THE ECONOMICS OF PHYSICAL ACTIVITY PROGRAMS: EVIDENCE FROM SASKATCHEWAN OLDER ADULTS

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ABSTRACT

Chronic diseases place a substantial economic burden on the health care system. Physical inactivity, poor diet and smoking are considered to be the main causes of high rates of chronic disease. Evidence clearly supports the positive influence of physical activity on health determinants, other health outcomes and quality of life. This implies that an increase in physical activity improves general health status and has the potential to reduce utilization of expensive healthcare services and disability days. Earlier studies show that physical activity programs would be an effective way of providing preventive care for people with chronic conditions. However studies that relate physical activity programs to health care utilization are limited in economics literature.

The aim of this paper is to examine the impact of physical activity programs on healthcare utilization. From 2002 to 2003, adults over the age of 50 years, in a mid-size Canadian city, presenting with excess weight, type 2 diabetes, hypertension, hyperlipidemia or osteoarthritis were recruited. Following a screening process, eligible participants were randomly assigned to one of two programs: a class-based structured program or a home-based unstructured program. Validated questionnaires related to health status and quality of life were completed and physical tests were carried out at baseline, 3, 6, 12 months and 24 months after the program initiation. In addition participants' use of physician and hospital services and pharmaceutical expenditures were accessed through their administrative data files for three years, one year before and two years after the intervention. Using administrative data from Sask Health and individual level survey data the effects of physical activity programs on health care utilization were estimated. The results showed that structured physical activity program can reduce annual physician costs significantly. The exponential effect of aging was found to be significant on hospital utilization, and the number of comorbidities was found to be significant on prescription drug utilization.

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CHAPTER 1

INTRODUCTION

The share of health care expenses in GDP in Canada was 7.1 percent in 1970, 7.3 percent in 1980, 9.2 percent in 1990 and 9.9 percent in 2002 (CIHI, 2005). One of the reasons behind the increase in health care costs is the increase in the number of cases of preventable chronic diseases; particularly obesity, smoking-related diseases, such as lung cancer and coronary artery diseases (CAD). As a result research has been focused on how to reduce preventable diseases. For instance the main risk factors for CAD, a primary preventable cause of death in Canada, are smoking, high blood pressure, high cholesterol levels and physical inactivity. Recent prevalence estimates indicate that 23 percent of Canadians smoke (Statistics Canada, 2003), 12.6 percent have high blood pressure (Statistics Canada, 1999), 26 percent have high blood cholesterol levels (MacDonald, 1992) and 62 percent are inactive (Craig, 1999). Thus, a decrease in physical inactivity may have a great potential to reduce the risk of CAD and health-related costs.

More recently efforts have focused on alternative policies to cut health care costs or at least keep them under control. Reducing dependency on high-cost institutional services, such as hospitals and nursing homes, while promoting less expensive and more efficient forms of care at the community level are initiatives have been adopted at the provincial level. Examples of these efforts are: home care programs and primary health care establishments, disease prevention and physical activity promotion and intervention programs. Federal and provincial policy makers and health region managers are looking for scientific facts to support their decision to spend limited budgets on such community-level programs.

Seniors in Canada account for approximately 30 percent of total health expenditures while representing only 12.7 percent of the population (Public Health Agency of Canada, 2006). The Canadian population is aging. In the coming decades seniors will comprise a larger share of the population, growing from 3.8 million people in 2000 (approximately 12.5 percent of the population) to an estimated 6.7 million by 2021 (approximately 19 percent of the population). Thus, as the population ages, health service utilization and the associated costs may escalate significantly unless effective population health strategies, geared towards the prevention and control of chronic disease, can be developed and implemented.

An extensive amount of research has been conducted on physical activity and its effects on health status. A common result of these studies is that physical activity has a positive effect on health status and thus physical activity programs may reduce health care costs. In a worksite physical activity program Golaszewski et al. (1992) found that participant employee health care costs and absent working days decreased and productivity of those employees increased. In another industrial fitness program Bowne et al. (1984) compared the health care utilization of the employees before and after the implementation of the program. They found a 45.7 percent reduction in major medical costs and a reduction of 20.1 percent in the average number of disability days at the end of the first year of the fitness program. Katzmarzyk et al. (2000) found that a 10 percent reduction in the prevalence of physical inactivity has the potential to reduce direct health care expenditures by $150 million annually in Canada.

The aim of this paper is to estimate the effect of physical activity programs on chronically ill older adults' health care utilization. Two questions will be answered in this paper. Firstly: do physical activity programs, in general, decrease the health care utilization of chronically ill older adults? Secondly: is there any difference between structured (supervised class-based) physical activity programs and unstructured (unsupervised home-based) physical activity programs in terms of effecting health care utilization?

CHAPTER 2

PREVIOUS LITERATURE

Treatment effect studies are very common in a broad range of fields in order to see the response of an intervention. The general methodology in these studies is to see the effect of the intervention by comparing a group of individuals before and after the intervention (i.e. a physical activity program) in terms of a variable (i.e. health care costs) or to compare two groups, one exposed to the intervention (treatment group) and the other not (control group).

If there are no observed or unobserved differences among the subjects in the study, and any differences occur while the study is being completed, the treatment effect of an intervention is easily identifiable. This, however, is hardly ever the case and how to control for observed and unobserved variables across heterogeneous individuals or variant over time is the main task of treatment effect analysis.

For instance, assume we want to know the effect of physical activity on the number of physician visits. We select a group of sedentary individuals and divide them into two groups: trial and control groups. We prescribe physical activity three times per week for the trial group and let the control group remain sedentary. At the end of the study period we compare the average number of physician visits of the trial group and the control group. If we expect the difference between the average number of physician visits of the trial group and the average number of physician visits of the control group to be the treatment effect of this study, the effect could be over or underestimated since the observed heterogeneity between the two groups was not taken into consideration. If the subjects in the trial group are younger than the subjects in the control group, they may be more receptive to treatment and the effect of physical activity in decreasing physician visits would be overestimated. Or if at least some of the subjects in the trial group have a chronic condition that may prevent them from being efficiently physically active, our results can underestimate the effect of physical activity. Thus, the correct methodology takes into account observed variables such as age, sex, current health condition, and time indifferent unobserved variables such as genes. In Table 2.1 below, a list of selected studies is provided with details on data collection methods, findings and shortcomings of methodologies used.

Two of the studies listed in the table are good examples of the differences in methodology. Skouen et al. (2002) tried to find the effect of multidisciplinary treatment programs for patients with chronic lower back pain on return to work from long-term sick leave. In their study, patients were randomized to a light multidisciplinary treatment program (trial group 1), an extensive multidisciplinary program (trial group 2) or treatment as usual by their primary physician (control group). After they were exposed to these three different programs, the patients' returns to work times were recorded for each group. In men they found significantly better results for full return to work for the light multidisciplinary treatment but no differences between extensive multidisciplinary treatment and treatment as usual. No significant differences among any of the three programs were found for women.

