Statistical cost analysis of long-terrm care facilities in Montana with policy implications
by Bernard Nicholas Ries

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University

Abstract:
The objective of this research is to determine the effects selected facility characteristics have on cost per patient day for long-term care in Montana. The main hypotheses test the relationships between cost and ownership, location, size, quality and occupancy rate. The final results are used to project added expenses incurred from subsidizing small relatively costly long-term care facilities.

Ordinary least squares regression analysis is the main statistical tool used in this study. The selected characteristics are defined as the explanatory (independent) variables and relevant cost categories are used as the dependent variables. The estimated regression coefficients indicate the change in the average cost per patient day given a change in explanatory variables.

The final estimated average cost model is used to estimate average cost per patient day given location, ownership, size, occupancy rate and quality level. A least cost facility is also determined and the average cost per patient day is estimated. This estimated cost is compared with the current actual cost of long-term care in Montana and savings to the State are determined for funding only least cost facilities.

The final conclusions indicate location has no significant effect on average cost. Economies of scale are indicated as inverse relationships between cost and size. A similar5 relationship exists between cost and occupancy rate and suggests economies of full utilization. The least cost facility size is 122 beds. The estimated potential cost saving to the State for funding only least cost facilities ranges from one to four million dollars. These savings may be totally offset by added costs of developing least cost facilities.

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A thesis submitted in partial fulfillment
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ABSTRACT

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Chapter 1

INTRODUCTION TO THE STUDY

Objectives

This research studies the nursing home industry in Montana. Certain objectives are used as guidelines to limit the scope of the research. They are:

1) Review of a general economic model which relates costs to operational characteristics, location (relative to the population of the community in which the facilities exist), and type of ownership.
2) Estimation and application of this model to determine the change in costs relative to changes in characteristics, the services provided and the ownership structures.
3) Use of the estimated results to determine if economies of scale have been reached in the industry in Montana.
4) Projection of added expenses to the State incurred from subsidizing small relatively costly nursing home facilities.

The ownership structure is tested to determine how it affects costs. The Montana industry is composed of proprietary, government (county) and charitable facilities. The costs differences are determined for the two categories of profit (proprietary) and non-profit (church, government) facilities. The main emphasis is placed on the test of the hypothesis that costs differ because of the different incentives for provision of care that exist between the two types of facilities.

This study also examines the influences of facility location on cost of operation. In particular, potential cost differences between rural and non rural areas are analyzed. The hypothesis that higher costs are found in rural areas is tested. It is believed that in the smaller communities the awareness of the conditions in the home and the personal acquaintances that exist between the employees, patients and families do affect the cost structure.

Finally, the research analyzes the relationship between costs and size. An analysis is conducted to determine if economies of scale have been reached in such categories as salaries, operation expenses, nursing services and total costs.

Demand for Long-Term Care

In 1972, for the first time, Medicaid expenditures for nursing home care exceeded payments for surgical and general hospitals in the United States. This amounts to \$2 out of every \$3 of revenue received by nursing homes.[1] The demand for public support is expected to

[1]"Nursing Home Care in the United States: Failure in Public Policy", Introductory Report. Subcommittee on Long-Term Care of the Special Committee on Aging, United States Senate, U. S. Government Printing Office, November 1974, pp. 1-7.

continue to increase because the fastest growing population group in the U. S. is the age group of 75 years and over.

In the past half century the percentage of older citizens in the U.S. has more than doubled with the present population of people 65 and older approaching the ratio of 1 to 10. Life expectancy has increased from 43 years in 1900 to 73 years at the present. By the end of this century it is expected that the number of Americans age 65 and over will approach 32 million.[2]

In recent years the population in the age group of 65 to 74 has ranged from 12.5 million in 1970 to 13.2 million in 1973, a 1.9 percent increase. In the age group of 75 and over the population ranges from 7.6 million in 1970 to 8.1 million in 1973, a 2.2 percent increase. Over the past ten years (1960-1970 the last census period) these age groups increased 1.2 percent and 3.1 percent respectively. The age group of 65 to 74 made up approximately 6.1 percent of the population in 1960 and also in 1970 (approximately 11 million in 1960 to 12.5 million in 1970). The 75 and over age group made up 3.1 percent of the population in 1960 and increased by 3.8 percent by 1970 (approximately 5.5 million in 1960 to 7.6 million in 1970).[3]

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[2] Simmons, Leo W. The Aged Ill. Appleton-Century-Crofts, Educational Division/Meredith Corp., New York, 1970, pp. 3.

[3] U.S. Bureau of the Census, Statistical Abstract of the U.S., 1974, pp. 31-33.

All of these statistics show that the older citizen in the U.S. is indeed a growing force. This force requires and demands services and aids of a special character which society has not been accustomed to providing. These services are in such areas as transportation, housing, financial aid and health care. To aid the reader in understanding the problems of providing long-term health care, a brief history of the nursing home industry follows.

History of the Industry

Facilities built to take care of the elderly have been discovered as far back in history as the pre-Renaissance period. As the Church became the main overseer of health care, hospitals and facilities for health care could always be found in cities where the large cathedrals were located. It was in the Renaissance period that the first institution that would later become the nursing home was developed -- the almshouse.[4]

The almshouse -- also called the poor farm, the county infirmary or the workhouse -- acted as a catch-all institution, housing orphans, diseased prostitutes, the blind, and other moral deviant and mentally distressed persons as well as the aged. The common denominator of the inhabitants was their dependence on the state for support

[4] Schneeweiss, Stephen, Nursing Home Administration. University Park Press, Baltimore, 1974, p. 1.

and their rejection by society. The passage of the English poor law enhanced the poor conditions in the almshouse even more (although it placed the responsibility on society to maintain the homes) by using the institution as a warning to everyone that idleness and lack of control in financial matters would not be tolerated by the state.[5]

These same general ideas were carried across the sea with the founders of our nation. The settlers established the almshouse to care for the undesirable, unwanted, and unfortunate of the early pioneer society. But one interesting fact that came about in the young society was the treatment settlers received when they suffered economic loss from Indian raids. Instead of having to go to the almshouse, they were given financial help by the community. This charitable deviation from the norm proved to be a significant step in reversing the errors of the almshouse.[6]

By the 1800's there was an increasing growing concern to improve the conditions which the poor faced. One of the main actions was to provide special care for particular groups which were previously confined to the almshouse. The objective was to develop a variety of institutions. Beginning in 1832 special attention was

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[5] McArthur, Ray F. "The Historical Evolution From Almshouse to ECF". Nursing Homes, Vol. 19, No. 4, 1970. p. 27.

[6] Schneeweiss, op. cit., p. 2.

given to the young blind. They were removed from the stifling atmosphere of the almshouse and placed in an institution of their own, receiving special training and aid. This led to the establishment of other facilities which could provide special treatment and specialized aid and training for such groups as the orphans, widows, veterans and other groups who were previously outcasts of the community. The discovery of the causes and cures for many communicable diseases also decreased the population of the almshouses by giving people who were once considered a deadly entity to the community a new start. All these changes had the effect of "skimming off" the people who had relatively solvable problems, leaving only the individuals for which society had no answers.[7]

The shift of the almshouse's population from a variety of aged and disadvantaged people to one of a highly concentrated type continued up into the 1930's. The almshouse became more and more a place where only old people were sent when their care became troublesome. But the almshouse, as it existed, had a short life left. In 1932, the Federal Government took the responsibility of providing for the poor, relieving much of the burden that was placed on the local governments. It was this shifting of responsibility, along with the

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[7] McArthur, op. cit., p. 26-27.

Social Security Act of 1935, which signalled the demise of the almshouse.[8]

With the creation of the Social Security Act, people were removed from the public institutions and brought back into the private sector--exactly opposite of the previous community goals. This shift was caused by the sudden awareness that local tax money could be saved by such action. To the surprise of the official agencies trying to place the people, unexpected aid was located in the private sector.[9]

A large proportion of the private aid was created by the economic conditions of the country. It was in the middle of the depression, with jobs and money both scarce. Many of the people affected were the ones who had large amounts of capital locked up in the ownership of their large homes. To protect themselves from further losses or even sale of their property, many individuals opened up their homes to the almshouse residents realizing the opportunity for increased income. The residents who were eligible for the Federal aid welcomed the chance to get out of the almshouse and into a more socially accepted existence. Finally, many of the almshouses closed down as

[8]Ibid, p. 27.

[9]Ibid, p. 27.

this initial start of the nursing home industry started to flourish across the country.[10]

As the industry grew, so did the problems that existed with it. The difference between the initial homes that were established and the homes that came into existence in the late 30's and early 40's was marked. The investors in the later homes soon realized that the method of payment not only provided no incentive to provide proper care, but also discouraged any aid beyond the minimal requirements to exist.[11] As the industry continued to grow, the government finally stepped in with regulations intended to increase quality of care.

The first count of nursing homes was conducted in 1939 by the Bureau of the Census. It revealed that there were approximately 1200 nursing, convalescent and rest homes with approximately 25,000 beds.[12] By 1954, there were 25,000 homes with more than 450,000 beds. These homes provided all types of care, ranging from boarding home care to intensive nursing care.[13]

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[10] Ibid, p. 27.

[11] Ibid, p. 27.

[12] Block, L. "Hospital and Other Institutional Facilities and Services, 1939." Vital Statistics - Special Report, Vol. 13, Nos. 1-57, U.W. Bureau of the Census, Washington, D.C. 1942.

[13] Division of Hospital and Medical Facilities: The Nation's Health Facilities, Ten Years of the Hill-Burton Hospital and Medical Facilities Program, 1946-56. PHS Pub. No. 616, U.S. Dept. of HEW, Washington, D.C., 1958.

Today there are more than 22,000 nursing and related homes in the U.S. There are approximately 12,800 nursing care homes (a facility in which over 50 percent of the residents receive nursing services and at least one R.N. or L.P.N. is employed more than 35 hours a week), 3,560 personal care homes without nursing care (a facility in which 3 or more personal services - eating, walking, bathing, etc. - are provided but not nursing services), and 190 domiciliary care homes (a facility in which less than 3 personal services are provided and no nursing care).[14]

There are more than 917,700 beds in nursing care and related homes today. This accounts for more than 3/4 of the total number of beds of all kinds for the care of the chronically ill and aged. There are also more than 283,890 beds available in other types of nursing care and related homes.[15]

A look at the ownership structure reveals that an estimated 75 percent of the nursing homes are operated under proprietary control with the rest under control of the government or some other non-profit entity. It is also estimated that proprietary homes have approximately 71 percent of the beds and 70 percent of the residents with an average

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[14] "Nursing Care and Related Homes". Health Resource Statistics. Health Services and Mental Health Administration, U.S. Dept. of HEW, Washington, D.C., 1974, p. 382.

[15] Ibid.

size home having 70 beds. The non-profit homes have the balance of the beds with an average size of 88 beds.[16] The services and costs vary, depending on the home, location, and type of ownership. The national expenditures for nursing home care rose from 1.1 percent of national health expenditures in 1950 to over 4.2 percent in 1969. Expenditures for nursing home care in actual dollars increased from $142 million to $2.84 billion, a 1,902 percent increase.[17]

The industry hires over 567,710 persons full-time. A breakdown analysis shows that there is approximately one full-time employee for every two patients. They consist of R.N.'s, L.P.N.'s, aids and orderlies, housekeepers, bookkeepers, and administrators.[18]

The number of homes in Montana has kept pace with national trends. In 1967 there were approximately 82 nursing homes in Montana. This number consisted of 45 nursing care homes, 20 personal care homes with nursing care, 15 personal care homes without nursing care and 2 domiciliary care homes. The number of residents in the facilities was 2,838. The facilities employed a total of 1,380 full-time employees.[19]

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[17] Rice, Dorothy P., and Barbara Cooper, "National Health Expenditures, 1929-1970", Social Security Bulletin, Vol. 34, January, 1971.

[18] "Nursing Care and Related Homes" Health Resources Statistics. p. 382.

[19] Ibid, 1969. pp. 269-281.

By 1971, the industry had grown to 103 homes, a 26 percent increase. This total consisted of 61 nursing care homes (36 percent increase), 27 personal care homes with nursing care (35 percent increase), 13 personal care homes without nursing care (13 percent decrease), and 2 domiciliary care homes (no change). The total number of residents in the facilities rose from 2,838 to 4,145, a 46 percent increase. The number of full-time employees increased 60 percent, from 1,380 to 2,201.[20]

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[20] Ibid, pp. 281-400.

Chapter 2

ECONOMIC THEORY OF COST

It is important to understand the economic concepts behind total, average and marginal costs in order to interpret any analysis of nursing home costs in Montana. These concepts are presented at the beginning of this chapter. Related studies are discussed in the second part of the chapter in an attempt to clarify the estimation techniques and economic theory used for this study.

Total Cost Curves

The starting point of a facility's cost structure is its total cost function. This function states the total cost of producing a given number of patient days of care in a certain time period. The function takes the following form:

$$TC(q) = f\ (q) + b$$

TC = Total Cost

q = number of patient days of care

b = fixed costs

The total cost function (TC) consists of costs incurred from producing "q" patient days of care plus total fixed cost "b".

The fixed cost is defined as the total cost incurred when "q" equals zero. It remains constant over all ranges of "q". The total variable cost is defined as the difference between total cost and total fixed cost.

$$TVC\ (q) = TC\ (q) - TFC\ (q)$$

In other words total variable cost is the portion of total cost which changes with changes in the number of patient days of care "q". Curves representing total cost, total variable cost and total fixed cost are shown in Figure 1.

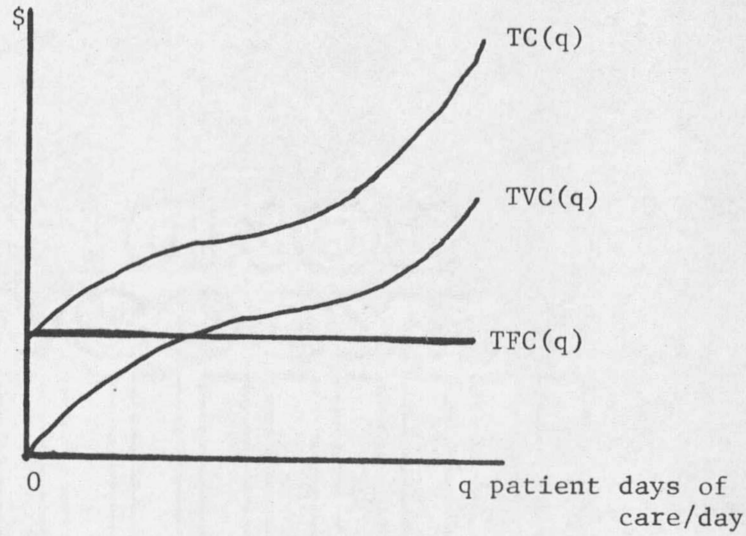

Figure 1. Total Cost Curves

Average Cost

Average cost can be broken down into two components, average variable cost and average fixed cost. Average variable cost is defined as total variable cost divided by the number of patient days of care "q".

$$AVC(q) = \frac{TVC(q)}{q}$$

For each unit of a variable input, output (q) increases. Ordinarily it increases at an increasing rate for the initial increments in variable inputs due to the positive effects which the additional units of inputs have on the productivity of the existing units of inputs. This means that the average variable cost is decreasing per patient day of care. However, as the amount of variable input continues to increase, the strength of this positive effect decreases and eventually becomes negative and output increases at a decreasing rate. This implies that average cost is increasing per patient day of care (Figure 2) as the number of patient days produced becomes larger.

Average fixed cost is defined as total fixed cost divided by the days of care "q".

$$AFC(q) = \frac{TFC(q)}{q}$$

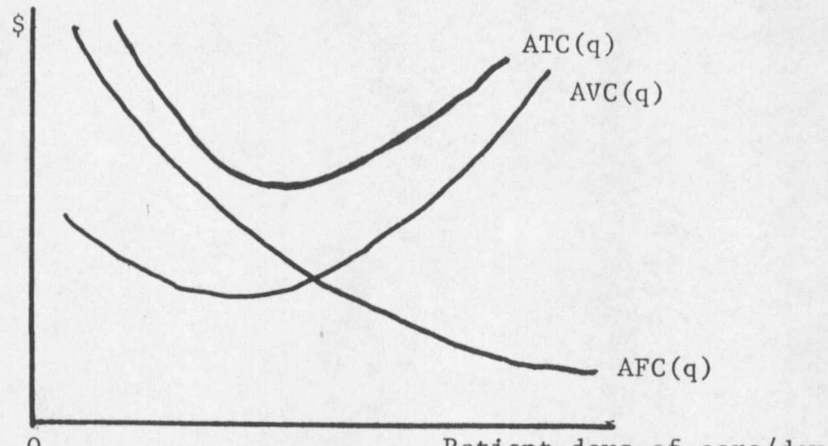

Figure 2. Average Cost Curves

Average fixed cost decreases continuously over the range of output (Figure 2). This is explained by the fact that total fixed cost remains constant over all levels of patient days of care. Average fixed cost is represented by the AFC(q) curve which approaches asymptotically both the vertical and horizontal. The curve markes AVC(q) represents average variable cost, first decreasing and then increasing as patient days of care provided in any given facility increases.

