number of labs
NO_NUR	Number of nurse specialists
OUT	Sum of reimbursements for hospital outpatient departments
EPSDT	Sum of reimbursements for EPSDT providers
CLINIC	Sum of reimbursements for clinics
DRUG	Sum of reimbursements for drugs
PHYS	Sum of reimbursements for physicians
LAB	Sum of reimbursements for labs
NUR	Sum of reimbursements for nurse specialists.
P_OUT	OUT/NO_OUT
P_EPSDT	EPSDT/NO_EPSDT
P_KLIN	CLINIC/NO_CLIN
P_DRUGS	DRUG/NO-DRUGS
P_PHYS	PHYS/NO_PHYS

Table 8 (continued)

VARIABLE	DESCRIPTION
P_LAB	LAB/NO_LAB
P_NUR	NUR/NO_NUR
CTY	County (1-56)
MONTH	Month (1-12)

Note: All variables were aggregated by county month.

Table 9. Estimates of Elasticities of Substitution

σ_{OE}	6.70
σ_{OK}	-0.38
σ_{OD}	1.93
σ_{OP}	-0.39
σ_{OL}	-14.68
σ_{ON}	3.82
σ_{EK}	0.60
σ_{ED}	0.25
σ_{EP}	0.56
σ_{EL}	3.77
σ_{EN}	1.18
σ_{KD}	0.76
σ_{KP}	0.92
σ_{KL}	-1.33
σ_{KN}	0.30
σ_{DP}	0.76
σ_{DL}	2.60
σ_{DN}	0.47
σ_{PL}	0.13
σ_{PN}	0.69
σ_{LN}	0.20

Note: All estimates were calculated at the means of the data.

Table 10. Estimates of Input Demand

INPUT	DEMAND
Outpatient Departments	0.300
EPSDT providers	2.108
Clinics	1.136
Drugs	106.014
Physicians	32.608
Labs	1.281
Nurse Practitioners	2.947

Note: Calculated at the means of the data.

Table 11. 2nd-order Derivatives of Cost Function w.r.t. Price

C_{OO}	-3.9350
C_{EE}	-0.0110
C_{KK}	-0.0035
C_{DD}	-3.7814
C_{PP}	-0.0647
C_{LL}	-0.0325
C_{NN}	-0.0275
C_{OE}	0.0006
C_{OK}	-0.00002
C_{OD}	0.0090
C_{OP}	-0.0006
C_{OL}	-0.0008
C_{ON}	0.0005
C_{EK}	0.0002
C_{ED}	0.0080
C_{EP}	0.0056
C_{EL}	0.0015
C_{EN}	0.0012
C_{KD}	0.0133
C_{KP}	0.0050
C_{KL}	-0.0003
C_{KN}	0.0001
C_{DP}	0.3804
C_{DL}	0.0512

Table 10 (Continued)

C_{DN}	0.0216
C_{PL}	0.0008
C_{PN}	0.0097
C_{LN}	0.0001

Note: All second order derivatives are calculated at the means of the data.

Figure 3. Bordered Hessian Matrix

$$H_B = \begin{bmatrix} C_{OO} & C_{OE} & C_{OK} & C_{OD} & C_{OP} & C_{OL} & C_{ON} & C_O \\ C_{EO} & C_{EE} & C_{EK} & C_{ED} & C_{EP} & C_{EL} & C_{EN} & C_E \\ C_{KO} & C_{KE} & C_{KK} & C_{KD} & C_{KP} & C_{KL} & C_{KN} & C_K \\ C_{DO} & C_{DE} & C_{DK} & C_{DD} & C_{DP} & C_{DL} & C_{DN} & C_D \\ C_{PO} & C_{PE} & C_{PK} & C_{PD} & C_{PP} & C_{PL} & C_{PN} & C_P \\ C_{LO} & C_{LE} & C_{LK} & C_{LD} & C_{LP} & C_{LL} & C_{LN} & C_L \\ C_{NO} & C_{NE} & C_{NK} & C_{ND} & C_{NP} & C_{NL} & C_{NN} & C_N \\ C_O & C_E & C_K & C_D & C_P & C_L & C_N & 0 \end{bmatrix}$$