Table 2.1. Summary of the previous literature

Researchers	Data Collection Method	Findings	Shortcomings of the Methodology
Skouen et al. (2002)	Longitudinal Experimental	Improvement in health status	No heterogeneity consideration among the groups
Aakvik et al. (2003)	Longitudinal Observational	Improvement in health status	Potential selection bias
Shephard et al. (1982)	Longitudinal Experimental	Decline in health care costs	No heterogeneity consideration among the groups and potential selection bias
Bowne et al. (1984)	Longitudinal Experimental	Decline in health care costs	No randomization
Baun et al. (1986)	Longitudinal Observational	Decline in health care costs	No heterogeneity consideration among the groups and potential selection bias
Wang et al. (2004)	Longitudinal Observational	Decline in health care costs	Potential selection bias and unobserved variables
Martinson et al. (2003)	Longitudinal Observational	Decline in health care costs	Potential selection bias and unobserved variables
Andreyeva and Sturm (2006)	Longitudinal Observational	Decline in health care costs (statistically not significant)	Potential selection bias and unobserved variables
Lee and Kobayashi (2001)	Longitudinal (two waves) Observational	Decline in health care costs in LR (statistically not significant)	Potential selection bias

In this study even though patients were randomly distributed to different treatment programs, researchers did not check if the groups were statistically homogeneous. When we look at the subjects in different groups we see significant differences among them. For instance the average age for men in the light multidisciplinary program is 39. This is 41.4 and 45.2 in the extensive multidisciplinary program and the control group, respectively. For women, the average age in the light multidisciplinary program is 46.8. This is 43.5 in the extensive multidisciplinary program and 43.3 in control group. So there may be an overt bias in the study due to age differences across three different groups for the men. Thus, the reason behind the better results for the men in light multidisciplinary program could be just because the subjects in that group were younger and more receptive to treatment compared to the men in the extensive multidisciplinary treatment program and control group. It is possible that we do not see any significant differences in the results for the women because ages in different groups are relatively closer to each other, if age is an important determinant of receptiveness.

Aakvik et al. (2003) studied the same issue: the treatment effect of multidisciplinary programs for patients with chronic lower back pain on return to work. But instead of just comparing the trial and control groups that are subject to the treatment, they ran a regression and controlled for heterogeneity among the participants. They found that when they did not control for observed differences among the groups, the return to work ratio was 7.3 percent better for the subjects in the multidisciplinary treatment program (i.e. 7.3 percent more of the subjects in the trial group returned to work compared to the subjects in the control group). When they controlled for observed variables treatment effect improved to 9.3 percent. When they controlled for both observed factors, treatment effect declined to 6.3 percent. They also found that even though sex, age and diagnosis type have no statistical significance, the income and number of sick days in the preceding year are the significant factors that affect the rate of return to work.

There are plenty of available studies on the treatment effect of physical activity on health status and health care costs. Shephard et al. (1982) studied the influence of an employee fitness and lifestyle modification program on medical care costs. The subjects were drawn from two similar insurance companies (test and control companies). For both companies the health expenses of the subjects were examined the year prior to and the year of instituting an employee fitness program at the test company. Test employees tended to have fewer hospital days and fewer medical claims of all types relative to employees of the control company once the fitness program had been instituted. In this study, none of the observed variables were taken into consideration. For instance, maybe the average age of test employees was lower than the average age of the control employees, thus the test employees would be more responsive to the intervention.

In another study Bowne et al. (1984) compared the health care utilization of employees in an insurance firm before and after the implementation of the fitness program. The members of the cohort were well-educated and held sedentary white-collar jobs. Participation to the study was voluntary. The group experienced a 46 percent reduction in major medical costs in the post-entry year and there was a 20 percent decline in the average number of disability days. The results in this study can be overestimated just because the entry to the program was voluntary and those who volunteered might already have been looking to achieve healthier life styles.

Baun et al. (1986) studied the effect of worksite fitness program on absenteeism and health care costs. Their study population was randomly selected from employees of a large corporation. 53 percent of the participants were members of the company fitness center and 47 percent were not. They compared a full year of health care utilization and absent days of those two groups and found that health care costs among exercisers were lower than non-exercisers (a $442 difference in male employees and a $896 difference in female employees) even though the amounts were not statistically significant. These differences may be the result of a selection bias since the subjects in the trial group (exercisers) were already active before the program initiation. Researchers did not take the heterogeneity between two groups into account either.

In another worksite study Wang et al. (2004) studied the effect of physical activity on health care costs considering the different weight groups of employees. They found that sedentary employees had $285 higher health care costs than the moderately active ones and $221 higher health care costs than the very active ones. For the obese subpopulation the differences were $499 and $436 respectively. The estimated maximum potential savings amounted to approximately 1.5 percent of total health care costs per year for the company if all obese sedentary employees could become physically active, even once or twice a week.

In most of the studies, such as the one conducted by Wang et al., researchers compare the health care utilization of already active people to sedentary people. This method comes with the disadvantage of selection bias. If our purpose is to see the effect of physical activity on health care utilization for the sedentary population that we try to convert from an inactive lifestyle to an active one, the method above can overestimate the potential benefits of physical activity.

Martinson et al. (2003) studied the effect of physical activity on short-term changes in healthcare charges of older adults. Unlike Wang et al., they checked the changes in healthcare charges due to changed physical activity status. They found that subjects who increased their physical activity from 0-1 to 3+ days a week had significant declines in their mean annualized total charges ($2.202 less) relative to those who remained inactive. They obtained their data about the physical activity level of the subjects through two waves of survey. It is a well-known fact that answers to survey questions tend to overestimate physical activity levels. Apart from that, they did not have any information about the change in physical activity behaviour between the two waves, especially for older adults since changes in physical activity levels are very frequent within a short period of time.

Andreyeva and Sturm (2006) studied the relationship between physical activity and changes in health care costs for older adults. Like most of the other studies they used longitudinal survey data. They controlled for the covariates such as health status, sex, age and some socioeconomic factors. They found that for older adults, the lack of physical activity was associated with an approximate increase of $500 in total healthcare costs over two years although the 95 percent confidence interval included the possibility of no effect. As in other studies mentioned, this type of observational data is likely to reflect the effects of reverse causality from health status to physical activity such as in the case of individuals hospitalized for a long period who have extremely high health care costs, but who are also physically inactive during that period.

Lee and Kobayashi's (2001) research on the effect of exercise on health care demand is a noteworthy one in terms of the econometric methodology used. The response variables in their study are number of physician visits and hospitalization days, and the treatments of interest are light and vigorous exercise. They found that light exercise increases health care demand by 3-5 percent in the short-run, whereas it decreases health care demand by 3-6 percent in the long-run. They also found that vigorous exercise decreases health care demand by 1-2 percent in the short-run, whereas it decreases health care demand by 1-3 percent in the long-run. However, many of those numbers are not statistically significantly different from zero. Even though the data that they used are observational non-experimental data, and are thereby subject to biases due to non-random selection of exercise, in their panel data regression they controlled for factors like age, sex, education, race, and diagnosis types.

Due to high costs and application difficulties, experimental studies in health care are infrequently conducted. Analyzing data already collected or obtaining data through survey questionnaires is easier and cheaper. Thus in observational studies, the size of the data (number of observations and/or subjects) is generally large; even after removing missing or imputed values it is still possible to have a considerably big data set.

But the main problem with the observational data is the selection bias possibility due to non-random selection of the treatment. Assume we want to understand the effect of standardized tests on academic achievements. Again assume one school conducts standardized tests for its students and the other school does not. If we compare the academic achievements of these two schools the results can mislead us since we did not take into account other factors that can effect academic achievement, such as income level. If the school with higher academic achievement is in a higher income neighbourhood the difference in results could be due to the difference in the income levels of the students. Better nutrition, more extracurricular activities or better living conditions could affect academic achievement.