Marginal Cost

Marginal cost represents the change in total cost with respect to a unit change in output. The marginal cost function is stated as follows:

$$MC(q) = \frac{d}{dq} TC(q)$$

Mathematically, marginal cost is the derivative of total cost with respect to output "q" (Figure 3).

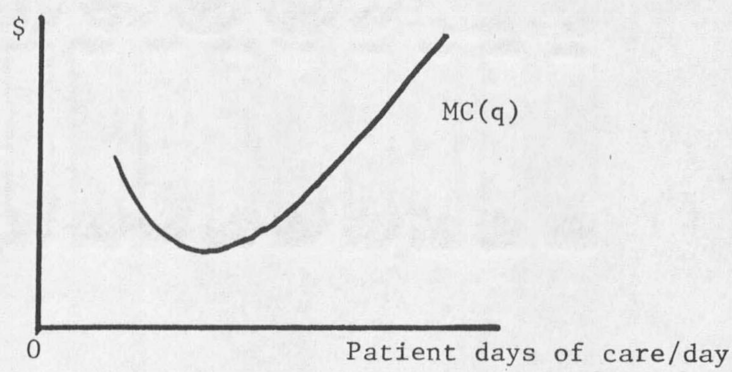

Figure 3. Marginal Cost Curve

Technically, the marginal cost curve represents the slope (rate of change) of the total cost (or total variable cost) curve as output increases from zero.

Figure 4 graphically shows how average and marginal cost are related. Average and marginal costs are equal when average cost is at a minimum.* Average cost multiplied by the number of patient days

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*Proof

1) Set derivative of average cost = 0

$$\frac{d}{dq} \frac{TVC}{q} = 0 \quad \text{AVC is at a minimum}$$

This equals:

$$\frac{q\frac{d}{dq} TVC - TVC}{q^2} = 0$$

2) To solve, the numerator must equal 0

$$q\frac{d}{dq} TVC - TVC = 0$$

This is the same as

$$q\ MC - TVC = 0$$

which equals

$$MC = \frac{TVC}{q}$$

Which is the same as

$$MC = AVC$$

$\therefore$ When average variable cost is at a minimum, it equals marginal cost.

of care "q" equals the total cost of care. Marginal cost indicates the rate of change in total cost.

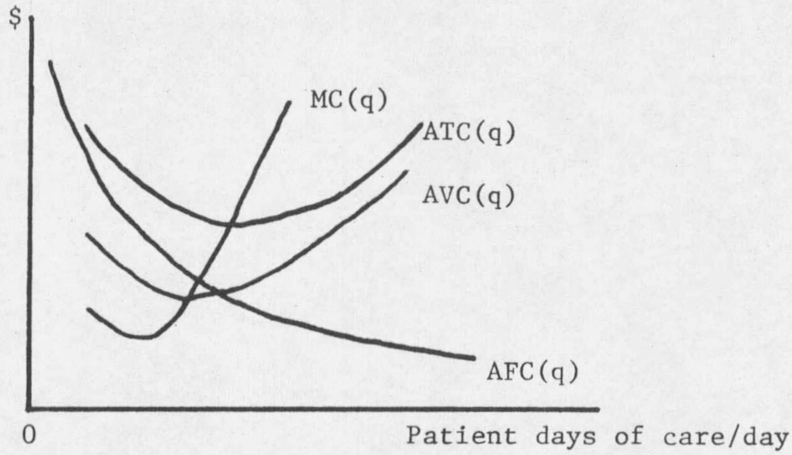

Figure 4. Marginal and Average Cost Curves

It is hypothesized that average cost will change as the selected characteristics of the long-term care facility change. The model developed in this study will be used to test specific hypotheses about the relationship between facility characteristics (ie, facility size, ownership structure, etc.) and average costs. An attempt will be made to determine a least cost facility size. In order to accomplish this objective, the concept of long run cost must be understood.

Long Run Cost

In the theories stated above, variable and fixed costs are discussed. By definition, fixed cost remains constant over all output, while the variable cost increases as output increases. In the long run all inputs (labor, capital, technology, etc.) and costs are variable. The relationship between the input mix and the total production of the facility is described by the concept of "returns to scale."

There are three types of "returns to scale"; decreasing, increasing and constant. Increasing returns to scale (economies of scale) are closely related to indivisibility of input units. In general, this means that productive equipment is available in a definite range of sizes. As the facility expands its output it moves from operating on a small scale to a larger more efficient operating size. Also, as the facility expands, specialization has a positive effect on productive returns. When a facility is experiencing increasing returns to scale (that is the percentage change in patient days of output is greater than the percantage change in inputs) long run average cost is decreasing.

Increasing returns to scale cannot last forever. At some point of production the percentage change in output will equal the percentage change of input. This is known as constant returns to scale. At this production level, long run average cost is at a minimum point.

Eventually decreasing returns to scale (diseconomies of scale) may set in. At this point of production, due to inherent inefficiencies of large scale operation, the percentage change in output is less than the percentage change of input. Long run average cost is increasing.

Using these concepts a least cost facility size can be determined.

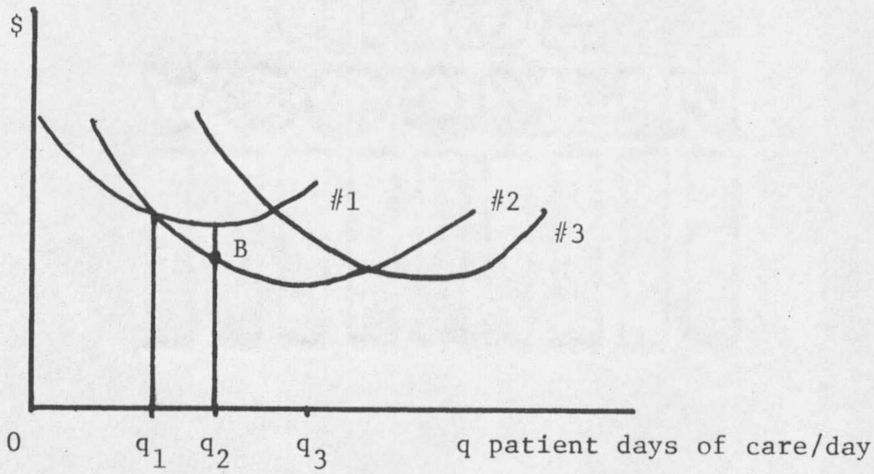

Figure 5. Short run average cost curves for three different facility sizes.

Three short run average cost curves are shown in Figure 5. Each represents the short run average variable cost of a different size facility. Curve #1 represents the variable cost of the smallest facility. Due to increasing returns to scale, the larger facility, size #2, has lower average variable cost, curve #2. Facility #3 is still larger and its average variable cost is higher (curve #3); the effect of decreasing returns to scale.

It can be seen that a facility of size #1 will be built if the expected patient days of output is between 0 and q_1. If output is expected to be approximately q_3, the facility of size #2 will be built. It can also be seen that if output is at q_2, (minimum average cost for facility #1) benefits could be gained by increasing facility size to that of facility #2, thereby lowering costs (point B). This proposition can be generalized:

> When there are increasing returns to scale, the minimum cost of any output can be obtained by operating, at less than its capacity, a facility that is larger than the facility whose own minimum cost corresponds to the output in question.[21]

Now, assume that the facility has the option to continuously adjust facility size upward. This would generate many short run average cost curves, as shown in Figure 6.

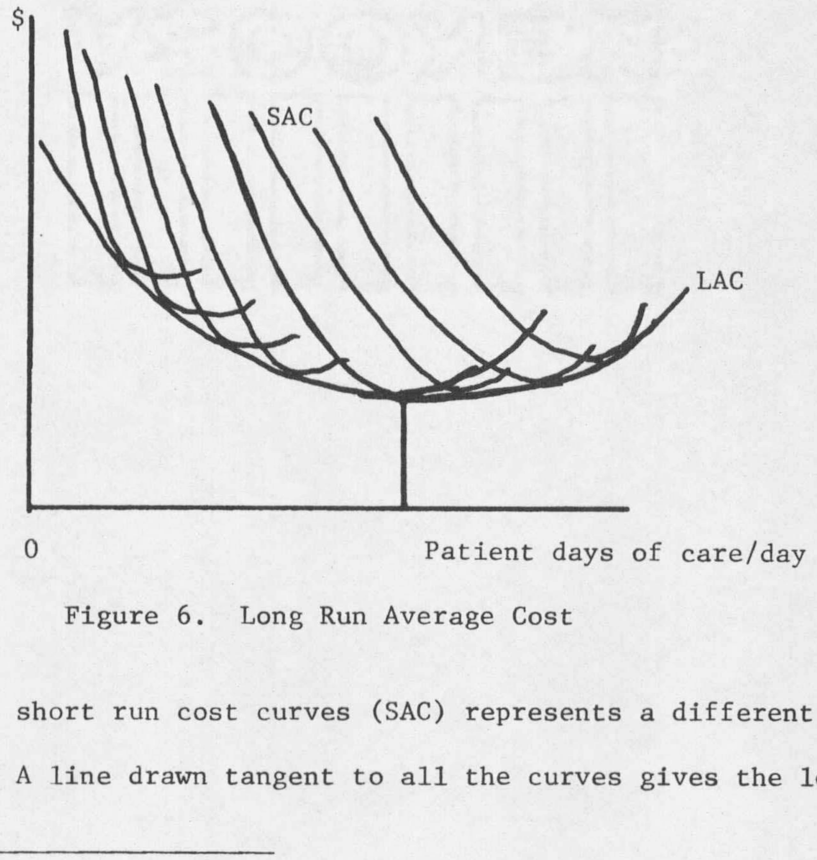

Figure 6. Long Run Average Cost

Each one of the short run cost curves (SAC) represents a different size facility. A line drawn tangent to all the curves gives the long

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[21] Ibid, p. 174.

run average cost curve (LAC). The short run and long run average cost curves are tangent at each other's minimum point only when constant returns to scale exist. When LAC is declining, it is tangent to the SAC to the left of their minimum points. When the LAC is rising, it is tangent to the right of the SAC minimum point.

The firm does not build all possible facility sizes to determine cost structures. In deciding what size facility to build, a survey is made of the range of minimum costs. These are determined by experience and/or research. The facility should then be capable of making a fairly reliable estimate of least cost facility size. For this reason the LAC curve is often called "the planning horizon" of the facility.

This study will attempt to determine a least cost long-term care facility size. This requires that the relationship between cost and size can be expressed as a cost minimizing function. The results will be analyzed to determine cost savings to the state, public and patients.

Empirical Cost Research

Various studies have been conducted to determine short run average cost of nursing home facilities. One such study will be used as a basic guide for this research. The study was conducted by Hersch S. Ruchlin and Samuel Levey on homes in the Commonwealth of Massachusetts as part of extensive research on nursing home care in Massachusetts.[22]

Their study was conducted on data covering the period from 1965 to 1969. The data was pooled and an aggregate regression equation was run setting operating costs per patient day as dependent variables and characteristics (size, ownership, age, percent public patients, etc.) as independent variables. Three alternative cost-size relationships were used for the regression equations. They consisted of a linear model, a parabolic model and a rectangular hyperbola model.

The Ruchlin-Levey study hypothesized that a positive relationship existed between cost and public (or charitable) homes as compared to private homes. The ownership variable was studies to determine if a difference existed between charitable and proprietary controlled homes. They hypothesized that the absence of a profit motive in the charitable homes leads to greater expenditures per patient (increased costs). An analysis of their findings revealed that there is a positive relationship between ownership type and cost. Charitable organizations generally have higher cost than proprietary organizations in all categories except for salaries, supplies, recreation, and property costs, where there is no relationship noted, except for property costs which are negatively related to charitable ownership. Their findings are supported by another study (conducted in 1972) in which the average total

[22] Ruchlin, Hersch S., Levey, Samuel, "Nursing Home Cost Analysis: A Case Study". Inquiry, Vol. 9, No. 4, September 1972, pp. 3-15.

cost per resident day was higher in non-profit homes ($17.71) than in proprietary homes ($14.86).[23]

Under proprietary control, the Ruchlin-Levey study showed that costs are lower in almost all categories. This fact is used in discussion by charitable organizations concerning the quality of care received in proprietary homes. The implication is made that costs are lower not because the homes are run more efficiently, but because corners are being cut to increase profits. The main problem with the complaint is that no scale has been devised (or at least one that is widely accepted) which measures the quality of care to cost ratio.

Another study conducted in Minnesota concluded that no statistically significant differences in quality of care exist between proprietary and nonproprietary institutions. The study concluded that the qualities of administration and the characteristics of the employees explain variation in quality of care better than structural variables, including ownership.[24]

A different study (conducted in 1975) states that there is no support for the belief that proprietary facilities are significantly

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[23] "Selected Operating and Financial Characteristics of Nursing Homes", <u>Vital and Health Statistics</u>, U.S. Department of HEW, Series 13, No. 22, 1975, p. 3.

[24] Sherwood, Sylvia (ed) <u>Long-Term Care: A Handbook for Researchers, Planners, and Providers</u>. Vol 5. Spectrum Publications, Inc., New York, 1975, p. 141.

different in terms of nursing services provided than non-profit homes. It does state that fewer non-nursing employee hours are provided per patient day in proprietary facilities. This study is based on a matched comparison of proprietary and non-profit homes in the State of Washington.[25]

Location in the Ruchlin and Levey study is analyzed but the variable is discounted as an important variable. In their study, they hypothesized that costs would be greater if homes were located in the greater Boston area as compared to the rest of the Commonwealth. The main reason for such a hypothesis is that the cost of living is higher in Boston. From the analysis of their data, they determined that there was no consistent significant relationship between the region variables as specified and cost. Upon this conclusion the variable was considered an unimportant factor in cost determination.

The Ruchlin-Levey study uses the size variable in the determination of economies of scale (increasing returns to scale). The number of beds per facility is used as a measure for the size variable. The models they used state size as having a linear effect, a parabolic effect, and a rectangular hyperbola effect on costs. They

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[25] Winn, Sharon, "Analysis of Selected Characteristics of a Matched Sample of Non-Profit and Proprietary Nursing Homes in the State of Washington". Medical Care, Vol. 12, No. 3, March 1974, pp. 221-228.

hypothesized that economies of scale would show up as a negative signed coefficient in the linear model, a positive signed coefficient in the parabolic model, and a positive signed coefficient in the rectangular hyperbola model.* Their analysis of the models shows that the regression coefficients are practically the same for all variables in all three runs, except for the size variable which changes due to the nature of the models.

The analysis of their linear model results reveals that there is a negative relationship between size and average total cost, but it proves to be statistically insignificant. Analysis of the cost categories (a negative relationship - decreasing cost - indicating economies of scale) reveals the economies of scale hypothesis was supported in six other categories which make up about 80 percent of the total costs. The coefficients of these categories were all statistically significant.

A study conducted by Douglas Skinner and Donald Yett also posed the question of economies of scale (least cost facility size). As did Ruchlin-Levey study, the Skinner-Yett study reported a negative cost-size relationship, but due to differences in methodology, they also reported the existence of a least cost facility size. Due to a

* These particular models are discussed in chapter 4.

continuous negative cost-size relationship for the size of the institutions represented in their study, Skinner and Yett feel that a least cost size has not been reached and that additional cost savings would occur if larger facilities were constructed. From an analysis of their study, they estimated an "optimal" size institution of 88 beds (given an 83 percent occupancy rate as reported in their study). This estimate is similar to estimates offered by nursing home administrators as reported in a study conducted by Wells (1965, p. 40) and Kottke and Trainor (1968, p. 28).[26]

The Ruchlin-Levey study discusses the implications which are generated from the specifications placed on the size variable. They state that the linear estimation technique relationship does not permit the calculation of a least cost point, but the parabolic specification does. From their study, coefficients from both the linear and parabolic regressions were only significant for three cost categories (depreciation, laundry-linen, and recreation-rehabilitation). But, due to the signs of the regression coefficients, the last two values maximize costs. They explain the cause of this inverted U-shaped cost curve as being either an overstating of the curvature due to the use

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[26] Sherwood, Sylvia, Long-Term Care: A Handbook for Researchers, Planners, and Providers. pp. 148-149.

of the size variable and the size variable squared or due to the lack of reliable and precise data, stating that the cost curves may be the result of observations from cost curves at different quality levels.*

In the Ruchlin-Levey study, the two most important cost categories are nursing and dietary expense (52 percent of the total cost) followed in order by supplies, salaries, property, operations, depreciation, housekeeping, laundry and linen, and others. An analysis of the standard deviations of the mean cost data revealed that many of the cost categories fluctuate within a wide range of their mean values. They believe this was caused by a wide variability in quality and quantity of care rendered and the lack of sufficient accounting requirements.

No current research of this type has been conducted for the nursing home industry in Montana. This research will estimate the average costs relevant to selected characteristics for Montana facilities. The estimation techniques will be similar to that used in related research but the final conclusions will only apply to the industry in Montana. The analysis of the results will focus on determining if the industry in Montana is similar to the industry in other

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* This is explained in greater detail in chapter 4.

parts of the country, and to provide an analytical background for decision analysis. The final results will provide useful information to law makers, administrators and inevestors in the area of nursing home care in Montana.