$$H_B = \begin{bmatrix} -3.9350 & 0.0006 & -0.00002 & 0.0090 & -0.0006 & -0.0008 & 0.0005 & 0.300 \\ 0.0006 & -0.0110 & 0.0002 & 0.0080 & 0.0056 & 0.0015 & 0.0012 & 2.108 \\ -0.00002 & 0.0002 & -0.0035 & 0.0133 & 0.0050 & -0.0003 & 0.0001 & 1.136 \\ 0.0090 & 0.0080 & 0.0133 & -3.7814 & 0.3804 & 0.0512 & 0.0216 & 106.014 \\ -0.0006 & 0.0056 & 0.0050 & 0.3804 & -0.0647 & 0.0008 & 0.0097 & 32.608 \\ -0.0008 & 0.0015 & -0.0003 & 0.0512 & 0.0008 & -0.0325 & 0.0001 & 1.281 \\ 0.0005 & 0.0012 & 0.0001 & 0.0216 & 0.0097 & 0.0001 & -0.0275 & 2.947 \\ 0.300 & 2.108 & 1.136 & 106.014 & 32.608 & 1.281 & 2.947 & 0 \end{bmatrix}$$

Table 12. Second-order conditions

DETERMINANT	CORRECT SIGN	VALUE
$\lvert H_2 \rvert$	Positive	0.3279
$\lvert H_3 \rvert$	Negative	-1.0330
$\lvert H_4 \rvert$	Positive	7.0089
$\lvert H_5 \rvert$	Negative	-0.0266
$\lvert H_6 \rvert$	Positive	0.0003
$\lvert H_7 \rvert$	Negative	-0.0012

Note: These second-order conditions were evaluated using the Bordered Hessian of Figure 3.