On the other hand, the experimental approach can handle the selection bias problem better than the observational approach due to the randomization of the subjects in the trial and control programs and controlling the observed heterogeneity between the trial and control subjects that most of the experimental studies mentioned above failed to do.

CHAPTER 3

DESIGN OF THE CLINICAL TRIAL

The Saskatoon-In-Motion project was introduced by the Saskatoon Health Region (SHR), under a legislated mandate to improve the health of people in Saskatoon through health promotion and illness prevention (In-Motion, 2006). The SHR developed a comprehensive, community-wide active living strategy with a focus on physical activity. This project includes a public awareness campaign about the importance of physical activity. The intent of the project is to ingrain understanding and behaviour changes into societal culture and make people more physically active. The partners in this project with the SHR are the University of Saskatchewan, the City of Saskatoon, the Community Service Department and ParticipACTION Canada. Together, the partners provided information to the public to increase the activity levels of the population and ensure that everyone has access to physical activity. Community awareness was increased through the media (i.e., TV, radio, print), newsletters and brochures, special events and campaigns and promotional materials.

One of the roles of the university in this partnership was to conduct research to measure the potential benefits of the Saskatoon-In-Motion project. For the research, 581 chronically ill older adults between 50 to 85 years old who previously had sedentary lifestyles were contacted. First, the eligible ones were observed for one year without any intervention and their health statuses were recorded. After one year, half of the eligible were assigned to a community-based structured physical activity program and other half of the eligible were assigned to a home-based unstructured physical activity program. Their health statuses were recorded for another two years under those physical activity programs. The aim of this process is to measure the differences between health status and health care utilization among those two periods (inactive and active periods) and to see if there is any difference in the potential benefits between the different physical activity programs.

3.1. Recruitments to the Trial

In order to choose the recruits, 581 older adults who were diagnosed with certain types of chronic diseases (type 2 diabetes mellitus, hypertension, hyperlipidemia, overweight or obesity, osteoarthritis) by their physician were contacted by telephone enquiries. 318 of them agreed to participate into the study. The recruits were excluded from participation in the study if they had a history of any kind of heart disease, or any other medical conditions that might prevent them from carrying out a moderate physical activity program, or were active more than twice a week for the last six months preceding the study enrolment.

Before the recruits were assigned to two alternative programs they were asked to complete a health and lifestyle questionnaire and perform functional activity tests. Their heart rate, blood pressure, height, weight, waist and hip girths were measured. 135 out of 318 were ineligible to carry on with the program at the baseline; another 11 withdrew. A total of 172 were left to be in those two alternative programs at the end of baseline assessment. At the end of the 24-month period 43 participants withdrew as well, which left the study with 129 participants. After the 24-month intervention period, participants' health care utilization was retrieved from the Sask Health database. The utilization included number of hospitalization days, number of physician visits, and the cost of outpatient prescription drugs.

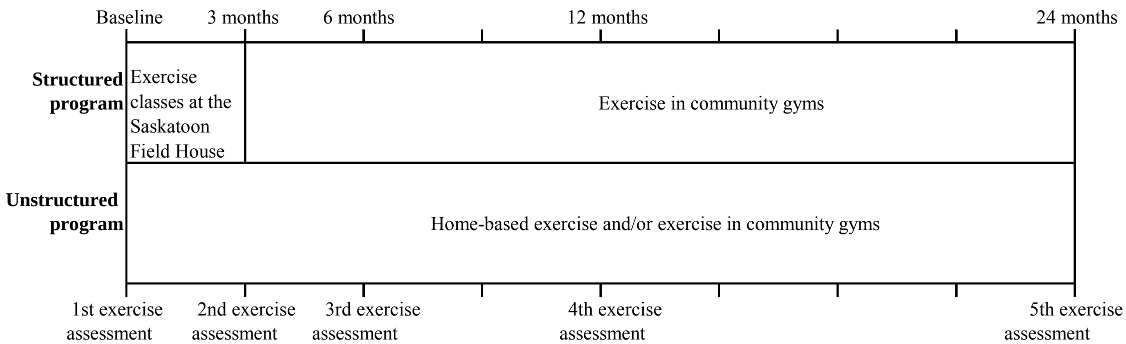
3.2. Structured and Unstructured Physical Activity Programs

After the baseline assessment, 84 recruits were randomly assigned to the structured class-based program and 88 recruits to an individual community-based program (at the end of 24^{th} month 60 recruits in the structured and 69 recruits in the unstructured program were left).

Those who were assigned to the structured program were encouraged to attend the exercise classes at the Saskatoon Field House three times per week for three months and attend the education sessions provided by the program during this time. The cost of attending the structured program was not covered by the study, paid out of pocket by the participants. The activity program included components of endurance (walking, stationary cycling), strength (light free weight) and flexibility. After the third month recruits were provided with a list of community programs offered by community groups and facilities such as the City of Saskatoon, YMCA and YWCA that are available for physical activity and encouraged to continue their activities at those sites.

In the unstructured community-based program, a fitness coach discussed with the recruits the tools to meet their activity goals through home-based physical activity and/or community physical activity programs offered by community groups and facilities such as the City of Saskatoon, YMCA and YWCA. The cost of programs chosen by participants was not covered by the project. This activity program consisted of moderate intensity physical activity for 60 minutes at least three times per week with

Figure 3.1. Timeline for the structured and unstructured programs



a combination of endurance, strength, and flexibility components, the same as in the structured program. Participants in the unstructured program were encouraged to attend group education sessions at the Saskatoon Field House along with the participants in the structured program.

Three months, 6 months, 12 months and 24 months after the baseline, recruits from both programs were asked to return to the Saskatoon Field House to complete the exercise assessment and health and lifestyle questionnaire.

Both groups were observed strictly only for three months in their prescribed structured and unstructured programs through phone interviews. After that they were recommended to continue being active as they were prescribed. After the third month there was no restriction to stay in the program they were originally assigned.

CHAPTER 4

DATA SOURCES AND DESCRIPTIVE ANALYSIS

In order to do the analysis two data sets were merged: Sask Health data and the College of Kinesiology data. In this chapter the data sources are explained and then a descriptive analysis is conducted.

4.1. Data Sources

Participants' health care utilization information was obtained from the Sask Health with the written consent of the participants. Their physical activity measures were collected by the College of Kinesiology. These two data have been merged with STATA.

4.1.1. Sask Health Data

Like all other provinces and territories in Canada, Saskatchewan has a fully government-funded health insurance system for most of the health services. When a patient visits a health provider, if the service is covered, the service provider charges the cost of the service to the provincial government through the health insurance card of the patient. As a result Sask Health has collected a large amount of health services information in electronic form for several decades. In most of the databases diagnosis is classified using the International Classification of Diseases (ICD). With the consent of the study participants Sask Health provided certain information about the participants from some of its database for three years; one year before the intervention and two years after the intervention.