Chapter 3

DATA

Nursing home cost reports filed with the Department of Social and Rehabilitation Service (SRS) are the source of data for this study. Each home which participates in the medicare-medicaid program is required to file such reports with the Department once a year. The reports consist of a balance sheet, statement of income and expenses, patient statistics and summary, cost per patient day, personnel staff, and charges to private pay patients schedules. Some reports are more complete than others in terms of information provided. Most reports are of the standard form supplied by the SRS and completed by an accountant or an accounting firm.

Permission for access to the cost reports of the private facilities was obtained by means of mail and telephone requests. The cost reports of government owned facilities are public knowledge and can be acquired upon request. Responsible personnel and administrators were informed as to what data was needed and why and assured of confidentiality.

The actual sample size consists of fifty nursing homes. These homes were in the medicaid-medicare program in 1974 (the sample time period). The potential sample size numbers 75 homes.* Of the

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*State institutions and homes not participating in medicare-medicaid twenty-five homes not in the actual sample, sixteen would not release such information, three had a change of administrators and could not release the preceding administrator's reports, four were still considering the request (time limit prevented further waiting), and two did not have the power to grant permission for release of their cost reports. The actual sample size is 66.7 percent of the potential sample.

Characteristics

The data was compiled and the mean, standard error and range were determined for each cost category. The categories and the results are listed in Table 1. The figures include reports that were filled out as hospital-nursing homes (26 percent of sample) in which costs were not broken down. Comparison of these means with means generated by facilities providing nursing services only, shows four categories significantly different. The cost categories of x-ray, laboratory, administrative and general, and total operating expense are statistically different at an .005 level of significanc indicating lower mean cost for nursing homes. Further analysis of the x-ray and laboratory expense categories shows they are not significantly different from zero for nursing homes. This implies that the average nursing

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*continued. are not included in the potential sample (potential sample equals 72.8 percent of total facilities).

Table 1

Expenses Incurred from Operation - Total Sample[1]

Expense Categories	Mean	Standard Error[3]	Range
Employee Health & Welfare	$24,838.00*	4,359.08	183,461.93
Dietary	63,408.74*	6,557.22	263,911.81
Housekeeping	14,977.40*	2,410.48	98,127.00
Laundry & Linen	12,760.58*	2,157.29	90,013.75
Operation & Maintenance	30,013.32*	3,443.42	132,306.68
Medical Supplies	3,254.69*	1,240.59	36,394.73
Pharmacy	6,174.27*	2,191.90	82,202.00
Therapy	3,342.62**	1,418.21	54,518.00
X-Ray	4,493.75[2]**	2,000.70	69.034.93
Laboratory	4,142.44[2]**	1,683.70	50,936.34
Others	23,498.24*	3,489.39	94,498.62
Administrative & General	47,272.00[2]*	5,924.00	189,922.00
Nursing & Supplies	133,336.65*	17,753.33	777,852.87
Total Operating Expense	372,829.00[2]*	44,703.00	1,918,203.00

[1]Data consist of all valid observations for nursing homes and hospital-nursing homes.

* Significant at .005 level.
** Significant at .01 level.

[2]Mean of expense category significantly different for nursing home data alone, at the .005 level;

Category	Mean (Nursing home data)
x-ray	184.87
laboratory	265.02
admin. & gen.	29840.00
Total oper.	344395.00

[3]Standard error = $\frac{\sqrt{\text{variance }(\bar{X})}}{\sqrt{n}}$

homes have little or no expenses in these categories. Therapy expense becomes insignificant at the .05 level and medical supplies and pharmacy at the .10 level indicating that these expenses are not important determinants of total operating cost for nursing homes. Additional analysis of the total sample size shows that therapy and laboratory expenses are statistically different than zero at the .01 level of significance while x-ray expenses become significant at the .025 level. The remaining categories are significantly different from zero at the .005 level (99.5 percent confident).

A breakdown of the cost categories into percentage of total cost is given in Table 2. The three largest cost categories are nursing and supplies, dietary, and administrative and general. They compose 65.5 percent of the total operating costs. Nursing and supplies covers all expenses dealing with nursing services including the cost of aides and orderlies. Dietary expense is composed of all costs dealing with food and kitchen help while administrative and general expense covers cost of administrative activities. A detailed breakdown of these cost categories is presented in Table 3. The smallest contributors to total cost, medical supplies and therapy, only make up 1.8 percent of the total expenses.

Table 2

Percentage Breakdown of Total Operating Expenses

Expense Category	Percentage of Average Total Operating Expense[1]
Employee Health & Welfare	5.7
Dietary	17.0
Housekeeping	4.0
Laundry & Linen	3.4
Operation & Maintenance	8.0
Medical Supplies	0.9
Pharmacy	1.6
Therapy	0.9
X-Ray	1.2
Laboratory	1.1
Others	6.3
Administrative & General	12.7
Nursing & Supplies	35.8
	99.6[2]

[1]Percentage = mean of Expense Category/mean total operating expense.

[2]Not equal to 100 due to rounding error.

Further breakdown of the three largest expenses (Table 3) shows that salaries for the aides and orderlies are the largest expense in the nursing and supplies category while food expense is the largest component of the dietary category. In the administrative and general category salaries for administration purposes are the largest expense followed by interest expense. Depending on the age of the nursing home and how the construction was financed, interest expense varies (with a range of $63,000.00) from home to home.

Looking at the category of nursing and supplies expense shows that the average number of aides and orderlies per home is 42.7 with a range going from 10 to 96. They work, on the average, 30,509 hours per home receiving an average gross salary of $71,723.44 per home. This means the average aide or orderly works 714.5 hours per year at a wage rate of $2.34 per hour. The average number of registered nurses working per home equals 6.3 ranging from a minimum of zero to a maximum of 18. The average gross hours worked per home is 5,843.3 with the gross wages averaging $25,062.15 per home. The average wage rate per registered nurse is $4.29 with the average work time equal to 927.5 hours per year. The average number of licenses practical nurses per home is 4.9 with the mean gross hours worked per home equal to 5,391.9. The average gross salary is $16,597.79 per home, resulting in a wage rate of $3.08 per hour with the average L.P.N. working 1,100 hours per year. The number of L.P.N.'s per home ranges from zero to a maximum of 14. A breakdown

Table 3

Breakdown of Nursing Service and Supplies, Administrative and General, and Dietary Expense Categories

Nursing & Supplies

Percentage of total operating expense 35.8 Category	Percentage of average nursing & supplies
Salaries - R.N.	14.8
Salaries - L.P.N.	11.8
Salaries - Aides & Orderlies	46.2
Supplies	2.7
Others[1]	24.5
	100.0

Dietary

Percentage of total operating expense 17.0 Category	Percentage of average dietary
Salaries	46.6
Food	49.0
Supplies	2.9
Others[1]	1.5
	100.0

Administrative & General

Percentage of total operating cost 12.7 Category	Percentage of average administrative & general
Salary - Administrative	36.7
Salary - Office	13.3
Office, Supplies	4.6
Telephone - Telegraph	2.8
Vehicle	1.0
Travel	1.9
Advertising & Public Relations	0.5
Licenses & Dues	1.6
Professional Service	7.5
Interest	23.9
Miscellaneous	6.2
	100.0

[1] Consist of costs that would not fit given categories.

of the personnel categories is listed in table 4.*

The size of the nursing home is determined by the number of licensed skilled nursing care beds (SNC) plus beds licensed as intermediate care A, care B, and boarding home care. Table 5 lists the types of licensed beds, giving the average number per home, actual patient days, and percent of occupancy.** It is noted that the average number of licensed boarding home care beds is almost insignificant. This can be explained by the fact that the sample consisted of only two homes with licensed boarding home care beds. The table also gives the cost per patient and the charge per patient day (private pay patients).*** The cost per patient day for SNC for the nursing home data is significantly different than that of the total sample, averaging close to $13.50. The means of the other costs are relatively the same for either data set.

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*Due to the lack of completed personnel wage and hours worked forms, these figures are based on a sample size of 12 homes. The data consist of full-time and part-time help.

**In some facilities the occupancy rate for a certain type of licensed bed may exceed 100 percent. This is explained by the fact that the facility is providing more patient days of service than the actual number of licensed beds can provide (ie., patients in beds licensed as intermediate care A receive SNC care).

***Cost per patient day equals total cost of providing care for a type of bed/total number of patient days reported for each type of bed.

Table 4

Personnel*

Job Title	Average # 1 home	Range
Housekeepers	4.3	0-14
Kitchen-Dietary	11.1	4-21
R.N.	6.3	0-18
L.P.N.	4.9	0-14
Aids-Orderlies	42.7	10-96
Laundry	2.3	0-11
Managers	1.2	0-4
Maintenance	1.5	0-6
Bookkeeper-Med. Records	2.1	0-10

*Sample size = 12, all categories include full-time and part-time help.

Table 5

Average Size, Cost per Day, Charge per Day in Total Sample[1]

	Mean	Std. Error[4]	Range
SNC			
Lic. Beds	30.9	5.13	229
Actual Patient Days	8991.5	1803.5	81,373
Percent Occupancy	79.9	5.56	117.2
Intermediate Care A			
Lic. Beds	14	2.38	78
Actual Patient Days	5786.4	895.3	32,034
Percent Occupancy	113.2	9.17	298.2
Intermediate Care B			
Lic. Beds	3.79	1.2	36
Actual Patient Days	1978	437.6	13,021
Percent Occupancy	142.9	6.29	170
Boarding Home Care			
Lic. Beds	18.1**	1.75	86
Actual Patient Days	618.4**	603.4	29,573
Percent Occupancy	93.6	2.7	100
Cost			
Cost/patient day - SNC	16.21[3]	1.35	30.99
Cost/patient day-Int. Care A	14.03	1.84	74.99
Cost/patient day-Int. Care B	5.99	1.0	19.5
Cost/patient day-Boarding Care	.50*	136	14.42
Charge (private day patient)			
Charge/day - SNC	17.92	.475	12.27
Charge/day- Int. Care A	15.51	.424	12.39
Charge/day - Others[2]	12.42	.715	10.59

[1]Data consist of all 49 valid observations, nursing home and hospital-nursing homes.

[2]Others = Int. Care B + Boarding Home Care.
* Significant at .10 level.
**Insignificant value (do not reject null hypothesis of mean = 0)

[3]The difference between the mean of the complete data sample (hospital-nursing home + nursing homes) and just nursing home data is significant at the .01 level.

[4]Standard error = $\sqrt{\frac{\text{variance }(\bar{X})}{\sqrt{n}}}$

A crosstabulation between ownership and number of licensed beds is given in Table 6. The homes are classified as either profit or non-profit, nursing home or nursing home-hospital. The number of beds per home are put into relative ranges. The number of homes in each range is also given.

Table 7 shows the relationship between ownership and total operating expense. The observations are put into ranges determined by their total operating expense. The percentage of each type of home within the range is also given. Inspection of the table reveals that government homes comprise 50 percent of the homes in the expense ranges of $100,000 to $150,000 and $400,000 to $450,000. Of all the homes with over $450,000 expenses, government homes lead the way with over 36 percent of the facilities in that range. Further analysis shows that 26.6 percent of all government nursing homes are in that range.

Analysis of other relationships using ownership type as the base show that 50 percent of the profitable corporate owned homes make over $10,000 net profit per year. This accounts for over 33 percent of the homes in that range. Over 78 percent of the non-profit government homes make under $100 net profit per year (could be negative). This comprises 55 percent of the homes in that range. Fifty-seven percent of profitable individually owned homes are in the range of $10,000 or over net profit while only 7.1 percent of the non-profit government

Table 6

Crosstabulation Between Ownership and Licensed Beds[1]

Type	SNC #	SNC Range	Intermediate A #	Intermediate A Range	Intermediate B #	Intermediate B Range	Boarding #	Boarding Range
Non-Profit/ Church	1	0-10	1	0-10	1	0-10	3	0-10
	1	30-40	2	10-20	2	20-30	1	Over 70
	1	40-50	1	30-40	1	30-40		
Non-Profit Assn.	1	50-60						
	1	20-30	1	20-30	1	0-10	1	0-10
Non-Profit Govt.	3	0-10	7	0-10	14	0-10	14	0-10
	4	30-40	2	10-20				
	4	40-50	3	20-30				
	2	50-60	1	30-40				
	1	Over 70	1	Over 70				
Proprietary/ Individual	4	0-10	4	0-10	4	0-10	7	0-10
	2	10-20	2	20-30	2	10-20		
	1	30-40	1	30-40	1	20-30		
Proprietary/ Partnership	1	20-30	1	40-0	1	1 - 10	1	0-10
Proprietary/ Corp.	2	0-10	4	0-10	7	0-10	8	0-10
	3	30-40	1	10-20	1	10-20		
	2	50-60	1	20-30				
	1	Over 70	2	30-40				
Non-Profit Assn.*	2	0-10	5	0-10	8	0-10	8	0-10
	4	10-20	2	10-20				
	1	20-30	1	20-30				
	1	30-40						
Non-Profit/ Gov't. H-N*	1	0-10	3	0-10	5	0-10	5	0-10
	2	10-20	2	10-20				
	2	20-30						
Proprietary/ Corp.H-N*	1	0-10	1	0-10	1	0-10	1	0-10

[1] Insufficient information for one home, sample size = 49.
* H-N = Hospital - Nursing home.

Table 7

Crosstabulation Between Ownership and Total Operating Expenses[1]

Type	Range ($1000)	% of type	# of observations
Non-Profit/ Church	250-300	25.0	1
	300-350	25.0	1
	350-400	25.0	1
	over 450	25.0	1
Non-Profit Assn.	250-300	100.0	1
Non-Profit/ Gov't.			
	100-150	13.3	2
	200-250	13.3	2
	250-300	20.0	3
	350-400	13.3	2
	400-450	13.3	2
	over 450	26.6	4
Proprietary/ Individual	.1-50	14.3	1
	50-100	14.3	1
	100-150	14.3	1
	150-200	28.6	2
	250-300	14.3	1
	not given	14.3	1
Proprietary/ Partnership	400-450	100.0	1
Proprietary/ Corp.	100-150	12.5	1
	150-200	12.5	1
	250-300	25.0	2
	300-350	25.0	2
	350-400	12.5	1
	over 450	12.5	1
Non-Profit Assn. H-N*	300-350	12.5	1
	350-400	12.5	1
	400-450	12.5	1
	over 450	25.0	2
	not given	37.5	2
Non-Profit Gov't. H-N	150-200	20.0	1
	over 450	40.0	2
	not given	40.0	2
Proprietary/ Corp. H-N	over 450	100.0	1

[1]Not given = information inadequate or not given in cost reports

*H-N = hospital-nursing home.

homes are in that range. A breakdown of the sample related to location shows 44 percent of the observations are located in communities under 2,000 population. Of this amount, 22.7 percent are non-profit government homes with the rest being profitable entities.

SUMMARY

The three largest cost categories are nursing services, dietary and administrative expense. A breakdown shows that salaries for aides and for administrators are the largest expense in nursing services and administrative expense, respectively. The average number of beds are 31 SNC, 14 intermediate care A, 4 intermediate care B and 2 boarding home care. The mean for boarding home care beds is not significantly different from zero. Forty-four percent of the homes in the sample are located in a community with a population of under 2,000 (1970 census). Of this amount, 22.7 percent are non-profit government (county) homes while the rest are for-profit, either corporate or private owned. One other noticeable occurrence is that four of the cost categories have significantly different means when comparing the complete data sample agains the nursing home data. All four (x-ray, laboratory, administrative, and total operating cost) have lower means for nursing homes indicating that higher costs are generated by the existence of the hospital facility. This is investigated further in the following chapter.

Chapter 4

MODEL DEVELOPMENT

Introduction

In this chapter (1) a cost estimation technique relevant to the Montana nursing home data is described, (2) the Ruchlin-Levey study is discussed, (3) the results of a similar model pertaining to Montana are presented, (4) alternatives to the Ruchlin-Levey model are evaluated, and (5) a final estimation model is developed. (See Table 8 for model descriptions.)