APPENDIX B

Sample SHAZAM Program

```
**TRANSLOG COST FUNCTION**
read(medtl.dif) / dif
stat / all pcor

*Generation of Variables
--------------------------------
gen y=mvisits
gen o=no_er
gen e=no_epsdt
gen k=no_clin
gen d=no_scrip
gen p=no_docs
gen l=no_labs
gen n=no_nur
gen po=p_er
gen pe=p_epsdt
gen pk=p_clin
gen pd=p_drug
gen pp=p_doc
gen pl=p_lab
gen pn=p_nur
gen lc=log(cost)
gen ly=log(y)
gen lpo=log(po)
gen lpe=log(pe)
gen lpk=log(pk)
gen lpd=log(pd)
gen lpp=log(pp)
gen lpl=log(pl)
gen lpn=log(pn)
gen ly2=.5*ly*ly
gen lpo2=.5*lpo*lpo
gen lpe2=.5*lpe*lpe
gen lpk2=.5*lpk*lpk
gen lpd2=.5*lpd*lpd
gen lpp2=.5*lpp*lpp
gen lpl2=.5*lpl*lpl
```

```
gen lpn2=.5*lpn*lpn
gen lpope=lpo*lpe
gen lpopk=lpo*lpk
gen lpopd=lpo*lpd
gen lpopp=lpo*lpp
gen lpopl=lpo*lpl
gen lpopn=lpo*lpn
gen lpepk=lpe*lpk
gen lpepd=lpe*lpd
gen lpepp=lpe*lpp
gen lpepl=lpe*lpl
gen lpepn=lpe*lpn
gen lpkpd=lpk*lpd
gen lpkpp=lpk*lpp
gen lpkpl=lpk*lpl
gen lpkpn=lpk*lpn
gen lpdpp=lpd*lpp
gen lpdpl=lpd*lpl
gen lpdpn=lpd*lpn
gen lpppl=lpp*lpl
gen lpppn=lpp*lpn
gen lplpn=lpl*lpn
gen lpoly=lpo*ly
gen lpely=lpe*ly
gen lpkly=lpk*ly
gen lpdly=lpd*ly
gen lpply=lpp*ly
gen lplly=lpl*ly
gen lpnly=lpn*ly
gen se=pe*e/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)
gen sk=pk*k/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)
gen sd=pd*d/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)
gen sp=pp*p/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)
gen sl=pl*l/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)
gen sn=pn*n/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)
gen con=1

*Generation Of County Dummy Variables
----------------------------------------------------
if(cty.eq.1) dum1=1
if(cty.eq.2) dum2=1
if(cty.eq.3) dum3=1
if(cty.eq.4) dum4=1
if(cty.eq.5) dum5=1
if(cty.eq.6) dum6=1
```

```
if(cty.eq.7) dum7=1
if(cty.eq.8) dum8=1
if(cty.eq.9) dum9=1
if(cty.eq.10) dum10=1
if(cty.eq.11) dum11=1
if(cty.eq.12) dum12=1
if(cty.eq.13) dum13=1
if(cty.eq.14) dum14=1
if(cty.eq.15) dum15=1
if(cty.eq.16) dum16=1
if(cty.eq.17) dum17=1
if(cty.eq.18) dum18=1
if(cty.eq.19) dum19=1
if(cty.eq.20) dum20=1
if(cty.eq.21) dum21=1
if(cty.eq.22) dum22=1
if(cty.eq.23) dum23=1
if(cty.eq.24) dum24=1
if(cty.eq.25) dum25=1
if(cty.eq.26) dum26=1
if(cty.eq.27) dum27=1
if(cty.eq.28) dum28=1
if(cty.eq.29) dum29=1
if(cty.eq.30) dum30=1
if(cty.eq.31) dum31=1
if(cty.eq.32) dum32=1
if(cty.eq.33) dum33=1
if(cty.eq.34) dum34=1
if(cty.eq.35) dum35=1
if(cty.eq.36) dum36=1
if(cty.eq.37) dum37=1
if(cty.eq.38) dum38=1
if(cty.eq.39) dum39=1
if(cty.eq.40) dum40=1
if(cty.eq.41) dum41=1
if(cty.eq.42) dum42=1
if(cty.eq.43) dum43=1
if(cty.eq.44) dum44=1
if(cty.eq.45) dum45=1
if(cty.eq.46) dum46=1
if(cty.eq.47) dum47=1
if(cty.eq.48) dum48=1
if(cty.eq.49) dum49=1
if(cty.eq.50) dum50=1
if(cty.eq.51) dum51=1
```

```
if(cty.eq.52) dum52=1
if(cty.eq.53) dum53=1
if(cty.eq.54) dum54=1
if(cty.eq.55) dum55=1
if(cty.eq.56) dum56=1

*Estimation Of Cost Function And Share Equations
------------------------------------------------------------
system 7 / restrict noconstant rstat predict=prdcst list

****Cost Function****
ols lc ly lpo lpe lpk lpd lpp lpl lpn ly2 lpo2 lpe2 lpk2 lpd2 lpp2 lpl2 &
lpn2 lpope lpopk lpopd lpopp lpopl lpopn lpepk lpepd lpepp lpepl &
lpepn lpkpd lpkpp lpkpl lpkpn lpdpp lpdpl lpdpn lpppl lpppn lplpn  &
dum2 dum3 dum4 dum5 dum6 dum7 dum8 dum9 dum10 dum11 &
dum12 dum13 dum14 dum15 dum16 dum17 dum18 dum19 dum20 &
dum21 dum22 dum23 dum24 dum25 dum26 dum27 dum28 &
dum29 dum30 dum31 dum32 dum33 dum34 dum35 &
dum36 dum37 dum38 dum39 dum40 dum41 dum42 dum43 &
dum44 dum45 dum46 dum47 dum48 dum49 dum50 dum51 &
dum52 dum53 dum54 dum55 dum56 con

****Share Equations****
ols se lpe lpo lpk lpd lpp lpl lpn  con
ols sk lpk lpo lpe lpd lpp lpl lpn  con
ols sd lpd lpo lpe lpk lpp lpl lpn  con
ols sp lpp lpo lpe lpk lpd lpl lpn  con
ols sl lpl lpo lpe lpk lpd lpp lpn  con
ols sn lpn lpo lpe lpk lpd lpp lpl  con

*Restrictions
-----------------
```