The health services information used in this analysis was provided in three files:

i. The *physician visits file* reported participants' physician visits. The file included the date of the visit, the major diagnosis by the physician, the approved amount paid by the government (because some services are not covered completely by the government such as chiropractor expenses), and the medical practitioner's specialty (i.e., grouped to family physician, specialist, or others like chiropractor).

ii. The *hospital services file* reports if the stay was an inpatient or day surgery stay, admission date, discharge date, diagnosis, certain procedures, and intensity weight (called resource intensity weight (RIW) for inpatient stays and day procedure group (DPG) weight for day surgery stays). Intensity weight is used to standardize the expression of hospital case resource consumption recognizing that not all patients require the same health care resources (CIHI, 2007)[1].

iii. The *prescription drugs file* includes the information about the medication dispensed. The file includes the type of drugs dispensed by the participants, the date of prescription and the cost of the drugs. There are two types of drug costs

[1] Hospital care in Saskatchewan is funded globally; therefore it is difficult to establish the cost of an individual hospital stay. But the cost of a particular stay in a given fiscal year can be estimated by multiplying the intensity weight by the estimated funding per weighted case for that fiscal year. A fiscal year's estimated funding per weighted case is based on funding provided by Sask Health for acute care and is an estimate derived from analyses of historical staffing and other cost standards.

in the file: the first one is the total cost of the drugs and the second is the government's share of the total cost since the drug costs are not entirely covered by the government. In Saskatchewan, unlike some other provinces in Canada such as Alberta or British Columbia, older adults are not necessarily eligible for free of charge prescriptions after a certain age.[2] In order to be eligible for social assistance for drug costs, the income of the individual should be low enough compared to his or her monthly prescription drug costs.

Costs of physician and prescription utilization were calculated from physician and pharmacy claims to Sask Health, utilization of hospital services was based on the intensity weight of the stay. Total medical claims for each individual were categorized and summed up by the ICD. Main diseases that are known to be associated with physical inactivity were determined using medical literature (Physical Activity and Health: A Report of the Surgeon General, 1996). The major interest here is to calculate the costs of health problems claimed by individuals that are related to physical inactivity. The yearly costs were adjusted to 2005 dollars using the medical inflation rates in Saskatchewan.

4.1.2. Physical Activity Survey Data

Physical activity survey data include some demographic information about the participants such as sex, age, marital status, education, ethnicity; some medical measures such as blood pressure, heart rate; some physical measures such as BMI, waist girth, hip girth; some physical activity measures such as distance covered in 6 minutes, chair

[2] Saskatchewan Health introduced a new program in July 2007 that allows 65 year-olds and older to pay $15 maximum per prescription drug. But, first of all, our study period ends in 2005 and second of all not all of our participants are older than 65 years old.

standing and stair climbing exercises; and some self-reported questionnaires such as physical component score (PCS-12), mental component score (MCS-12), and physical activity scale for elderly (PASE). The questionnaires include questions such as “In general would you say your health is: ❑ excellent, ❑ very good, ❑good, ❑ fair, ❑poor”. The accuracy of showing the true physical condition of an individual for the self-reported questionnaires has been proven in literature (Ware et al. 1995). PCS-12 and MCS-12 intend to measure the quality of health of the individual, and PASE intends to measure the physical activity level of the individual.

The change in the medical and physical measures in Table 4.1 below throughout the study gives us a clue about the potential effect of physical activity on these measures. The measures are expected to improve from baseline to the end of the study. The variables can be measured for the participants in structured and unstructured programs separately, and the effect of the intervention on those two different programs can be observed. During the intervention period participants in the structured program attended gym classes for three months under the supervision of the fitness coaches. They were also encouraged to attend the same structured work out in community fitness centers. Participants in the unstructured program were encouraged to do physical activity programs at home or community fitness centers without supervision.

Table 4.1. Description of the variables

Variable	Description	Mean	Standard Deviation	Min	Max
Log (physician)	Log of yearly inflation adjusted physician cost	5.76	0.99	1.36	8.16
Log (drug cost)	Log of yearly inflation adjusted prescription drug cost	5.76	1.28	1.68	7.94
RIW	Yearly hospital resource utilization	0.07	0.29	0.00	3.72
Structured	Physical activity program dummy for the participants in structured program	0.31	0.46	0.00	1.00
Unstructured	Physical activity program dummy for the participants in unstructured program	0.36	0.48	0.00	1.00
Sex	Sex of the participant; 1 = male 0=female	0.74	0.44	0.00	1.00
Age	Age of the participants	61.63	7.38	50.00	84.00
Age square	Square of the participant's age	3852.31	946.99	2500.00	7056.00
Residence	Where participant lives; 1 = own home, a family member home, own apartment 0 = senior's housing or other	0.96	0.19	0.00	1.00
Marital	Marital status of the participant; 1 = married / common in law or living with a partner 0 = single, separated, divorced, or widowed	0.75	0.43	0.00	1.00
Residence	Where participant lives; 1 = own home, a family member home, own apartment 0 = senior's housing or other	0.96	0.19	0.00	1.00
Employment	Employment status; 1 = full time employed, part-time employed 0 = retired or unemployed	0.48	0.50	0.00	1.00
Income	Total family income; 1= <$20.000, 2=$20.000 to <$30.000 3=$30.000 to <$40.000 4=$40.000 to <$50.000 5=$50.000 to <$60.000 6=>$60.000	4.17	1.73	1.00	6.00
Smoker	Participant's current smoking status; 1 = smoker 0 = non-smoker	0.03	0.16	0.00	1.00

Ex-smoker	Participant's former smoking status; 1 = ex-smoker, 0 = non ex-smoker	0.48	0.50	0.00	1.00
SBP	Max. blood pressure when the heart contracts (mmHg)	130.08	16.38	90.50	186.50
DBP	Blood pressure when the heart is at rest (mmHg)	75.90	9.16	55.50	103.00
RHR	Heart beats in minute when resting	71.63	10.43	43.00	103.00
Waist	Circumference of the waist in cm	97.68	13.20	61.50	132.70
PCS-12	Physical component score btw 0 and 100 (100 being the best)	47.20	8.97	19.60	61.83
MCS-12	Mental component score btw 0 and 100 (100 being the best)	52.72	8.83	18.18	67.86
PASE	Physical Activity Score for Elderly	105.46	49.68	4.29	310.21
Comorbidity	Number of chronicle disease a participant possess	2.28	0.87	1.00	5.00

Individuals in the study have been assigned to structured and unstructured programs randomly. A mean test can show if the observed variables are balanced between the two groups. The results of the test are in Table 4.2. The summary statistics show no evidence that participants in the structured and unstructured programs are statistically significantly different from each other at the baseline.

Table 4.2. Mean difference tests between the two groups

	Structured program (N=60)		***Unstructured program (N=69)***		
Variable	**Mean**	**SD**	**Mean**	**SD**	**Differences in means***
Age	60.87	7.09	60.42	7.62	-0.45
Income	4.16	1.78	4.23	1.67	0.07
SBP	131.34	14.03	135.30	17.39	3.96
DBP	77.73	9.78	77.92	7.72	0.19
RHR	72.95	10.25	71.46	11.15	-1.50
Waist	98.59	11.88	99.26	14.54	0.66
PCS-12	47.32	7.93	46.91	9.08	-0.41
MCS-12	50.36	9.15	52.16	8.63	1.80
PASE	95.54	40.54	104.48	48.82	8.94

*NOTES: * None of the differences is statistically significant at $\alpha=0.01$*

Since the participants have some chronic conditions such as diabetes, hypertension, and obesity and they are physically inactive, the following variables were followed during the intervention: SBP, DBP, and RHR (variables related to hypertension); Waist (variable related to obesity); PCS-12, MCS-12, and PASE (variables related to physical inactivity). The summary statistics for these variables are in Table 4.3, 4.4, and 4.5.