Statistical Estimation Model

Ordinary least squares (OLS) regression analysis is the main statistical tool used in this study. It hypothesizes that a change in one variable (the "dependent" variable) can be explained by reference to changes in other explanatory variables. This relationship is described by a "multiple linear regression equation" of the following form:

$$Y_i = \beta_1 + \beta_2 X_{i2} + \beta_3 X_{i3} + \ldots \beta_k X_{ik} + \varepsilon_i$$

Y denotes the dependent variable and the X's the explanatory variables (independent variables). The stochastic nature of the regression model implies that for every value of X there is a whole probability distribution of values of Y. The stochastic disturbance ε imparts this randomness to Y. The β_1 coefficient is equal to the

Table 8

Regression Model Analyzed in Chapter 4

Independent Variables	Model Study Area Table #	Ruchlin-Levey Boston area 10	Similar Model Montana 11	Ruchlin-Levey (Parabolic) Boston area 12	Similar Model (Parabolic) Montana 13	Final Model Montana 14
Size		X	X	X	X	X
$Size^2$				X	X	X
Ownership		X	X	X	X	X
Age		X		X		
Location		X	X	X	X	X
% Public Pay Patients		X		X		
Occupancy Rate		X	X	X	X	X
Year		X		X		
Quality						X
Interaction (Location & Size)						X
Certification		X		X		

mean of Y when each of the explanatory variables is equal to zero. Each β_k equals the change in the dependent variable Y corresponding to a unit change in the k^{th} explanatory variable, holding the remaining variables constant.[27] The disturbance term (ε_i) is assumed to possess the following properties:

1) $E(\varepsilon_i) = 0$ (all i)
2) $E(\varepsilon_i \varepsilon_j) = 0$ ($i \neq j$)
3) $E(\varepsilon_i^2) = \sigma^2$ (all i)

The first property states that if all the unobservable error terms could be summed, their total would equal zero. Assumption number two implies that there is no linear relationship between error terms. The final assumption states that the variance remains constant across all observations.

The regression analysis in this study uses average cost per patient day of nursing home care as the dependent variable (Y) and selected characteristics of the facilities as the explanatory variables (X_k). Each estimated β_k measures the change in average cost given a change in the k^{th} characteristic. The sign of the estimated coefficient will depend on the relationship between the dependent and explanatory variables. A negative coefficient indicates

[27] Kmenta, Jan, Elements of Econometrics, Macmillan Comp., New York 1971, pp. 347-349.

an inverse relationship between average cost and the explanatory variable, while a positive coefficient implies a positive relationship.

Variables

The cost categories, as determined by the use of the nursing home cost reports, act as dependent variables. Each category is stated as cost per patient day, and is determined by dividing total cost by total patient days. Each cost category along with its variable name and mean value is given in Table 9. The variable name is used for identification purposes in the regression program. Selected characteristics of the nursing homes are used as explanatory variables. The hypotheses being tested act as the guide for the specification of the variables. The explanatory variables used in this analysis and their mean values are listed in Table 9. The ownership and location variables are stated as binary variables.* The ownership variable enters the regression as "1" if the home is run for profit and "0" if it is non-profit. Location enters as "1" if the facility is located in a community of under 2,000 population and "0" if the community has more than 2,000 residents.

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*A binary variable is used in regression analysis to indicate the occurrence of a certain event. It is stated as either 0 if the event does not occur or 1 if it does. A more complete description can be found in Elements of Econometrics, Jan Kmenta, pp. 409-430.

Table 9

Cost Categories (Dependent Variables)

Cost Category ($/patient/day)	Variable Name	Mean Values
Administrative (salaries, office supplies)	TAG	1.912
Employee's health & welfare	TEHW	1.006
Dietary (salaries, food, supplies)	TDE	2.877
Housekeeping	THE	.563
Laundry & Linen	TLLE	.511
Operating & Maintenance (utilities, repairs, insurance)	TOME	1.394
Medical Supplies	TMSE	.045
Pharmacy	TPE	.081
Therapy	TTE	.083
X-ray	TXRE	.003
Laboratory	TLE	.004
Nursing services (salaries - RN, LPN, aides)	TNSE	5.864
Other operating (depreciation, rent, taxes)	TOOE	.985
Total Operating Expense	TOPE	15.403

Selected Characteristics (Independent Variables)

Characteristics	Variable Name	Mean Values
Ownership (Profit or non-profit)	OWN	.455
Location (located in a community of under 2,000 or over 2,000, 1970 census)	POPI	.333
Percent Occupancy (total actual patient days/total available patient days)	PERC	.952
Size (SNC + care A + care B + boarding home care beds)	SIZE	62.667
Size squared	SIZX	5744.788
Interaction Variable (Size * POPI)	INTER	12.727
Quality (ratio of SNC beds to total number of beds)	QUAL	.544

Hospital-Nursing Home Data

Eight of the observations are from combination hospital and nursing homes. From examination of the cost reports it is not clear that costs are reported specific to each type of service. One could assume that all data in the cost reports pertain only to nursing home beds. However, is this assumption were false, there would be an overstatement of the estimated regression coefficient for any explanatory variable. Therefore it is necessary to attempt to determine on a statistical basis if the reported data from hospital-nursing homes in fact pertain only to nursing home beds.

The Chow Test[28] provides one method of addressing this question. The following regression equations are estimated:

1) $Y_i = \beta_1 + \beta_2 X_{i2} + \ldots + \beta_k X_{ik} + \varepsilon_i$ (nursing home data only)

2) $Y_i = \alpha_1 + \alpha_2 X_{i2} + \ldots + \alpha_k X_{ik} + \varepsilon_i$ (hospital-nursing home data only)

3) $Y_i = \theta_1 + \theta_2 X_{i2} + \ldots + \theta_k X_{ik} + \varepsilon_i$ (combined data sets)

The null hypothesis is stated as:

$$Ho: \beta_1 = \alpha_1, \beta_2 = \alpha_2 \ldots \beta_k = \alpha_k$$

This hypothesis states that the estimated coefficients from a regression run on nursing home data only are equal to the estimated coefficients from the same regression run on hospital-nursing home data. The alternative hypothesis is that they are not equal:

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[28] Kmenta, Jan, Elements of Econometrics, Macmillan Company, New York, 1971, pp. 373-4.

H_A: $\beta_1 \neq \alpha_1, \beta_2 \neq \alpha_2, \ldots, \beta_k \neq \alpha_k$

The results are given in Appendix B-1. They indicate that the estimated parameters for the hospital-nursing home data are significantly different from those of the nursing home data for only three cost categories: pharmacy, laboratory, and x-ray expenses. This suggests that the regression model for the nursing home data does not fully explain the variation in the hospital-nursing home data for these three cost categories.

Another method of analyzing the hospital-nursing home data set is by the use of interaction terms.*[29] The parabolic form of the linear

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[29]Kmenta, Jan, Elements of Econometrics, The Macmillan Company, New York, 1971, p. 418.

*The following demonstrates how an interaction term works:

$$Y = \beta_1 + \beta_2 X_1 + \beta_3 X_2 + \delta_1 X_1 Z + \varepsilon$$

β_2 and β_3 are the partial effects of X_1 and X_2, respectively. δ_1 shows the addition to β_2 given that the additional information pertaining to independent variable X_1 is entered in the equation.

$$E(Y|X_1 = 1, X_2 = 1, Z = 1) = \beta_1 + \beta_2 + \delta_1 + \beta_3$$

If the additional information does not apply to the observation, Z = 0 and the β_2 coefficient does not change,

$$E(Y|X_i = 1, X_2 = 1, Z = 0) = \beta_1 + \beta_2 + \beta_3.$$

regression model for Montana data is used as the basic regression equation.* A variable to control for the observation of a hospital-nursing home is added. Next, five interaction variables are added to control for the effect of the hospital-nursing home data in respect to size, size squared, location, percent occupancy, and ownership status (profit or non-profit).

An F-test statistic is used to determine the significance of the five interaction variables as a group. The null hypothesis tests if the coefficients of the additional explanatory interaction variables, as a group, are significantly different than zero:

$$H_o: \beta_{k+1} = \beta_{k+2} = \ldots = \beta_Q = 0$$

The results of the test conducted on the five interaction variables are presented in Appendix B-2. They indicate that the interaction variables are relevant in explaining the variation in all the cost categories. Apparently, with the use of interaction variables, the effects of the hospital-nursing home data can be controlled.

On the basis of the above tests it was decided not to use the hospital-nursing home data in further analysis. Any additional information gained by their inclusion is offset by a necessity to include six additional explanatory variables to control for the differences in the two data sets.

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*This model is described in full in the next section.

Similar Regression Models

The Ruchlin-Levey study estimated three regression equations. The two specifications of interest for this study are presented below.*

(1) $Y = \beta_1 + \beta_2 + \Sigma\beta_1 X_i + \varepsilon$ (linear)

(2) $Y = \beta_1 + \beta_2 + \beta_3 S^2 + \Sigma\beta_i X_i + \varepsilon$ (parabolic)

Y = dependent variable (costs)

β_1 = intercept

β_i = regression coefficient

S = size

Σ = summation symbol

X = independent variable

ε = error term

As independent variables, Ruchlin-Levey used size, ownership, certification, age, region, percent public patients, occupancy rate, and year of reimbursement payment. They hypothesized a positive relationship between cost and ownership, certification and region, and a negative relationship between cost and size, age (newer facilities having lower cost), percent of public patients and occupancy rate. The results of their regression for the linear model are presented in Table 10.

*The rectangular hyperbola model is not significantly different than the linear model and is not discussed.

The ownership variable shows the difference between non-profit and proprietary controlled homes. It was hypothesized that this variable would have a positive effect on cost because of the lack of profit incentives in non-profit facilities. The certification variable indicated if the facility was certified as an extended-care facility. It was hypothesized to have a positive effect on cost due to the higher cost of providing extended-care services. Age of facility was expected to reflect lower costs of operating a newer facility. Their region variable controlled for differences in "cost of living" within the sample area. The occupancy rate was expected to have a negative effect on costs reflecting the efficiencies of utilizing the facility to its capacity. Finally, the size variable was expected to show economies of scale by having a negative effect on cost.

The Ruchlin-Levey results indicate economies of scale in average total cost, salaries, supplies, operation and nursing care. The fact that the facility is run as a charitable facility has a positive effect on costs for all categories expect property expense. The certification variable also has the same effect. Newer facilities have lower costs for all categories except salaries, housekeeping and "other operating expenses". There were economies of full utilization (using the facility to its optimal capacity) for all categories except for "other

Table 10

Linear Regression Results - Ruchlin-Levey Study

	Dependent Variables											
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}
Independent Variables	Average total cost	Salaries	Supplies and Expenses	Property	Depreciation	Operations	Dietary	Laundry and Linen	Housekeeping	Nursing	Other Services	Recreation, Rehabilitation
Intercept	17.44	2.12	1.89	2.54	0.85	1.26	2.67	0.26	0.42	5.21	0.26	0.04
X_1 Size	-0.002 (0.85)	-0.003** (4.80)	-0.002** (4.28)	0.01** (10.68)	0.001 (1.02)	-0.002** (5.93)	0.003** (5.25)	0.001** (4.79)	0.001* (2.47)	-0.003** (3.05)	-0.001** (4.16)	-0.004** (2.64)
X_4 Ownership	2.56** (7.55)	0.11 (1.29)	0.07 (1.05)	-1.24** (11.27)	0.39** (7.11)	0.83** (14.85)	1.04** (15.51)	0.06** (2.76)	0.40** (9.83)	0.63** (4.41)	0.13** (4.71)	0.02 (1.09)
X_5 Certification	1.55** (6.67)	0.03 (0.50)	0.20** (4.08)	0.12 (1.63)	-0.11** (2.84)	0.08* (2.01)	0.19** (4.10)	0.03* (2.33)	0.10** (3.67)	0.74** (7.54)	0.06** (3.43)	0.09** (7.02)
X_6 Age	-0.83** (4.08)	0.13* (2.44)	-0.07* (1.99)	-0.41** (6.15)	-0.02 (0.58)	-0.03 (0.87)	-0.10* (2.48)	0.01 (0.71)	0.03 (1.19)	-0.33** (3.87)	-0.03 (1.66)	-0.01 (0.42)
X_7 Region	0.25 (1.43)	-0.13** (2.68)	0.05 (1.59)	0.11 (1.79)	-0.04 (1.32)	0.05 (1.77)	0.16** (4.58)	-0.004 (0.37)	0.04 (1.85)	-0.02 (0.23)	0.01 (0.22)	-0.01 (1.09)
X_8 Percent public patients	-0.05** (13.40)	-0.01** (9.51)	-0.01** (6.55)	-0.01** (5.41)	-0.001* (2.30)	-0.002** (4.04)	-0.005** (7.21)	-0.001** (3.28)	-0.001** (2.64)	-0.01** (8.95)	-0.002** (7.61)	0.0008** (4.10)
X_9 Occupancy Rate	-0.06** (7.29)	-0.01** (3.03)	-0.01** (4.49)	-0.02** (5.92)	-0.01* (2.23)	-0.005** (3.69)	-0.01** (5.10)	-0.001 (1.49)	-0.002 (1.53)	-0.01** (3.72)	-0.0003 (0.46)	-0.001 (0.09)
X_{10}(1)	1.29** (5.47)	0.24** (3.83)	0.12** (2.81)	0.02 (0.30)	-0.01 (0.38)	0.04 (1.16)	0.16** (3.36)	0.04** (2.60)	0.06* (2.06)	0.49** (4.98)	0.03 (1.41)	0.03* (2.32)
X_{10}(2) Year (2)	2.29** (11.79)	0.12** (2.29)	0.25** (7.15)	0.15* (2.33)	-0.01 (0.20)	0.04 (1.41)	0.19** (4.86)	0.06** (4.98)	0.15** (6.37)	1.21** (14.84)	0.05** (3.43)	0.05** (4.79)
$\bar{R}^2$	0.61	0.23	0.29	0.43	0.10	0.33	0.47	0.21	0.31	0.53	0.22	0.25
F	110.17**	21.52**	29.71**	54.70**	9.15**	35.31**	64.29**	19.47**	32.68**	81.46**	20.25**	24.17**

Note: T values are in parentheses.
* Denotes significant at the .05 level.
** Denotes significant at the .01 level.

operating" expenses.

Most of the variables in the Ruchlin-Levey study have a significant effect on the selected cost categories. The proportion of total variance explained in the model (R^2) varies from a high of .61 for the average total cost category to a low of .05 for the "other operating" expense category. The next step in the comparison is to develop a similar model suitable for the data collected on Montana nursing homes.

Due to the nature of the data collected, the closest model that could be developed contains only four independent variables: ownership, location, size and occupancy rate. The relationship between ownership and cost is hypothesized to indicate higher cost for non-profit facilities. The variable specifies if the facility is run for profit and should have a negative regression coefficient in all categories. The location variable describes the facility as being located in a community of under 2,000 population.* This variable is hypothesized to indicate higher cost of operation for facilities located in smaller communities due to different employee mix, input prices and community awareness. The size variable should reflect economies of scale, with a negative relationship between size and cost.

*This population level was selected after analysis of various population levels and how they related to the given sample (1970 census).

Table 11

Linear Regression for Montana Data

	TAG	TEHW	TDE	THE	TLLE	TOME	TMSE	TTE	TPE	TLE	TXRE	TNSE	TOOE	TOPE	MEAN	ST. ERROR
SIZE	-.0014	.0024	-.0023	.0022*	.0007	-.0022	.0008	.0024**	.0031**	.0004**	.0003**	-.0067	.0029	.0035	62.667	7.5367
	(.289)	(.943)	(.706)	(1.807)	(.571)	(.736)	(1.515)	(3.378)	(3.876)	(5.396)	(5.396)	(.794)	(.815)	(.195)		
OWN	.9809**	-.6291**	-.8379**	-.2148*	-.4485**	-.3389	-.0268	.0106	.0344	.0018	.0013	-2.2258**	.4482	-3.0844*	.455	.088
	(2.724)	(3.167)	(3.28)	(2.301)	(4.938)	(1.439)	(.610)	(.190)	(.543)	(.342)	(.342)	(3.359)	(1.620)	(2.160)		
PERC	3.5385	-.8222	-1.3226	-.7968	.6223	-2.4758	.3572	.6514	.8335	.0539	.0376	-2.6595	-5.4547*	-6.3578	.952	.0108
	(1.211)	(.51)	(.638)	(1.052)	(.844)	(1.296)	(1.003)	(1.433)	(1.621)	(1.251)	(1.251)	(.495)	(2.429)	(.549)		
POP1	-.3993	.3723	-.0747	.0403	.056	-.0542	.0258	-.0563	-.031	.0063	.0044	-.3593	.2915	.0142	.333	.0833
	(.987)	(1.669)	(.261)	(.385)	(.550)	(.205)	(.522)	(.895)	(.436)	(1.061)	(1.061)	(.483)	(.938)	(.009)		
INTER-CEPT	-1.6854	1.801	4.6844	1.2699	.0626	4.0596	-.3428	-.6739	-.9134	-.0736	-.0513	9.946	5.6962	22.6296		
R^2	.2558	.3366	.2855	.3249	.5126	.1148	.1308	.3905	.4173	.5314	.5314	.2976	.2623	.1686		
F	2.4063	3.5517*	2.7966*	3.3684*	7.3613**	.9077	1.0532	4.4841**	5.0121**	7.9379**	7.9379**	2.9656*	2.4893	1.4189		
MEAN	1.912	1.006	2.877	.563	.511	1.394	.045	.083	.081	.004	.003	5.865	.985	15.403		
ST. ERROR	.1857	.1086	.1345	.0506	.0579	.1114	.0209	.0319	.0369	.0006	.0024	.3519	.1434	.6971		

Note: T values are in parentheses.
* Significant at the .05 level.
** Significant at the .01 level.