****$\sum_i \alpha_i = 1$ and $\sum_i \beta_{ij} = \sum_i \beta_{ji} = 0$****

```
restrict lpo:1+lpe:1+lpk:1+lpd:1+lpp:1+lpl:1+lpn:1=1
restrict lpo2:1+lpope:1+lpopk:1+lpopd:1+lpopp:1+lpopl:1+lpopn:1=0
restrict lpope:1+lpe2:1+lpepk:1+lpepd:1+lpepp:1+lpepl:1+lpepn:1=0
restrict lpopk:1+lpepk:1+lpk2:1+lpkpd:1+lpkpp:1+lpkpl:1+lpkpn:1=0
restrict lpopd:1+lpepd:1+lpkpd:1+lpd2:1+lpdpp:1+lpdpl:1+lpdpn:1=0
restrict lpopp:1+lpepp:1+lpkpp:1+lpdpp:1+lpp2:1+lpppl:1+lpppn:1=0
restrict lpopl:1+lpepl:1+lpkpl:1+lpdpl:1+lpppl:1+lpl2:1+lplpn:1=0
restrict lpopn:1+lpepn:1+lpkpn:1+lpdpn:1+lpppn:1+lplpn:1+lpn2:1=0
```

```
****Equality of coefficients in cost and share equations****
restrict con:2-lpe:1=0
restrict lpe:2-lpe2:1=0
restrict lpo:2-lpope:1=0
restrict lpk:2-lpepk:1=0
restrict lpd:2-lpepd:1=0
restrict lpp:2-lpepp:1=0
restrict lpl:2-lpepl:1=0
restrict lpn:2-lpepn:1=0

restrict con:3-lpk:1=0
restrict lpe:3-lpepk:1=0
restrict lpo:3-lpopk:1=0
restrict lpk:3-lpk2:1=0
restrict lpd:3-lpkpd:1=0
restrict lpp:3-lpkpp:1=0
restrict lpl:3-lpkpl:1=0
restrict lpn:3-lpkpn:1=0

restrict con:4-lpd:1=0
restrict lpe:4-lpepd:1=0
restrict lpo:4-lpopd:1=0
restrict lpk:4-lpkpd:1=0
restrict lpd:4-lpd2:1=0
restrict lpp:4-lpdpp:1=0
restrict lpl:4-lpdpl:1=0
restrict lpn:4-lpdpn:1=0

restrict con:5-lpp:1=0
restrict lpe:5-lpepp:1=0
restrict lpo:5-lpopp:1=0
restrict lpk:5-lpkpp:1=0
restrict lpd:5-lpdpp:1=0
restrict lpp:5-lpp2:1=0
restrict lpl:5-lpppl:1=0
restrict lpn:5-lpppn:1=0

restrict con:6-lpl:1=0
restrict lpe:6-lpepl:1=0
restrict lpo:6-lpopl:1=0
restrict lpk:6-lpkpl:1=0
restrict lpd:6-lpdpl:1=0
restrict lpp:6-lpppl:1=0
restrict lpl:6-lpl2:1=0
restrict lpn:6-lplpn:1=0
```

```
restrict con:7-lpn:1=0
restrict lpe:7-lpepn:1=0
restrict lpo:7-lpopn:1=0
restrict lpk:7-lpkpn:1=0
restrict lpd:7-lpdpn:1=0
restrict lpp:7-lpppn:1=0
restrict lpl:7-lplpn:1=0
restrict lpn:7-lpn2:1=0
end

gen so=1-se-sk-sd-sp-sl-sn
gen socheck=po*o/(po*o+pe*e+pk*k+pd*d+pp*p+pl*l+pn*n)

stat / all
stop
```

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