Table 4.3. Summary statistics for the whole population

	Inactive year		***First active year***		***Second active year***		***Differences in means***		
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**First versus inactive**	**Second versus inactive**	**Second versus first**
SBP	133.46	15.98	128.04	16.27	128.08	16.49	-5.42*	-5.38**	0.04
DBP	77.83	8.70	74.84	9.21	74.61	9.35	-2.99*	-3.22*	-0.23
RHR	72.15	10.72	71.53	10.35	71.02	10.19	-0.62	-1.13	-0.51
Waist	98.95	13.32	97.48	13.22	96.16	12.97	-1.47	-2.79	-1.32
PCS-12	47.10	8.54	47.51	8.85	46.92	9.70	0.41	-0.18	-0.59
MCS-12	51.33	8.88	53.34	8.62	53.70	8.90	2.01	2.37	0.36
PASE	100.33	45.21	106.93	51.79	110.51	52.48	6.60	10.18	3.58

NOTES: * Statistically significant at α=0.01, ** Statistically significant at α=0.05

Even though we see improvement in all measures from baseline to the end of the study for the whole population, except for blood pressure measures (SBP, DBP), none of the differences are statistically significant. A potential reason for this is the low size of the population and a high standard deviation among participants.

Table 4.4. Summary statistics for the participants in the structured program

	First active year*		***Second active year****		***Differences in means*****		
Variable	**Mean**	**SD**	**Mean**	**SD**	**First versus inactive**	**Second versus inactive**	**Second versus first**
SBP	127.87	16.59	127.12	16.79	-3.47	-4.22	-0.75
DBP	75.03	10.17	73.94	9.15	-2.71	-3.79	-1.09
RHR	72.23	9.45	71.34	8.43	-0.73	-1.62	-0.89
Waist	97.75	12.83	94.36	11.85	-0.84	-4.23	-3.39
PCS-12	47.45	8.71	47.55	8.17	0.13	0.23	0.10
MCS-12	53.93	9.18	54.29	7.80	3.58	3.93	0.36
PASE	101.33	43.09	112.45	45.07	5.79	16.91	11.12

*NOTES: * Variables measured at the end of first and second active years, ** None of the differences are statistically significant at α=0.01, *** Inactive year values for the variables are at Table 4.2*

For participants in the structured program all of the measures improve consistently from the inactive year through to the second active year as in for the whole population. These changes are consistent with the literature that claims physical activity improves health status. For the same potential reasons as in Table 4.3, none of these improvements in Table 4.4 are statistically significant.

Table 4.5. Summary statistics for the participants in the unstructured program

	First active year		***Second active year***		***Differences in means****		
Variable	**Mean**	**SD**	**Mean**	**SD**	**First versus inactive****	**Second versus inactive**	**Second versus first**
SBP	128.18	16.11	128.85	16.36	-7.11	-6.44	0.67
DBP	74.68	8.34	75.15	9.55	-3.24	-2.77	0.47
RHR	70.9	11.13	70.76	11.49	-0.56	-0.70	-0.14
Waist	97.24	13.65	97.60	13.75	-2.02	-1.65	0.36
PCS-12	47.55	9.05	46.45	10.76	0.64	-0.47	-1.11
MCS-12	52.81	8.12	53.25	9.70	0.65	1.09	0.44
PASE	111.92	58.34	109.02	57.95	7.43	4.54	-2.90

*NOTES: * None of the differences is statistically significant at α=0.01, ** Inactive year values for the variables are at Table 4.2*

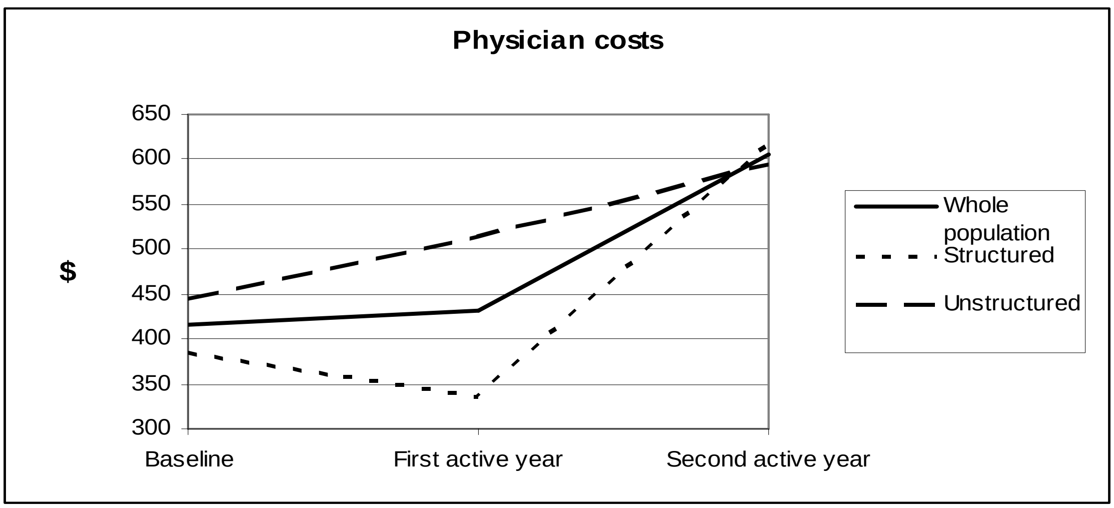
For participants in the unstructured program, for almost all the variables, there is an improvement from the inactive to the first active year, but a decline from the first active to the second active year. For instance, first SBP decreases from the inactive to the first active year, and then it increases from the first active to the second active year. The reason behind this may be that the participants in the unstructured program quit being physically active during the last year of the intervention program[3]. But it is noteworthy to point out that none of the differences in Table 4.5 is statistically significant at α=0.01 as Table 4.3 and Table 4.4.

[3] There is no available data about the participants' activity level after the 3rd month of implementation of the intervention program except for the self-reported questionnaire answers at the end of the first active year.