Size is stated as the number of licensed skilled nursing care, intermediate care A, care B and boarding home care beds within the facility. The occupancy rate is determined by dividing the actual patient days by the available patient days. This variable is hypothesized to have a negative relationship with cost indicating greater efficiencies with fuller utilization of the facility.

Using these variables, the following linear model is estimated.

$$Y = \beta_1 + \beta_2 \text{ SIZE} + \beta_3 \text{ OWN} + \beta_4 \text{ PERC} + \beta_5 \text{ POP1} + \varepsilon$$

Y = dependent variable (cost)

β = regression coefficient

ε = error term

The results are given in Table 11. An analysis of the correlation matrix for the various combinations of the independent variables indicates that there is no high degree of inter-correlation among the variables, thus minimizing the chance of multicollinearity. The proportion of variation in each dependent variable accounted for by the specified independent variables ranges from a high of .5314 for laboratory and x-ray expense to a low of .1148 for operation and maintenance expense. The F-statistics indicate that nine out of fourteen regression equations are statistically significant but the t-statistics reveal that only a small proportion of the regression coefficients are significantly different from zero.*

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*The test statistics are explained in Appendix A.

Summarizing the results of the linear regression model for Montana data:

1) Location (as specified) does not have a significant effect on per patient day cost. The hypothesis which states that facilities located in small communities have higher cost is not supported in this model for the given data sample.

2) The economies of full utilization, using the facility to its optimal capacity, does appear to have a negative effect on the cost for half of the cost categories as indicated by the occupancy rate - cost relationship. But, it is only significant for the "other operating" expense category. This implies that as the initial cost of providing these services is spread out over a large number of patients, costs per day decrease.

3) Economies of scale are not indicated, significantly, by this model. The coefficients for which a significant relationship was indicated are all positive, indicating increased cost per patient day as the number of beds increase.

4) Facilities run for profit cost less, per patient day, than non-profit facilities. This is true for all

significant relationships except administrative. This can be explained by the fact that profit facilities generally pay higher salaries in order to attract more experienced and trained administrative personnel. The remaining significant ownership coefficients indicate lower cost in profitable facilities as hypothesized.

Model Comparison

Even though the Ruchlin-Levey linear regression model and the linear regression model for Montana data are not identical in specification, certain comparisons can be made.

1) The relationship between size and costs indicate economies of scale for six cost categories in the Ruchlin-Levey model but not in the linear model for Montana data. Also, the relationship between size and the categories of housekeeping and medical supplies is significantly positive in both models. This apparent contrast, similar results for some categories and not for others, could indicate a specification error in the linear model for Montana data relative to size.
2) The location variable tends to be an insignificant factor in both models.

3) Economies of full utilization are indicated in both models. The relationship between total operating cost and occupancy rate in Ruchlin-Levey model was negative and highly significant (.01 level) while the same relationship in the linear model for Montana data is negative, but not significant.

4) The relationship between cost and ownership confirmed the same hypothesis in both equations. Facilities run for profit have lower cost per patient day.

In conclusion, the Ruchlin-Levey linear model is generally a "better" estimation equation for its given data, than the linear regression model for Montana is for its data. It has a higher R^2 and all F-values are significant, while the linear model for Montana data has low R^2's and less significant F-values. From the analysis of these results it is apparent that the linear model for Montana data can be improved upon. However, first a brief analysis of the two models in parabolic form is conducted.

Size Specification

The size variable is respecified in a parabolic form (size and size squared) to determine if its statistical significance is improved and if a least cost facility size can be estimated. Since a linear relationship does not attain a mininum point within a finite quality range, neither of the linear regression models can be used to estimate least cost facility size. The least cost facility size

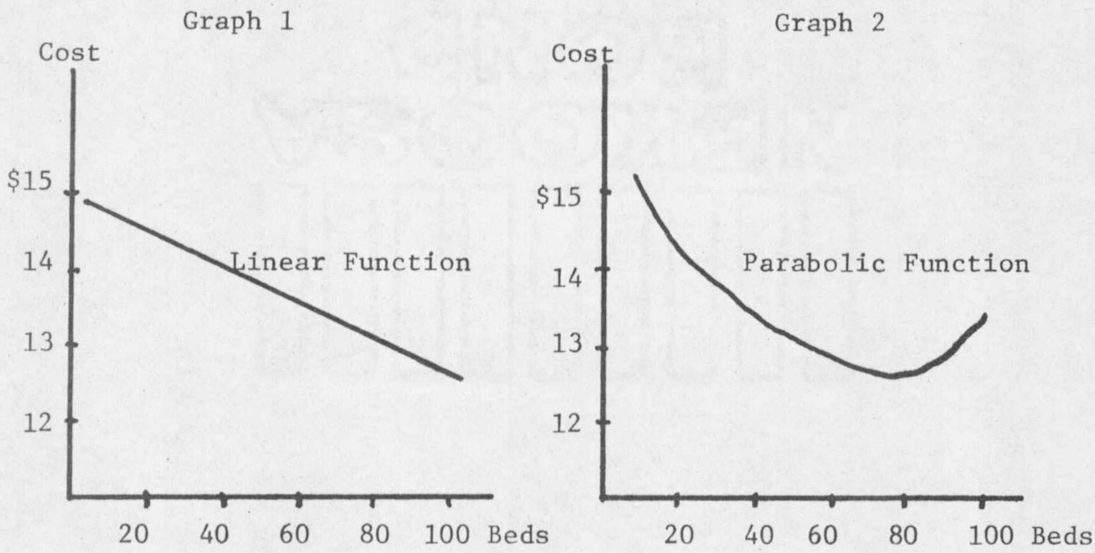

Figure 7. Linear and Parabolic Average Cost Functions

can be determined if a parabolic relationship exists between average cost per patient day and size. This is illustrated in Figure 7 (contrasting parabolic with linear functions). Graph 1 illustrates a linear function which never reaches either a minimum or maximum. Graph 2 demonstrates a parabolic function in which costs are minimized at 80 units. This parabolic function implies that as size increases from 20 to 80 units cost decreases per unit indicating more efficient operation, but as size increases past 80 units costs increase indicating inefficiencies. The Ruchlin-Levey linear model and the linear model for Montana data are respecified in parabolic form and an analysis of the results is conducted.

Regression Results of Parabolic Functions

The regression results of the parabolic function in the Ruchlin-Levey study are almost identical to those of their linear model, except for the size and size squared variable results (Table 12). The relationship between size and cost is significant, for both size and size squared, in only three cost categories: depreciation, laundry and linen, and recreation-rehabilitation. At first it appears that the least cost points are 100, 150 and 50 beds, respectively. However, the last two values are cost maximizing points indicated by the signs of the regression coefficients. This is demonstrated in Figure 8.

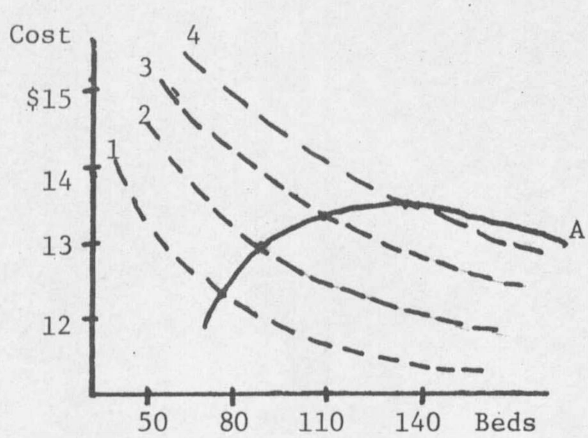

Figure 8. Cost Maximizing Point

Table 12

Ruchlin-Levey -Regression Coefficients: Size Entered in a Linear and Squared Form[1]

	Independent variables			
	Size		Size Squared	
Dependent variable	Coefficient	T value	Coefficient	T Value
Average total cost	0.01	0.53	-0.00003	0.88
Salaries	-0.01**	3.18	0.00001	1.59
Supplies and expenses	0.0006	0.53	-0.00001*	2.16
Property	0.01**	5.16	-0.00002	1.49
Depreciation	-0.002*	2.12	0.0001**	2.66
Operations	-0.0001	0.27	-0.00001	1.95
Dietary	-0.001	0.90	-0.00001	1.01
Laundry and linen	0.003**	7.31	-0.00001**	5.96
Housekeeping	-0.001	0.11	0.00001	1.05
Nursing	-0.002	0.62	-0.00001	0.48
Other services	-0.001	1.50	0.00001	0.03
Recreation and Rehabilitation	0.001**	3.59	-0.00001**	2.84
Other	-0.001	0.29	0.00001	1.35

Note: *Denotes significance at the .05 level.

**Denotes significance at the .01 level.

[1]Ruchlin, Hersh S., Levey, Samuel, "Nursing Home Cost Analysis: A Case Study." Inquiry, Vol. 9, No. 4, Sept. 1972, p. 11.

The reason Ruchlin-Levey gave for this inverted u-shaped cost curve is that the simultaneous use of size and size squared leads to an overstating of the curvature, if not a complete inversion of the average cost curve (curve A). They try to overcome this apparent difficulty by restating size as three alternative sets of dummy variables, but the same results were achieved. Their alternative explanation for these results was the lack of a variable in the regression equation to control for quality, resulting in the inverted u-shaped cost curves being generated by observations from a series of cost curves representing various quality levels (Figure 8, curves 1-4).

The results of the linear regression model for Montana data, with size stated as a parabolic function, are presented in Table 13. The relationships between size, size squared and cost are only significant for the categories of medical supplies (TMSE), laboratory (TLE), and x-ray (TXRE) expenses. The least cost facility size for each is 110, 250*, and 200* beds, respectively. These are all cost minimizing points.

A comparison between the least cost sizes for the two models cannot be made since the cost categories for which the relationships were significant are different. The parabolic form of the regression

*The least cost size estimate exceeds the relevant range for nursing homes in Montana and is not useful in further analysis.

Table 13

Linear Regression Model for Montana Data with Size Expressed as Size and Size Squared

	TAG	TEHW	TDE	THE	TLLE	TOME	TMSE	TTE	TPE	TLE	TXRE	TNSE	TOOE	TOPE	MEAN	ST. ERROR
SIZE	-.01238	-.0099	-.0062	-.0033	.0008	-.0108	-.0044**	.0016	-.003	-.0005**	-.0004**	-.0508*	-.004	-.0892	62.667	7.5367
	(.802)	(1.203)	(.558)	(.804)	(.212)	(1.074)	(2.821)	(.65)	(1.234)	(3.743)	(3.743)	(1.863)	(.338)	(1.513)		
SIZX	.0001	.0001	.00002	-.00001	-.00001	.0001	.00002**	.000001	.00003**	.000001**	.000001**	.0002	.00003	.0004	5744.78	1738.7
	(.750)	(1.562)	(.367)	(.286)	(.045)	(.897)	(3.516)	(.358)	(6.888)	(6.596)	(6.596)	(1.695)	(.605)	(1.647)		
OWN	.9697**	-.6417**	-.8419**	-.2137*	-.4483**	-.3477	-.0322	.0098	.0281	.0009	.0006	-2.271**	.4411	-3.1795*	.454	.088
	(2.669)	(3.309)	(3.241)	(2.249)	(4.843)	(1.47)	(.869)	(.173)	(.488)	(.268)	(.268)	(3.537)	(1.574)	(2.292)		
PERC	2.7463	-1.7036	-1.5998	-.7175	.6351	-3.0925	-.0217	.5921	.3934	-.0104	-.0072	-5.8257	-5.9478*	-13.0074	.952	.0108
	(.877)	(1.02)	(.715)	(.877)	(.796)	(1.518)	(.071)	(1.207)	(.792)	(.359)	(.359)	(1.054)	(2.465)	(1.088)		
POP1	-.5026	.2574	-.1109	.0507	.0577	-.1345	-.0236	-.064	-.0884	-.0021	-.0014	-.7719	.2272	-.8523	.3333	.0833
	(1.168)	(1.121)	(.361)	(.451)	(.526)	(.481)	(.539)	(.949)	(1.294)	(.516)	(.516)	(1.015)	(.685)	(.519)		
INTER-CEPT	-.4711	3.1519	5.1092	1.1484	.0431	5.0047	.2378	-.5831	-.2389	.0249	.0174	14.7987	6.4519	32.8212		
R^2	.271	.3916	.289	.3269	.5126	.1404	.4038	.3933	.5357	.8206	.8206	.3652	.2722	.2445		
F	2.0074	3.4758*	2.195	2.6229*	5.6796**	.8818	3.6575*	3.5012*	6.2303**	24.6931**	24.6931**	3.1061*	2.0195	1.7475		
MEAN	1.9118	1.0057	2.8765	.5616	.5109	1.3935	.0464	.0825	.0803	.0035	.0024	5.8652	.9852	15.4033		
ST. ERROR	.1858	.1086	.1345	.0506	.0579	.1114	.0209	.0319	.0369	.0035	.0024	.0352	.1434	.6971		

Note: T values are in parentheses.
* Significant at the .05 level.
** Significant at the .01 level.

model for Montana data does indicate economies of scale do exist for the significant relationships (medical supplies, laboratory, x-ray, nursing services). This is opposite of the results for the linear regression and is assumed to indicate that size is misspecified as a linear explanatory variable. Even though it is insignificant, the negative relationship between size and total operating cost per patient day does suggest economies of scale, which is more in line with the linear regression results of the Ruchlin-Levey study and stated hypothesis.

Final Model

The linear regression model for Montana data is used as a base for the development of the final model. The independent variables for this model include ownership, size, location and percent occupancy. Size squared is also introduced as discussed in the preceding section. Furthermore, two other explanatory variables are included in the final model - "quality" and an interaction variable relating facility size in rural areas to costs.

The hypothesized relationship between the characteristics of ownership, size, and percent occupancy and cost are the same as stated above. The so-called "quality" variable is entered into the equation as a ratio of skilled nursing care (SNC) licensed beds to the total number of licensed beds per facility. It is hypothesized that the greater the ratio, the higher the cost per patient day. It is assumed that a licensed SNC bed will require more services and time, increasing the cost per patient day. This variable is named the quality variable because it is assumed that the additional care required for SNC beds also increases the quality of care for the non-SNC beds. Support for this hypothesized relationship will be indicated by a positive quality regression coefficient.

The interaction variable is included in the equation to determine if location affects the economies of scale. This tests the hypothesis that if factors affecting operating cost (cost of supplies, wages, food, maintenance) and input mix are different in small communities, then there can be different least cost size facilities for small communities. This effect should show up as a significant regression coefficient for the interaction variable, being either positive or negative depending on how the influencing factors affect the cost-size relationship.
The final model is:

$$Y = \beta_1 + \beta_2 \text{ OWN} + \beta_3 \text{ POP1} + \beta_4 \text{ PERC} + \beta_5 + \beta_6 \text{ SIZX}$$
$$+ \beta_7 \text{ QUAL} + \beta_8 \text{ INTER} + \varepsilon$$

Variable definitions are found in Table 9.