4.2. Descriptive Analysis

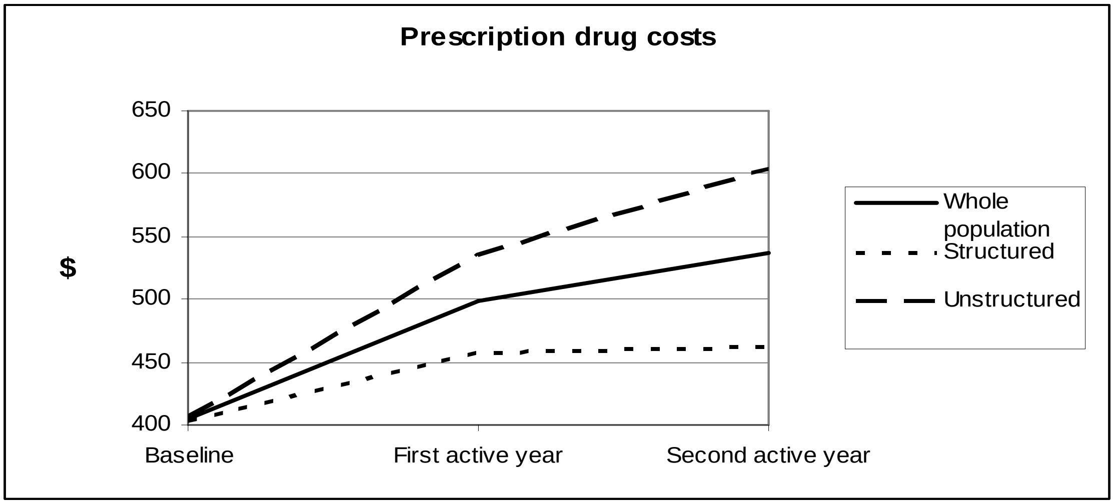
The purpose of analyzing the data described above is to calculate the health care utilization before and after the intervention, thus to see the effect of physical activity programs on health care utilization, if there is any. This comparison can be done from different points of view. Simply before and after costs can be calculated for all of the participants (Figure 4.1). If the purpose is to see the different effects of structured and unstructured programs the population can be divided into two subgroups and a before and after comparison can be done after (Figure 4.2, and Figure 4.3).

Figure 4.1. Annual physician cost ($)



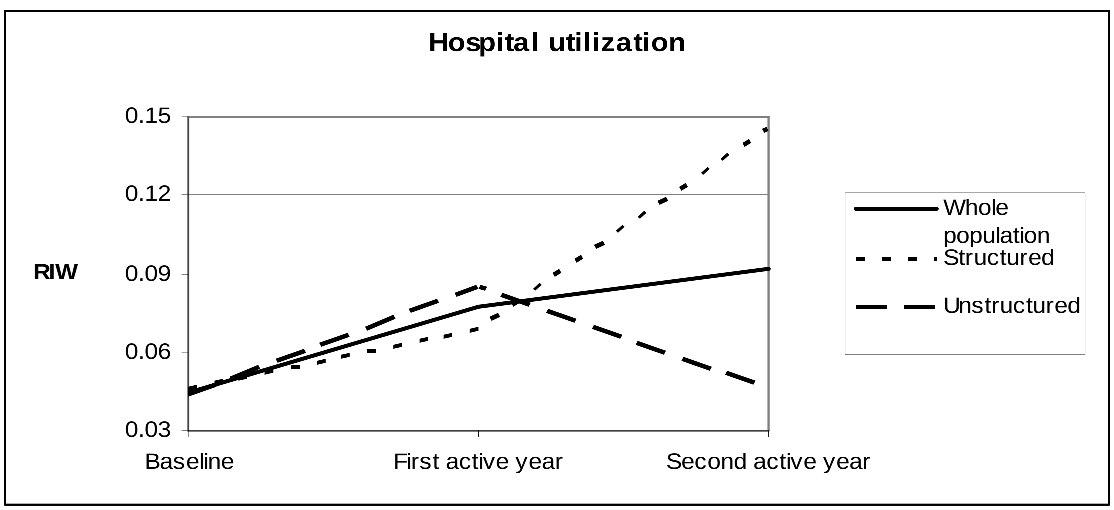
There is a slight incline in the physician costs from baseline to first active year for the whole population. This incline gets very steep from the first active year to the second active year. These descriptive results tell us that as the population gets physically active, physician utilization increases, thus physical activity does not particularly decrease physician costs.

Figure 4.2. Annual prescription drug cost ($)



The prescription costs and hospital resource utilization are not different from the physician costs. As the whole population gets physically active the prescription costs and hospital resource utilization increase.

Figure 4.3. Annual hospital resource utilization (RIW)



Physician utilization increases from baseline to the end of second active year for both structured and unstructured groups. Trend is the same for the prescription drug utilization. For the participants in the structured group hospital utilization increases from baseline to the end of second active year, but for the participants in the unstructured group utilization increases from baseline to the end of first active year and again goes back to the baseline level at the end of first active year. Most of these changes are statistically insignificant (see Appendix Table A1, A2, and A3).

It is possible that the type of physical activity program can play a role in the utilization changes. Dashed lines in the figures above show the information separately for the participants in the structured and unstructured programs. But neither for the participants in the structured program nor for the participants in the unstructured program is there a different trend from the whole population (except for the hospital utilization of the unstructured group from the first active year to the second active year). Thus health care utilization increases over time for both groups. There are even some statistically significant increases for the unstructured group, such as physician and drug costs.

CHAPTER 5

METHODOLOGY

In treatment effect studies the researcher tries to find the effect of an intervention on a response variable. The effect of a new corporate tax law on unemployment rate, the effect of a new education system on academic achievement or the effect of a new drug on blood pressure level are all examples of treatment effect studies. The purpose of this study is to find the treatment effect of physical activity programs on the health care utilization of chronically ill older adults.

In order to see the effect of physical activity programs on health care utilization, health care costs were compared before and after the treatment in the 'Descriptive Analysis' section of chapter 4. If participants' health care utilization declines after the intervention, it is possible to say that physical activity helps to decrease health care costs.

On the other hand, this kind of simple 'before and after' comparison may not reflect the mere effect of physical activity on health care costs. There are lots of observed and unobserved variables that may affect the period after the intervention. In order to see the pure effect of physical activity on health care costs, those variables should be controlled. Most of the previous studies about the effects of physical activity on health status were conducted by comparing two separate groups assigned to two different studies or by using one of the groups as a control group. The changes of the health status of these two groups was compared at the end of the study and an effort was made to decide if the conducted physical activity had any effect on the trial group relative to the comparison group. The problem with some of these studies is that there is no certain way to determine which part of the change in health status is due to the intervention program and which part is due to observed or non-observed group specific factors such as genetic, physical and lifestyle differences and geographical differences between the groups. In some studies a resolution to this problem was attempted by conducting a randomization of the participants into alternative programs, program type 1 versus program type 2 or trial group versus control group (Shephard et al. 1982).

In some of the other studies, a solution to the problem was attempted by comparing individuals by themselves, assigning them into a physical activity program and measuring their health care utilization before and after the intervention (Bowne et al. 1984). If, however, the treatment takes a long time to implement or the effects take a long time to manifest itself, like in the physical activity intervention programs, then some variables that affect the results may change during that time (Lee, 2005). In this case at least some portion of the change in the response variable may be due to changes in those variables. Or, if the duration of the analysis is not long enough time, the effect of the program may not completely appear in the results, which means an underestimation of the intervention.

5.1. Why Panel Data Regression? Benefits and Limitations

Panel data observe cross-sectional units (i.e., individuals, firms, countries, etc.) over time. There are several features of panel data that are advantageous to cross-sectional or time-series data (Kennedy, 2003):

i. Panel data are useful to deal with heterogeneity in micro units. Micro units are all different from each other in unmeasured ways. For instance two women of the same age can be different in genetics and the difference in their health care expenditures may be result of the genetic differences. Omitting this variable can cause a bias in the estimation. Panel data are helpful to correct this problem.

ii. Especially when data are observational, some variables move systematically together and in this case there is no guarantee that the data will be rich in information. This problem is referred to as multicollinearity. Panel data create more variability through combining variation across micro units with variation over time and lessen the effect of multicollinearity problem. With more informative data, more efficient estimation is possible.

iii. Panel data can deal with issues that cross-sectional or time-series data cannot. For instance assume we want to see the effects of two alternative drugs on cholesterol levels. We prescribe Drug 1 to the treatment group and Drug 2 to the control group. Since the cross-section method collects the data at one point in time it will not show any increase or decrease in the cholesterol levels of the treatment or control groups due to a new drug treatment. If, for instance, we see a lower cholesterol level in the treatment group it does not mean that Drug 1 is more effective as compared to Drug 2; it's possible that the treatment group had a lower cholesterol level to start with. Thus we need to compare the measurements to a reference point (i.e., another measurement in time). Things are worse with time-series data on a single individual. If we prescribe both drugs to the same individual we can not separate the effects of each drug.

iv. Panel data avoid the need for a lengthy time series by exploiting information on the dynamic reactions of each of several individuals, thus allowing for better analysis of dynamic adjustment.

Although panel data have some significant benefits, there are also some limitations (Baltagi, 2001):

i. Cost problems: To observe a number of individuals over time requires high costs and a lot of effort.
ii. Design and data collection problems: These include incomplete accounts of the population's interest, no response due to lack of cooperation of the respondents, etc.
iii. Distortion of measurement errors due to unclear questions, memory problems and misreported responses.
iv. Typical panels involve annual data covering a short time span for each individual. This means that asymptotic arguments rely crucially on the sufficiently large enough number of individuals.

5.2. Fixed-Effect Estimation versus Random-Effect Estimation

In panel data we can simply assume that intercept and slope coefficients are constant across cross-sectional units and time, and the error term captures differences over time and individuals. But this would be a very naïve assumption since the real world data can be different from this simplistic supposition. In the real world one of the following may be the case (Gujarati, 2003): the slope coefficients are constant but the intercept varies over individuals; the slope coefficients are constant but the intercept varies over individuals and time; all coefficients (the intercept as well as slope coefficients) vary over individuals; or the intercept as well as slope coefficients vary over individuals and time.

Fixed-effect estimation (FEE) deals with these complexities by putting a dummy for each individual and/or time and omits the intercept. Doing this allows each individual to have a different intercept. At first glance this seems to be difficult to estimate due to a large number of dummies for each individual and time. But the transformation of the data into a simpler form helps. This transformation consists of subtracting from each observation the average of the values for that individual. OLS on these transformed data produces the desired slope estimate.

Suppose the observation for the i_{th} individual in the t_{th} time period is written:

$$y_{it} = \alpha + \beta x_{it} + \gamma z_i + \varepsilon_{it} \tag{5.1}$$

Here, "x" represents time variant variables such as blood pressure level for each individuals and "z" represents time invariant variables such as genetic features of the individuals.

The average of the observations on the i_{th} individual over T time period is written:

$$\overline{y}_i = \alpha + \beta \overline{x}_i + \gamma z_i + \overline{\varepsilon}_i \tag{5.2}$$

Subtracting equation (2) from equation (1) we get:

$$y_{it} - \overline{y}_i = \beta(x_{it} - \overline{x}_i) + \gamma(z_i - z_i) + (\varepsilon_{it} - \overline{\varepsilon}_i) \qquad (5.3)$$

or,

$$y_{it}* = \beta x_{it}* + \varepsilon_{it}* \qquad (5.4)$$

where $y_{it}* = y_{it} - \overline{y}_i$, $x_{it}* = x_{it} - \overline{x}_i$, and $\varepsilon_{it}* = \varepsilon_{it} - \overline{\varepsilon}_i$. Now, the intercept and time invariant variables have been eliminated. Now, equation (5.4) produces the fixed effects estimators.

The FEE has two major drawbacks. We lose degrees of freedom as many as the added dummy variables and the transformation of the data wipes out all explanatory variables that do not vary within an individual (i.e., time invariant), such as sex and race.

Another way of allowing for different intercepts is by using the random effects estimation (REE). This model is similar to the fixed effects model in that it postulates a different intercept for each individual but it sees the different intercepts as having been drawn from a bowl of possible intercepts; so they may be interpreted as random and treated as they were a part of the error term.

The REE performs Estimated Generalized Least Squares (EGLS). The EGLS calculation is done by finding a transformation of the data that creates a spherical variance-covariance matrix and then performing OLS on the transformed data.

The equation for the REE can be shown as:

$$y_{it} = \mu + \beta x_{it} + (u_i + \varepsilon_{it}) \quad (5.5)$$

where μ is the mean of the random intercepts, $\alpha_i = \mu + u_i$, and the errors u_i and ε_{it} in the composite error term have variances σ_u^2 and σ_ε^2, respectively.

The transformation for REE can be shown to be:

$y_{it}* = y_{it} - \theta \overline{y}_i$ and $x_{it}* = x_{it} - \theta \overline{x}_i$, where $\theta = 1 - \dfrac{\sigma_\varepsilon}{\sqrt{T\sigma_u^2 + \sigma_\varepsilon^2}}$

Another way of summarizing the differences between the FEE and REE is in terms of omitted variable bias. If the collective influence of the unmeasured omitted variables (that give rise to the different intercepts) is uncorrelated with the included explanatory variables, omitting them will not cause any bias in OLS estimation. In this case they can be bundled into the error term and efficient estimation undertaken via EGLS - the REE is appropriate. If, however, the collective influence of these omitted unmeasured variables is correlated with the included explanatory variables, omitting them causes bias. In this case, they should be included to avoid this bias. The FEE does this by including a dummy for each cross-sectional unit.

The REE is recommended whenever it is unbiased (i.e., whenever it's composite error is uncorrelated with the explanatory variables). We can use a Hausman test to test the null hypothesis that the error term and explanatory variables are independent from each other (i.e., orthogonal). Regardless of the truth of the null hypothesis, the FEE is unbiased because it includes dummies for the different intercepts. But the REE is unbiased only if the null hypothesis is true. If the explanatory variables are correlated with the error term, the FEE is consistent but the REE is not consistent. If the explanatory variables are uncorrelated with the error term, the FEE is still consistent, but inefficient, whereas the REE is consistent and efficient, thus providing a better estimation of the coefficients for explanatory variables. Consequently, if the null is true the fixed and random effects estimators should be approximately equal. If the null is false they should be different. The Hausman test compares the two estimators by testing if they are significantly different from one another.

CHAPTER 6

RESULTS

Table 6.1 shows the regression results (models supported by Hausman tests) for physician and prescription costs, and hospital resource utilization (see Appendix Table A4 for the models that are not supported by Hausman tests). Physical activity programs "Structured" and "Unstructured" were considered as explanatory variables along with other control variables. According to the regression results, a structured physical activity program plays a significant role in decreasing physician costs. From the inactive period to the active period the yearly physician costs of the participants in the structured physical activity program decreased 40 percent on average.

These regression results are interesting because according to the descriptive analysis in chapter 4, yearly physician costs are increasing from the inactive year to the active years on average both for the participants in structured and unstructured programs, meaning being physically active increases yearly physician costs. But when the data were controlled for observed variables through the panel data regression we see that the structured physical activity program actually decreases physician costs. It is noteworthy to point out that these results are valid at 10 percent significance level (p-value is 0.07). At 5 percent significance level the effect of structured program on physician costs is not significant.