Results

The regression results are presented in Table 14. The relationship between ownership and cost is significant for the following

Table 14

Final Model

	TAG	TEHW	TDE	THE	TLLE	TOME	TMSE	TTE	TPE	TLE	TXRE	TNSE	TOOE	TOPE	Mean	St. Error
SIZE	.0119	-.0077	-.0053	-.0024	-.0055	-.0129	-.0048*	.0034	-.005	-.0008**	-.0006**	-.0935**	.0088	-.1148*	62.6667	7.5367
	(.63)	(.68)	(.402)	(.508)	(1.118)	(.936)	(2.210)	(1.072)	(1.584)	(4.964)	(4.964)	(3.123)	(.568)	(1.735)		
SIZX	-.00004	.00004	.00001	.00001	.00002	.00004	.00002**	-.000002	.00003**	.000001**	.000001**	.00034**	-.00002	.00047*	5744.788	1738.769
	(.585)	(1.0)	(.228)	(.810)	(1.133)	(.814)	(2.842)	(.235)	(2.693)	(7.515)	(7.515)	(2.897)	(.307)	(1.844)		
OWN	1.3001**	-.5919**	-.7373**	-.2275**	-.4818**	-.3308	-.0391	.014	.0268	-.0011	-.0008	-2.3713**	.6293*	-2.7019*	.455	.088
	(3.669)	(2.788)	(2.834)	(2.564)	(5.248)	(1.277)	(.956)	(.232)	(.451)	(.345)	(.345)	(4.211)	(2.174)	(2.173)		
INTER	-.0461*	-.0057	-.0086	.0058	.0079	.0005	.0009	-.0019	.0018	.0004*	.0003*	.0437	-.0254	-.0156	12.727	3.746
	(2.311)	(.482)	(.589)	(1.167)	(1.53)	(.032)	(.370)	(.56)	(.529)	(2.298)	(2.298)	(1.380)	(1.557)	(.224)		
QUAL	.7065	.2118	.751*	.3148**	.2145*	.2846	-.0251	-.1069	.1381*	.0074*	.0052*	2.4187**	.4803	5.5363**	.544	.0677
	(1.652)	(.826)	(2.391)	(2.938)	(1.935)	(.910)	(.507)	(1.467)	(1.924)	(1.946)	(1.946)	(3.558)	(1.374)	(3.688)		
PERC	2.4522	-1.7812	-1.8597	-.8141	.5743	-3.1861	-.0123	.6251	.350	-.0123	-.0086	-6.5697	-6.1399**	-14.8612	.952	.0108
	(.86)	(1.042)	(.888)	(1.14)	(.777)	(1.528)	(.032)	(1.286)	(.731)	(.483)	(.483)	(1.449)	(2.635)	(1.485)		
POP1	1.6386	.5204	.2687	-.2337	-.3208	-.1651	-.0628	.0289	-.1762	-.0215*	-.0150*	-2.9071*	1.4026	-.3052	.333	.0833
	(1.615)	(.856)	(.361)	(.92)	(1.221)	(.05)	(.536)	(.167)	(1.035)	(2.375)	(2.375)	(1.803)	(1.692)	(.084)		
INTER-CAPT	-1.8553	2.9835	4.8715	1.3372	.2919	5.0281	.263	-.6449	-.1801	.0377	.0263	16.2174	5.6932	32.5333		
R^2	.4407	.4119	.4248	.5262	.6134	.1682	.4125	.4503	.6017	.8708	.8708	.6063	.3735	.5107		
F	2.8139*	2.5017*	2.6371*	3.9659**	5.6675**	.7222	2.5077*	2.9256*	5.3949**	24.071**	24.071**	5.4988**	2.1287	3.7281**		
MEAN	1.9118	1.0057	2.8765	.5616	.5109	1.3935	.0464	.0825	.0803	.0035	.0024	5.8652	.9852	15.4033		
ST. ERROR	.1858	.1086	.1345	.0506	.0579	.1114	.0209	.0319	.0369	.0035	.0024	.0352	.1434	.6971		

NOTE: T values are in parentheses. * Significant at the .05 level. ** Significant at the .01 level.

categories: administrative (TAG), employee health and welfare (TEHW), dietary (TDE), housekeeping (THE), laundry and linen (TLLE), nursing services (TNSE), "other operating" expense (TOOE), and total operating expense (TOPE). Of these categories, the relationship is not negative as hypothesized for administrative and "other operating" expenses. The regression coefficients for these categories indicate that costs are higher for profit as compared to non-profit facilities. This can be explained for administrative expenses, as stated before, by traditionally higher wages in proprietary facilities for trained, experienced administrative personnel. The "other operating" expense category is composed of taxes, depreciation and other miscellaneous expenses. The positive effect of ownership indicates increased cost for profit run facilities.

The relationship between ownership and total operating cost (TOPE) per patient day is significant at the .05 level, and indicates cost to be $2.70 lower for profitable facilities. Among the other relationships that are significant, nursing service (TNSE) showed the largest marginal change in cost,($-2.37)while housekeeping had the smallest change,($-0.23). The ownership coefficient for administrative expense indicates a higher per patient day cost of $1.30 for profitable facilities.

Even though economies of full utilization are indicated by the estimated occupancy rate coefficients in all categories except administrative (TAG), laundry and linen (TLLE), pharmacy (TPE), and therapy (TTE) expenses, occupancy rate is significant only for the category of "other operating" expenses. The regression coefficient (-6.1399) indicates a decrease in per patient day cost for "other operating" expenses of \$.0613 for every 1 percent increase in the occupancy rate. Even though the relationship between occupancy rate and total operating cost per patient day is not significant at the .05 level, it is at the .10 level and indicates cost will decrease \$.148 for a 1 percent increase in the occupance rate.

The quality relationship with cost is significant for the categories of x-ray (TXRE), nursing services (TNSE), dietary (TDE), housekeeping (TNE), laundry and linen (TLLE), pharmacy (TPE), laboratory (TLE), and total operating costs (TOPE). All of the relationships are positive as hypothesized, indicating higher cost as the ratio of SNC beds increases. The coefficient for total operating cost indicates a \$.0554 increase in per patient day cost for every 1 percent increase in the number of beds licensed as SNC beds, with nursing services showing the largest increase and x-ray expense the smallest.

The interaction variable (INTER) is significant for the categories of administration (TAG), laboratory (TLE), and x-ray (TXRE) expense. The relationship indicates a change in economies of scale relative to location. The relationship between administrative expense and the interaction term indicates greater economics of scale for rural located facilites. The remaining two suggest less efficient operation for facilities located in rural areas.

The relationship between location and cost is significant for the categories of laboratory (TLE), x-ray (TXRE), and nursing services (TNSE). None of these relationships are positive as hypothesized, but negative, indicating lower cost for facilities located in small communities. This can be explained for laboratory and x-ray expenses by the fact that most of the facilities in small communities do not offer services in these areas. They either contract the services out, probably at a lower cost per patient than if they owned they own equipment, or transfer the patient to a hospital at which all the services are provided and billed directly to the patient (this would not show up in the cost reports). An explanation for the negative relationship between nursing service and location ($-2.901) is not so easily explained. One explanation could be different wages and/or personnel mix for facilities located in small communities. This possibility will be discussed in more detail in Chapter Five.

The relationship between size and cost is significant for the categories of medical supplies (TMSE), laboratory (TLE), x-ray (TXRE), nursing services (TNSE), and total operating expense (TOPE). Economies of scale are indicated, as hypothesized, in all five. The largest cost change per unit size change is for nursing services, $-0.094, with the overall marginal change in total operating cost per unit size change equal to \$-0.1148. The size squared relationship is also significant for the same categories, with all relationships being positive as hypothesized.

Since the relationship between size and cost was hypothesized to be a parabolic function, an F-test is used to determine if size and size squared (together) have a significant effect on cost.* The results are presented in Appendix C and indicate that the specified parabolic relationship is signficant for all but one of the categories above (medical supplies, laboratory, x-ray and nursing services) plus the categories of therapy and pharmacy expenses.

The amount of variation in each dependent variable (cost category) accounted for by the specified independent variables (characteristics) ranges from a high of .8708 for laboratory (TLE) and x-ray (TXRE) expense to a low of .1682 for operation and maintenance (TOME) expense. This wide range suggests that apparently not all cost categories are influenced by the same characteristics. The low R^2 for operating and maintenance indicates that size, ownership, location and the remaining selected characteristics do not have much influence on the cost incurred in operating and maintaining the facility

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*The test statistic is the same as the one used to check the significance of the interaction variables in the first part of the chapter.

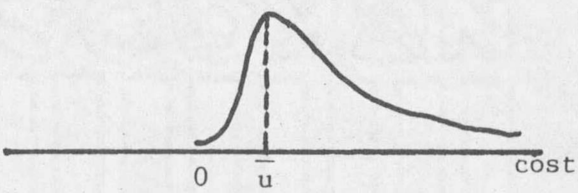

Figure 9. Skewed Distribution

(utilities, repairs, supplies, insurance, etc.). The high R^2 for laboratory and x-ray expense tends to indicate that the selected characteristics explain quite well the variation in cost for these categories. But, inspection of the data reveals that the distribution of costs in these categories is skewed to the right. Figure 9 indicates the mean value $(\bar{u})$ of a sample is close to zero with a nonsymmetric distribution. If the data collected for the laboratory and x-ray cost categories is plotted, it would appear similar to Figure 9 with a mean of .0035 for laboratory expense and .0024 for x-ray expense with a standard error of .0035 and .0024, respectively. The test data collected for these two categories do not have a normal distribution; therefore, the test statistics can be unreliable.

The basic statistical assumption that the variance of the disturbance is constant for all observations was made throughout the above analysis. There exists the possibility that the variance of the disturbance may vary from observation to observation ($E(\varepsilon_i^2) = \sigma_i^2$). To determine the reliability of the constant variance assumption a statistical test developed by Goldfeld and Quandt is conducted.[29] First the data is ordered by magnitude of the independent variable which is thought to be related to the error variance (size). Secondly, an arbitrary number of middle observations are deleted. Next, a separate regression is run on both parts of the data. The null hypothesis that the variance remains constant across all observations can be rejected at a chosen level of significance if the calculated test statistic is greater than the critical value of the F distribution as determined from an F table.* The results (Appendix D) indicate that the null hypothesis cannot be rejected. This implies that the assumption of constant variance should be maintained and that the ordinary least squared (OLS) estimates are likely to be efficient (smallest possible variance). This insures that the t-test statistics are accurate.

Conclusions

From the initial comparison of the regression equations to the

[29]Goldfeld, S.M., Quandt, R.E., "Some Tests for Homoskedasticity", Journal of the American Statistical Society, Vol. 60, 1965, pp. 534-547.

*The test statistic is defined in Appendix D.

development and analysis of the final model, the main objective has been to determine the relationship between certain descriptive characteristics and selected cost categories. The analysis indicates the following:

1) There are economies of scale for the given cost categories. This implies that larger facilities are more efficient and less costly, up to a point.

2) There is no significant change in economies of scale for homes located in smaller communities.

3) Facilities run for profit do have lower cost. This could be explained by the profit incentive leading to a more efficient use of equipment and personnel or a lower quality of services being provided to the patients.

4) The overall effect of location, as defined in this study, is minimal in the determination of cost.

5) The greater the proportion of licensed SNC beds in a facility, the higher the per patient day cost. Assuming this to be a good indication of quality, costs are definitely increased as these services change.

Further implications of the results with respect to least cost size and policy-making are discussed in Chapter Five.

Chapter 5

MODEL IMPLEMENTATION

In this chapter the final form of the estimated model is used to determine average costs for an average facility. Differences between profit and non-profit facilities are discussed. Ownership, location, occupancy rate and the percent of SNC beds are changed to show their effect on costs. Costs of existing facilities are compared to those of a least cost facility and potential dollar savings to the State of funding least cost size facilities are calculated.

Average Cost

Average cost per patient day can be projected for different facility types using the estimated final model. It is important to remember that average cost is total cost divided by total output, with output defined as a patient day of care. Average cost can be expected to decrease over the lower range of facility size and then increase (see Chapter Two). Estimated average costs for facilities with sizes ranging from 20 to 140 beds are presented in Appendix F, Table 1. The upper and lower bounds of a 95 percent confidence interval placed around these values are also given.* The calculations in this table are graphed in Figure 10.

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*Confidence intervals are explained in Appendix E.

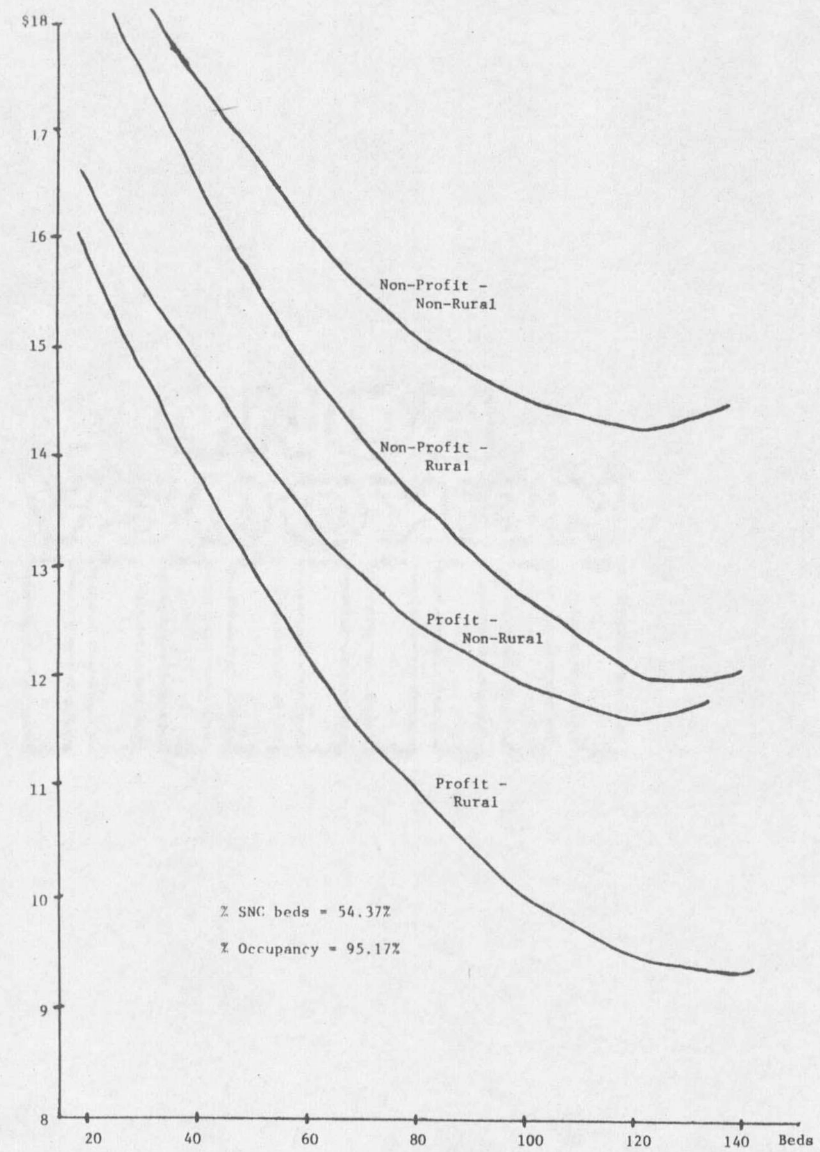

Figure 10. Average Cost per Patient Day

Figure 10 illustrates that average patient day cost is lower for profit-run facilities. Average cost is decreasing, indicating total cost is increasing at a decreasing rate, up to approximately 122 beds. For the average facility size in Montana (62.7 beds), the average cost ranges from a high $16.05 for non-profit, non-rural facilities to a low of approximately $12.05 for a for-profit, rural facility.

Average costs are also determined holding size constant and changing occupancy rates and percent of SNC beds. This is done for three selected sizes: 62.7 beds, 122 beds, and 140 beds. The results (including upper and lower bounds of a 95 percent confidence interval) are given in Appendix F, Tables 2 and 3.

The estimated short run average cost per patient day for a facility with 33.3 percent and 75 percent SNC licensed beds is graphed in Figures 11 and 12. Changing the percent of SNC beds shifts the average cost curves shown in Figure 10. It can be seen from Figure 12 that in a for-profit, non-rural facility with 40 beds, average cost per patient day increases from approximately $13.75 to $15.85 as the percent of SNC beds increases from 33.3 percent to 75 percent. For a comparative non-profit non-rural facility average cost per patient day ranges from approximately $16.30 to $18.45. Similar relationships for rural facilities are presented in Figure 12.

An analysis is conducted with the occupancy rate changed to 75 percent and 99.9 percent. The results are graphed in Figures

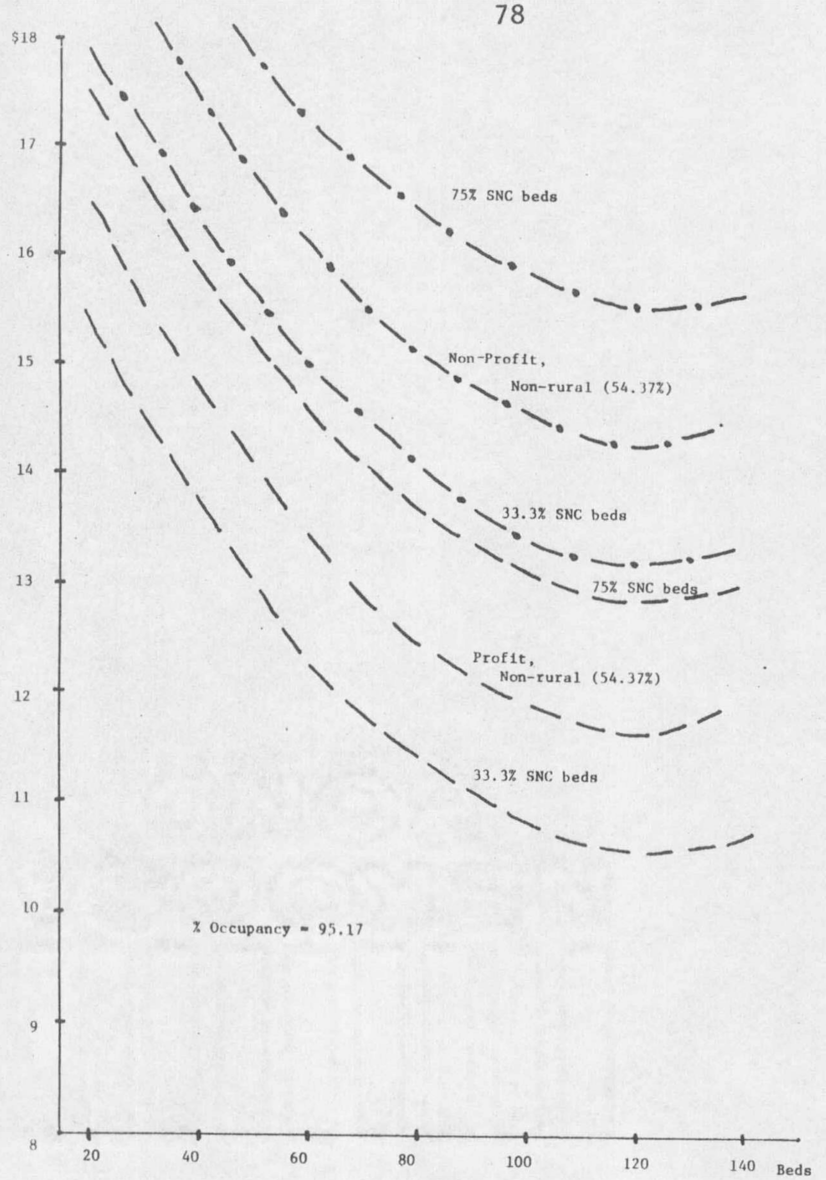

Figure 11. Shifts in Average Cost Curves for Change in the Percent of SNC Beds, Non-Rural

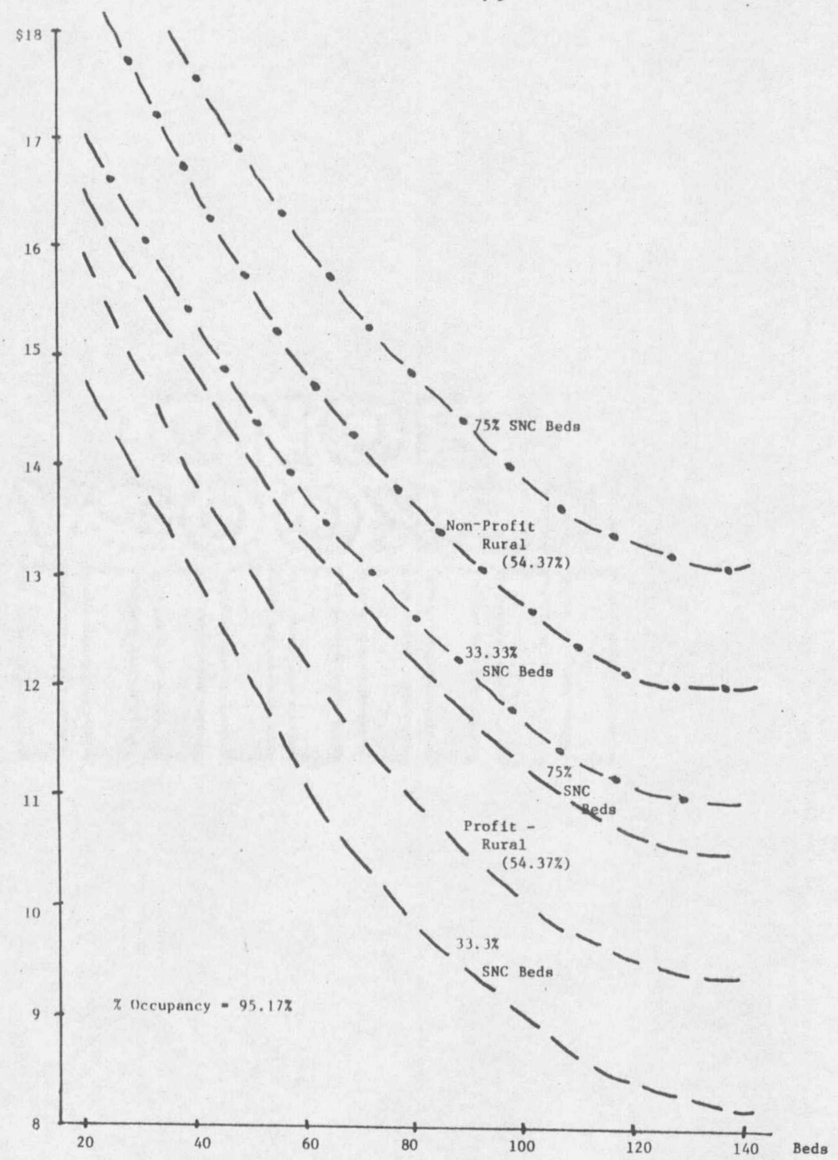

Figure 12. Shifts in Average Cost Curves for Change in the Percent of SNC Beds, Rural

13 and 14. Figure 13 demonstrates that as the occupancy rate for an average 40 bed for-profit, non-rural facility increases from 75 percent to 99.9 percent, average cost per patient day decreases from approximately $17.85 to $14.00. For a non-profit, non-rural facility, the average cost ranges from approximately $20.12 to $16.78 per patient day for similar occupancy rates.

The graphs illustrate that (1) short run average cost per patient day is lower when high occupancy rates are maintained, (2) the average facility in Montana (62.7 beds) is operating on the downward sloping portion of its short run average cost curve, and (3) average cost per patient day is increased for facilities with a high percent of SNC licensed beds.

Location Effect

It was initially hypothesized that facilities located in rural areas would have higher average costs. Different employee mix, less availability of low cost inputs and increased public awareness are the main assumptions behind this hypothesis. The results, however, do not support this hypothesis. From inspection of Figure 10 it can be seen that average costs for facilities located in rural communities are estimated to be lower than costs for non-rural facilities. The difference varies from approximately $.070 to $1.25 per patient day depending on the size of the facility.

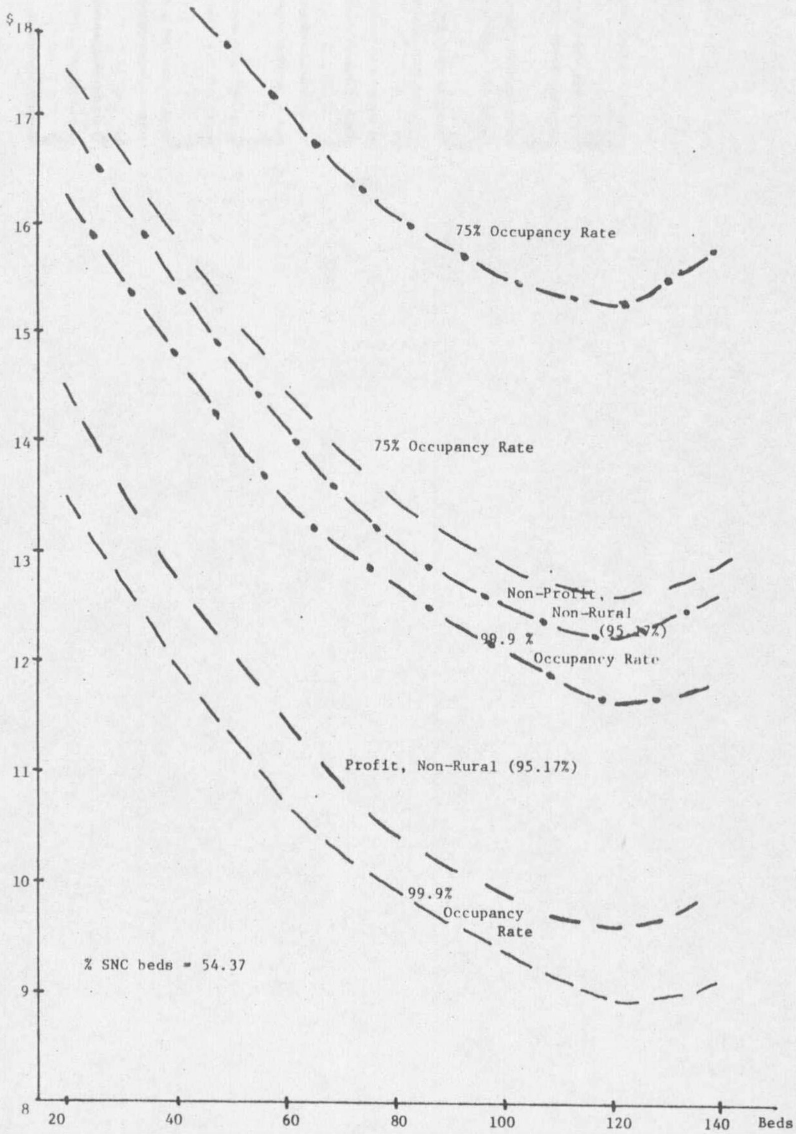

Figure 13. Shifts in Average Cost Curves for change in the Occupancy Rate, Non-Rural

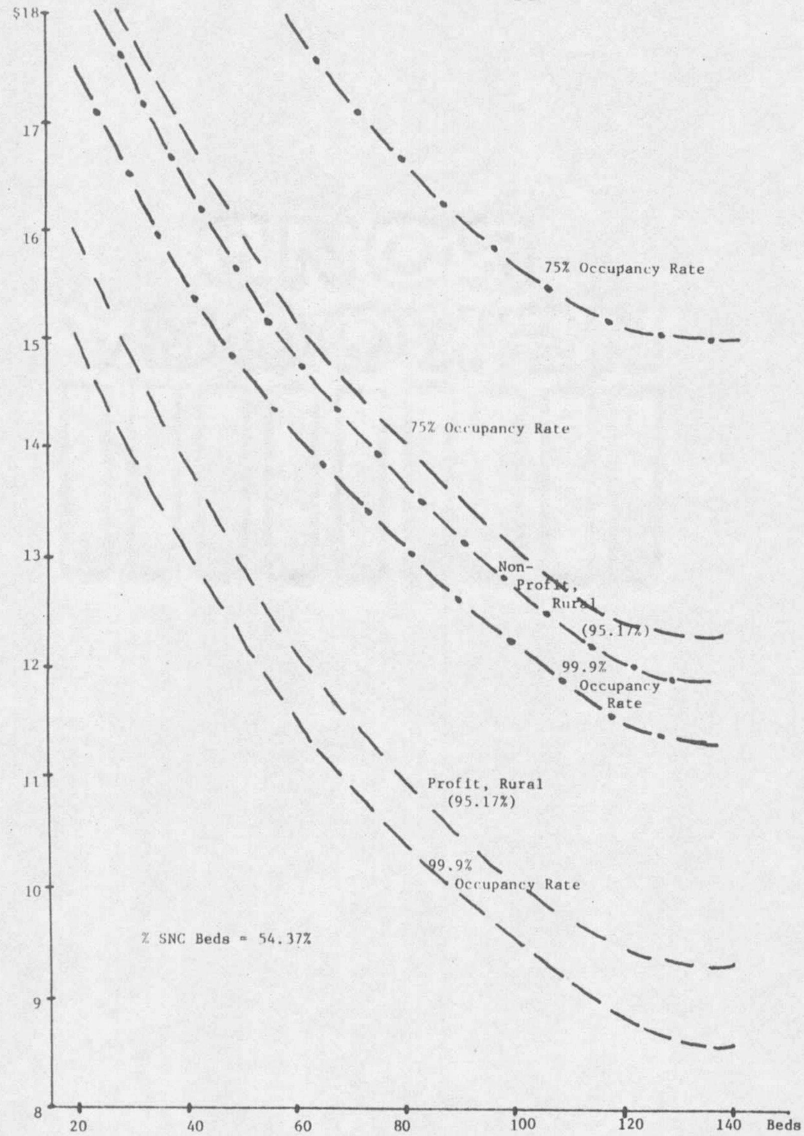

Figure 14. Shifts in Average Cost Curves for Change in the Occupancy Rate, Rural

The regression results show that in the category of nursing services (the largest cost category) the coefficient for location is negative. There are lower costs for nursing services per day of approximately \$2.98. To explain this unexpected relationship the nursing services category is broken down into salary expense for non-professional employees (aids and orderlies), RN's and LPN's. From estimation equations for RN and LPN expense (Table 15),it can be seen that costs are \$.041 higher per patient day for RN care and \$0.137 lower for LPN care in rural facilities. For the category of non-professional employees the location variable indicates that costs per patient day are \$1.35 lower in rural areas. Combining the three estimations indicates that nursing services expenses are approximately \$1.076 less in the small rural facilities. Apparently this large negative effect relative to location for nursing services over powers any positive effect on costs due to the remaining expense categories, yielding a negative location coefficient in the total cost per patient day equation.

The above results also suggest that the employee mix differs between rural and non-rural facilities. Using the estimated equations, the average cost per patient day for the three categories are determined in a facility size range from 20 to 100 beds (Table 16). As the percent of change indicates, costs change quite differently for rural facilities as compared to non-rural facilities. These results tend to

Table 15

Average Cost per Patient Day Estimation Equation for RN, LPN, and Non-professional Employees

R^2	F	Equation
.6241	4.981**	RN = 5.65 - .679 OWN** - .007 SIZE + .00001 $SIZE^2$ - 4.69 PERC* + 1.108 QUAL** + .41 POP1 - .0137 INTER
.3595	1.684	LPN = 2.00 - .077 OWN + .005 SIZE - .00005 $SIZE^2$ + 2.67 PERC + .491 QUAL -.137 POP1 + .0065 INTER
.6049	4.593**	NONPRO = 8.11 - 1.37 OWN** - .024 SIZE - .00001 $SIZE^2$ - 2.428 PERC + .232 QUAL -1.372 POP1 + .023 INTER

Variable	Mean	St. Error
RN	.97	.15
LPN	.90	.10
NONPRO	3.60	.19
OWN	.517	.09
SIZE	56.58	6.11
$SIZE^2$	4248.79	1068.2
PERC	.951	.01
QUAL	.523	.07
POP1	.379	.09
INTER	14.48	4.16

* Significantly different than zero at .05 level

** Significantly different than zero at .01 level

Table 16

Estimated Average Cost Per Patient Day for LPN, RN and Nonprofessional Employees[1]

% SNC Beds = 52.3, Occupancy Rate = 95.15%

Non Profit, Rural				Profit, Rural			
Size	RN	LPN	NONPRO	Size	RN	LPN	NONPRO
20	1.75	.88	4.52	20	1.07	.80	3.15
62*	.89	1.21	4.44	62*	.21	1.13	3.07
100	.14	1.36	4.35	100	-.53	1.28	2.98
% change	-92	54	-3	% change	-150	60	-5

Non Profit, Non Rural				Profit, Non Rural			
Size	RN	LPN	NONPRO	Size	RN	LPN	NONPRO
20	1.61	.88	5.43	20	.94	.81	4.06
62*	1.33	.94	4.39	62*	.65	.87	3.02
100	1.10	.84	3.42	100	.42	.77	2.05
% change	-31	-4	-37	% change	-54	-5	-49

[1]The average cost estimation equations are presented in Appendix G.

*Average facility size for given data sample.

indicate that a different RN and LPN mix exists. This may be explained by the minimum staffing regulations as stated in the Montana administrative code for hospitals and medical facilities.[30]

In Table 17 there is a comparison of required hours for RN, LPN, and nonprofessional employees with hours predicted by the equations in Table 15. This comparison indicates that smaller rural facilities under hire LPN's and over hire nonprofessional employees relative to the requirements stipulated in the regulations. The medium size non-rural facilities tend to over hire RN and LPN employees and under hire nonprofessional personnel. The large non-rural facilities appear to under hire RN and LPN's and over hire nonprofessional personnel relative to the regulations.

In summary:

1) Location has a large negative effect on small rural facilities nursing service epxense. This tends to overpower any positive effect due to location.

2) There appears to be a different personnel mix for small rural facilities compared to the larger non-rural facilities.

3) These results are not consistent with existing regulations.

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[30]"Montana Administrative Code", State Department of Health and Environmental Science, Hospital and Medical Facilities Division, February 1973, Cahpter 22, 16-2.22 (1) - S2220, p. 16-507.

Table 17

Required vs. Estimated Nursing Services Hours for Selected Facilities*

Size/ Location		Category RN	LPN	NONPRO
20/	Required HR**	8	16	12
Rural	Estimated HR	8.1	5.7	38.6
62/	Required HR	16	16	92
Non Rural	Estimated HR	19.2	18.9	37.5
100/	Required HR	32	32	120
Non Rural	Estimated HR	25.6	27.2	146.1

*Non-profit facilities with size chosen relevant to location.

**Required hours may be lower if facility is given approval.

Least Cost Facility Size

The estimation model developed in this study is capable of estimating a minimum average cost facility size. The variable of size is squared and the results of size and size squared are used in the analysis. The estimation model is restated as:

$$Y_i = \beta_1 + \beta_2 S + \beta_3 + \Sigma B_i X_i + \varepsilon$$

By taking the first derivative with respect to size and setting it equal to zero, least cost size is determined.

$$\frac{dac}{ds} = \beta_2 + 2\beta_3 S = 0$$

Solving for size,

$$= 2 \beta_3 S = \beta_2$$

$$S = \frac{-\beta_2}{2\beta_3}$$

In order for the results to indicate a cost minimizing point, β_1 has to be negative. Therefore, the final equation equals:

$$S = \frac{|\beta_2|}{2\beta_3}$$

At this size a facility's average cost will be minimized.

The estimated regression coefficients for size and size squared are -.1148 and .00047 respectively. Therefore,

$$S = \frac{.1148}{2(.00047)} \approx 122 \text{ beds.}$$

In the long run a facility with 122 beds (95.2 percent occupancy rate) has the lowest average cost per patient day. At this point long run average costs equal short run average costs, both being at a minimum point. Beyond this point average costs begin to increase.

Relative to the given data sample:

1) One facility is near the estimated least cost size.

2) Two facilities are over the estimated least cost size.

3) Thirty facilities are smaller than the estimated least cost size.

4) The least cost facility size is approximately 60 beds larger than the current average size facility.

If nursing home care was provided in Montana only in least cost size facilities the hypothesized cost savings range from \$5.39 to \$0.23 per patient day of care.

One way of obtaining least cost facility size is by consolidation of small facilities. There are certain restrictions and/or additional costs which may make such action uneconomical. First, because the small facilities are generally spread out across the state, consolidation would require selection of locations at which the least cost facilities would be developed. The cost involved in studying and determining such locations has to be subtracted from the potential cost savings.

Costs relative to the patients and their families also have to be considered. If central facilities are constructed, patients and their families would incur additional costs due to transportation, communication, etc., implicitly increasing the per patient day cost. The effect on patients being located away from home is also a "cost". Many of the small facilities exist because there is a demand for such services in the local communities. Patients and their families who have lived in a community most of their lives wish to remain. Patients may object to living in unfamiliar surroundings separated from their families. These "costs", along with monetary costs, may have the effect of decreasing demand for nursing home services, further reducing the potential for cost savings through consolidation. Consolidation also requires large capital investments for building, equipment and personnel.

If consolidation does take place, which types of facilities are consolidated? Does one consolidate only non-profit facilities and fill them with only state supported patients or should one require consolidation of all facilities that wish to continue receiving state supported patients? If all facilities in Montana receiving Medicaid-Medicare payments were consolidated to achieve least cost size, the number of facilities would drop from approximately 75 to 38. If consolidation was forced only on non-profit facilities, the number of non-profit facilities would decrease from approximately 18 to 8. These estimates assume that optimal locations for the least cost facilities can be determined.

The main decision rule concerning consolidation should be to determine if the cost savings due to lower operating costs are greater than the added costs incurred in the consolidation process. It is possible to estimate cost savings due to lower operating costs with the use of the average cost estimation model. However, the offsetting costs of consolidation are not measured easily and are not determined in this study.

Potential Medicaid-Medicare Cost Savings

The Department of Social and Rehabilitation Services (SRS) is in charge of administering nursing home reimbursements. Each facility's reimbursement payment is based on a reasonable cost schedule. Reasonable cost is defined as being the provider's allowable cost for services related to patient care as defined under the Medicaid and Medicare acts. The payments also include an efficiency incentive increment. This incentive is equal to 7.5 percent of the prior year's state-wide average patient day cost for all classes of patient care. In order to receive the reimbursement, the facility theoretically must meet all regulations and rules.

The interim rate is established to approximate the actual current cost of providing nursing home care. The method of calculation is as follows:[31]

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[31] "Manual of Reimbursement for Nursing Home Care", Montana Department of Social and Rehabilitation Service, Helena, Montana, July 1, 1976.

Actual allowable cost	xxxx
Plus allowable projected cost (a firm commitment)	xxxx
Total interim allowable cost	xxxx
Divided by projected patient days	÷xxxx
Cost per patient day	xxxx
Plus incentive increment	xxxx
Interim rate	xxxx

Based on this technique of estimating the reimbursement rate, the average patient day cost for all classes of patient care in 1974 was \$14.93. This is only 0.7 percent higher than the patient day cost estimated by the model. The average cost per patient day for the sample data used in this study is approximately \$15.40.

Using the estimated model and the concept of least cost size, cost savings can be estimated. Assuming that the average size of the facility in the Medicaid-Medicare program in Montana is 62.67 beds with an average occupancy rate of 95.2 percent, the average number of patient days of service provided per facility per day is 59.658. By using different rates of patient days covered under the programs, cost differences between existing facilities and all least cost size facilities can be estimated. These savings are approximations based on assumptions of size, ownership, occupancy rates, percent of SNC beds and the number of facilities. They are presented in Table 18.

The total number of patient days per year is determined by taking the average patient days per facility times the number of facilities times 365. The number of facilities participating in the program was approximately 75 in 1974. The total number of patient days per year equals 1.6 million.

The average cost per patient day for least cost facility size consist of two parts, the average cost for profit and non-profit facilities. Each cost is weighted by the appropriate percentage relevant to facility type. This gives a mean average cost for a least cost facility equal to $12.311.

Not all patient days are covered under the program. Therefore, the cost differences are determined for various levels of coverage. The range is from 100 percent down to 30 percent of the patient days covered. The cost savings range from approximately $4.2 million down to $1.2 million.

The above demonstrates how cost can be lowered by least cost conditions. These numbers are approximate, but they do give a good idea of the annual savings from funding only least cost operations.

Conclusions

This chapter discusses the average cost of nursing home facilities in Montana and the cost differences between profit and non-profit

Table 18

Estimated Mean* Cost Savings of Operating Least Cost Facilities, Montana Nursing Home Facilities covered by Medicare and Medicaid, 1974

% of Covered Patient Days	Covered Patient Days	Current Cost	Est. Mean Cost - Least Cost Facility Size	Difference
100	1,633,137.7	$24,387,640.00	$20,105,558.00	$4,282,082.00
90	1,469,823.9	21,948,880.00	18,095.002.00	3,853,878.00
80	1,306,510.1	19,510,115.00	16,084,445.00	3,425,670.00
70	1,143,196.3	17,071,350.00	14,073,889.00	2,997,461.00
60	979,882.6	14,632,587.00	12,063,334.00	2,569,253.00
50	816,568.8	12,193,822.00	10,052,778.00	2,141,044.00
40	653,255.1	9,755,058.00	8,042,223.00	1,712,834.00
30	489,941.3	7,316,293.00	6,031,667.00	1,284,625.00

Average patient days per facility =	59.658
Approximate number of facilities =	X 75
Total patient days/day	4474.35
X 365 day/year	X 365
Total patient days/year	1,633,137.7

Current average cost/patient day = $14.933

Estimated average cost/patient day - Least cost facility
Non-profit = $14.393
Profit = 11.691

Weighted by percent of facility type
Non-profit 23% X 14.393 = $3.309
Profit 77% X 11.691 = 9.001

Estimated average cost/patient day = $12.31

*The estimated mean costs for least cost facilities are determined with the use of the estimated average cost/patient day ($12.31). A 95% Confidence Interval placed around this estimate is equal to: Lower $6.50, Mean $12.31, Upper $18.81. Therefore, the actual estimated mean costs may vary ± 49% with a probability of .95.

facilities. Profit run facilities have lower cost per patient day. This supports the stated hypothesis and is similar to results of numerous studies that have been conducted across the United States.

The location coefficient, even though insignificant, indicates lower average cost for facilities in rural areas. This is opposite of what was hypothesized. An analysis of the regression model indicates that there are different nursing personnel mixes for the small rural facilities.

Least cost facility size, in Montana, is estimated at approximately 122 beds. Cost savings were then determined by comparing reimbursement rates under present conditions versus rates under least cost conditions. The results indicate annual savings ranging from $4.2 million to $1.2 million, depending on how many patients days are covered under the program. These savings over estimate gains from consolidation since they ignore the "disruptive" costs of centralizing long-term care in consolidated facilities. If policy makers judge that these "disruptive" costs are greater than the potential savings from consolidation, the consolidation strategy should be rejected.

APPENDICES

APPENDIX A

TEST STATISTICS

<u>T - test</u>[1]

$$t_{(n-k)} \sim \frac{\hat{B}-0}{S_{\hat{B}}}$$

t = T statistic

n = number of observations

k = number of parameters estimates

$\hat{B}$ = estimated coefficient

$S_{\hat{B}}$ = square root of estimated variance of $\hat{B}$

The t distribution is always symmetric; its mean is equal to zero with a variance equal to $(n-1)/(n-3)$. As the sample size increases, the t-distribution approaches the standard normal distribution. The t-test is used to test the null hypothesis of no relationship between an independent and dependent variable,

$$H_o: B \neq 0$$

<u>F - test</u>[2]

$$F\ (k-1,\ n-k) \sim \frac{SSR/(k-1)}{SSE/(n-k)}$$

F = F statistic

k = number of parameters estimated

n = number of observations

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[1] Kmenta, Jan, <u>Elements of Econometrics</u>, Macmillan Company, New York, 1971, pp. 142,236.

[2] Ibid, pp. 147-148, 366-367.

SSR = proportion of total variance explained by the regression

SSE = proportion of total variance not explained by the regression

The F-distribution is asymmetric and depends on two parameters, the number of degrees of freedom in the numerator and the number of degrees of freedom in the denominator. The F-test is used to test the hypothesis that there is no relationship between the independent variables and the dependent variable,

$$H_0: B_1 = B_2 = . . . B_x = 0$$

The alternative hypothesis is that such a relationship exists.

Appendix B-1

Chow Test Results

The test statistic is defined as :

$$F(K, n + m - 2k) - \frac{(SSE_c - SSE_1 - SSE_2)/k}{(SSE_1 + SSE_2)/(n + m - 2k)}$$

F = test statistic

K = number of parameters to be estimated

n = number of nursing home observations

m = number of hospital-nursing home observations

SSE_c = proportion of variance unexplained by regression for total sample

SSE_1 = proportion of variance unexplained by regression for nursing home

SSE_2 = proportion of variance unexplained by regression for hospital-nursing home

Critical F-value 6,29 dF
95% = 2.43
99% = 3.5

Category	F-Value
Administrative and general	.5404
Employee health and welfare	.3752
Dietary	.0679
Housekeeping	.5670
Laundry and linen	.9253
Operation and maintenance	1.166
Medical supplies	1.073
Therapy	1.3137
Pharmacy	2.713*
Laboratory	17.621**
X-ray	17.86 **
Nursing services	1.182
Other operating expense	.1959
Total operation expense	.2677

*significant at the .05 level
**significant at the .01 level

Appendix B-2

Interaction Variable Results

The test statistic is as follows:

$$F(Q-k,\ n-Q) = \frac{(SSR_Q - SSR_k)/Q-k}{SSE_Q/(n-Q)}$$

F = test statistic

Q = number of new explanatory variables plus original

k = number of original explanatory variables

n = sample size

SSR_Q = amount of variance explained by the regression of all variables

SSR_k = amount of variance explained by the regression of the original variables

SSE_Q = amount of variance unexplained by the regression of all variables

K = 7	Critical F - value	5, 29 dF
Q = 12	95% = 2.54	
N = 41	99% = 3.73	

Category (dependent variables)	F-value
Administration	373.96*
Employee health and welfare	22.26*
Dietary	33.98*
Housekeeping	15.50*
Laundry and linen	6.42*
Operation and maintenance	18.26*
Medical supplies	63.99*
Therapy	11.79*
Pharmacy	77.56*
Laboratory	807.93*
X-ray	976.62*
Nursing services	131.06*
Other operating expense	14.75*
Total operation expense	317.16*

*significant at the .01 level

APPENDIX C

F-TEST CONDUCTED ON SIZE AND SIZE SQUARED

K = 6	Critical F-value	2,25 dF
Q = 8	95% = 3.38	
N = 33	99% = 5.57	

Category	F-value
Administration and general	.2053
Employee health and welfare	1.2564
Dietary	.317
Housekeeping	1.0196
Laundry and linen	.6447
Operation and maintenance	.5174
Medical supplies	6.7286**
Therapy	6.3428**
Pharmacy	13.0944**
Laboratory	76.7463**
X-ray	76.7463**
Nursing services	5.0428*
Other operating	.6988
Total Operating expense	1.7283

* Significant at .05 level

**Significant at .01 level

APPENDIX D

GOLDFELT - QUANDT TEST

H_o: Constant Variance $(E(\varepsilon_i^2) = \sigma^2)$

H_A: Reject

Test statistic = ESS_2/ESS_1

ESS_2 = residual sum of squares associated with high values of the independent variable

ESS_1 = residual sum of squares associated with low values of the independent variable

Size = independent variable

Degrees of freedom - $(N - d - 2k)/2$ (for numerator and demonstrator)

N = sample size

d = number of variables deleted

k = number of independent variables

$ESS_2 \doteq 39.7098$ $\qquad$ $N = 33$

$ESS_1 = 148.3557$ $\qquad$ $d = 1$

$k = 8$

$\frac{ESS_2}{ESS_1} = 2.67$ $\qquad$ d.F. = 8

Critical F = 3.44 at .05 level of significance

= 6.03 at .01 level of significance

$\therefore$ Do not reject H_o

APPENDIX E

The following expression is used to determine the confidence interval around the estimated average cost.

$$\hat{Y} - T_{n-q1}\ \alpha/_1\ S_Y \leq \alpha + \beta_i \bar{X}_i \leq \hat{Y} + T_{A-q_1}\ \alpha/_2\ S_{\hat{Y}}$$

T = Value from T distributor.	=	2.06
$S_{\hat{Y}}$ = Standard error of the estimate	=	3.1689
$\hat{Y}$ = Estimated mean average cost		
$\alpha/_2$ = degree of condifence	=	95%
n = sample size	=	33
q = estimated parameters	=	8

In an infinite number of samples for which confidence are determined, 95 percent of those intervals can be expected to contain the true average cost.

APPENDIX F-1

AVERAGE COST PER PATIENT DAY*

	Non-Profit Rural			Profit Rural		
Size	Lower	Mean	Upper	Lower	Mean	Upper
20	$12.14	$18.67	$25.19	$9.44	$15.97	$22.49
40	10.10	16.63	23.15	7.40	13.93	20.45
62.7**	8.24	14.77	21.29	5.54	12.07	18.59
80	7.14	13.67	20.19	4.44	10.97	17.49
100	6.22	12.75	19.27	3.53	10.06	16.58
122	5.65	12.18	18.70	2.95	9.48	16.01
140	5.53	12.06	18.58	2.82	9.25	15.87

	Non-Profit Non-Rural			Profit Non-Rural		
Size	Lower	Mean	Upper	Lower	Mean	Upper
20	$12.76	$19.29	$25.81	$10.06	$16.59	$23.11
40	11.03	17.56	24.08	8.33	14.86	21.38
62.7**	9.52	16.05	22.57	6.82	13.35	14.87
80	8.70	15.23	21.75	5.99	12.52	19.04
100	8.10	14.63	21.15	5.39	11.92	18.44
122	7.86	14.39	20.91	5.16	11.69	18.21
140	8.01	14.54	21.06	5.31	11.84	18.36

* SNC Beds = 54.37%
Occupancy Rate = 95.17%

**Average facility size for given data sample.

APPENDIX F-2

AVERAGE COSTS PER PATIENT DAY FOR CHANGING SNC BED PERCENTAGE**

Size	Non-Profit Rural Lower	Non-Profit Rural Mean	Non-Profit Rural Upper	Profit Rural Lower	Profit Rural Mean	Profit Rural Upper
	% SNC beds = 33.3%					
62.7*	$7.07	$13.60	$20.12	$4.37	$10.90	$17.42
122	4.49	11.02	17.54	1.79	8.30	14.84
140	4.36	10.89	17.41	1.65	8.18	14.70
	% SNC beds = 75%					
62.7*	9.38	15.91	22.43	6.68	13.21	19.73
122	6.79	13.32	19.84	4.10	10.63	17.15
140	6.66	13.19	19.71	3.96	10.49	17.01

Size	Non-Profit Non-Rural Lower	Non-Profit Non-Rural Mean	Non-Profit Non-Rural Upper	Profit Non-Rural Lower	Profit Non-Rural Mean	Profit Non-Rural Upper
	% SNC beds = 33.3%					
62.7*	$8.36	$14.89	$21.41	$5.65	$12.18	$18.70
122	6.70	13.23	19.75	4.00	10.53	17.05
140	6.85	13.38	19.90	4.15	10.68	17.20
	% SNC beds = 75%					
62.7*	10.66	17.19	23.71	7.96	14.49	21.01
122	9.06	15.59	22.11	6.31	12.84	19.36
140	9.15	15.68	22.20	6.45	12.98	19.50

*Average facility size for given data sample.
**Occupancy rate = 95.17%.

APPENDIX F-3

AVERAGE COST PER PATIENT DAY FOR CHANGING OCCUPANCY RATES**

	Non-Profit Rural			Profit Rural		
Size	Lower	Mean	Upper	Lower	Mean	Upper
	Occupancy Rate = 75%					
62.7*	$11.23	$17.76	$24.28	$8.53	$15.06	$21.58
122	8.65	15.18	21.70	5.95	12.48	19.00
140	8.52	15.05	21.57	5.82	12.35	18.87
	Occupancy Rate = 99.9%					
62.7*	7.52	14.05	20.57	4.82	11.35	17.87
122	4.93	11.46	17.98	2.24	8.77	15.24
140	4.81	11.34	17.86	2.11	8.64	15.16

	Non-Profit Non-Rural			Profit Non-Rural		
Size	Lower	Mean	Upper	Lower	Mean	Upper
	Occupancy Rate = 75%					
62.7*	$12.52	$19.05	$22.87	$9.82	$16.35	$22.87
122	10.86	17.39	23.91	8.16	14.69	21.21
140	11.01	17.54	24.06	8.31	14.84	21.36
	Occupancy Rate = 99.9%					
62.7*	8.81	15.34	21.86	6.10	12.63	19.15
122	7.15	13.68	20.20	4.44	10.97	17.49
140	7.30	13.83	20.35	4.60	11.13	17.65

*Average facility size for given data sample.
**Percent of SNC beds = 54.37%

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