Table 6.1. Regression results[†]

	Dependent Variables		
	Log (physician) Model 1 FEE (t-stat)	**Log (drug cost) Model 2 REE (z-stat)**	**RIW Model 3 REE (z-stat)**
Constant	0.55	-3.61	2.40**
	(0.03)	*(-0.56)*	*(2.63)*
Structured	-0.40*	-0.08	0.02
	(-1.86)	*(-0.66)*	*(0.67)*
Unstructured	-0.35	0.19*	0.02
	(-1.62)	*(1.81)*	*(0.70)*
Comorbidity		0.44**	0.02
		(3.32)	*(0.95)*
Sex		0.32	0.01
		(1.06)	*(0.16)*
Age	0.02	0.22	-0.08**
	(0.04)	*(1.10)*	*(-2.75)*
Age square	0.002	-0.002	0.001**
	(0.36)	*(-0.99)*	*(2.93)*
Marital		0.24	-0.08**
		(0.83)	*(-2.02)*
Residence	-0.88	0.33	0.08
	(-1.25)	*(0.81)*	*(1.04)*
Employment	0.32	0.15	0.02
	(0.75)	*(0.67)*	*(0.68)*
Income	-0.01	-0.003	0.001
	(-0.08)	*(-0.05)*	*(0.02)*
SBP	-0.002	-0.001	0.001
	(-0.27)	*(-0.21)*	*(-0.16)*
DBP	0.001	-0.02	-0.003
	(0.08)	*(-1.52)*	*(-1.48)*
RHR	0.01	0.001	-0.001
	(0.91)	*(0.10)*	*(-0.10)*
Waist	-0.01	0.01	0.002
	(-0.70)	*(1.00)*	*(1.40)*
PCS-12	-0.01	-0.004	0.001
	(-0.68)	*(-0.67)*	*(0.04)*
MCS-12	-0.01	0.003	0.001
	(-0.67)	*(0.51)*	*(0.47)*
PASE	-0.003	-0.001	-0.001
	(-1.63)	*(-0.31)*	*(-0.71)*
Smoker		0.75	-0.05
		(1.00)	*(-0.51)*
Ex-smoker		0.62**	-0.02
		(2.67)	*(-0.60)*
R-sq	0.072	--	--

NOTES:[†] Models that are supported by Hausman tests ** Significant at 10 percent, ** Significant at 5 percent*

At a 10 percent significance level, the unstructured physical activity program increases prescription drug costs. As participants get physically active through the unstructured program, their prescription costs increase 19 percent per year on average. Again at a 5 percent significance level the effect is insignificant.

For prescription costs, the number of comorbidity has a significant effect. As was previously mentioned, the participants were chosen among chronically ill older adults. Each participant had at least one of the following chronic diseases: type 2 diabetes mellitus, hypertension, hyperlipidemia, overweight or obesity, osteoarthritis. According to regression results, having one more of these illness increases yearly prescription drug cost 44 percent on average.

To be an ex-smoker also has a negative effect on prescription drug costs. Ex-smokers have 62 percent more prescription drug costs as compared to non ex-smokers.

The regressions results in Table 6.1 show that the explanatory variables "age" and "age square" are statistically significant for hospital resource utilization. The partial derivative of the regression for the hospital utilization with respect to age will yield

$$\frac{\mathrm{d}(RIW_{\mathrm{it}})}{\mathrm{d}(\mathrm{age}_{it})} = \beta_1 + 2\beta_2 Age_{it} \tag{6.1}$$

The result shows that there is a nonlinear relationship between the hospital resource utilization and age. It means that as the individuals get older they use more hospital resources at an increasing rate. For instance from 50 to 51 years-old, hospital resource use is expected to increase 0.02 RIW (-0.08 + 2 x 0.001 x 50) and from 69 to

70 years-old, hospital resource use is expected to increase 0.06 RIW (-0.08 + 2 x 0.001 x 70). No significant effect of aging on physician or prescription drug costs was found.

Marital status was found to have an effect on hospital utilization. Being married or living common-in-law decreases hospital utilization 0.08 RIW.

CHAPTER 7

CONCLUSION

The increasing cost of Canada's healthcare system is one of its main problems. As of 2002 Canadians spent 9.9 percent of their GDP on health care compared to 7.1 percent in 1970. One of the reasons behind this increase is the increasing number of cases of preventable chronic diseases. If we can control the increase of chronic cases it is possible to control the impact of these diseases on health care spending. Previous literature illustrates that it is possible to prevent some chronic diseases or to reduce the severity of them through physical activity. Thus, physical activity has the potential to control increasing health care costs and even to decrease them.

The purpose of this paper is to see the effect of physical activity programs on health care utilization for those who suffer from any of the following chronic diseases: hypertension, hyperlipidemia, obesity, diabetes and/or osteoarthritis. An effort was made to answer the questions "Do physical activity programs help decrease yearly physician and prescription costs, and hospital resource utilization for chronically ill, sedentary older adults?" and "Is there any difference between structured and unstructured physical activity programs in effecting health care utilization?"

The Saskatoon Health Region, the University of Saskatchewan, the City of Saskatoon and ParticipACTION introduced the Saskatoon-In-Motion project in order to modify the behaviour of a sedentary population and make people more active. One of the roles of the university in this partnership was to measure the effects of physical activity programs on health status and health care utilization. For this reason, 129 chronically ill older adults who had sedentary lifestyles were recruited. They were observed for one year without interfering with their inactive lifestyles. Then they were randomly assigned to two different activity programs: structured and unstructured. Their health status was measured and recorded through their blood pressure, anthropometrics, functional fitness tests, and physical performance tests by the College of Kinesiology. At the same time their health care costs of physician visits and prescription drugs, and hospital resource utilization was obtained from the Sask Health database.

These two separate databases were merged and analyzed with STATA Version 8. The aim of this process is to measure the differences between health care utilization between two periods; inactive and active, and to see the potential benefit of physical activity programs.

Two separate programs were designed for the group older adults; structured and unstructured. The structured program was a class-based program supervised by fitness coaches. The unstructured program was a home-based program in which the participants were encouraged to do prescribed physical activities at home. Participants were randomly distributed to the programs. The purpose of having two separate programs was to see if there were any significant differences in the outcomes for those who attend different programs.

The first way to explain the effect of physical activity programs on health care utilization is through descriptive analysis. In the “Descriptive Analysis” section in chapter 4, the utilization of the participants was compared for the inactive and active periods without considering observed differences that may affect the results. According to the descriptive analysis, the average yearly physician costs increased from $416.86 in the inactive year to $431.72 in the first active year (3.6 percent) and to $605.21 in the second active year (45.2 percent). The average yearly prescription drug costs increased from $404.95 in the inactive year to $499.10 in the first active year (23.2 percent) and to $537.52 in the second active year (32.7 percent). The average yearly hospital resource intensity increased from 0.0447 RIW in the inactive year to 0.0774 RIW in the first active year (73.2 percent) increase and to 0.0921 RIW in the second active year (106 percent). All these results tell us that, when these individuals changed their lifestyle from sedentary to physically active through activity programs their health care utilization in all areas increases.

Descriptive analysis results above do not take any observed variables into account. Regression analysis, on the other hand, considers any other factor that may affect the relationship between physical activity programs and health care utilization. According to the regression results, the structured physical activity program decreases yearly physician costs around 40 percent on average. We do not see any significant decline in physician costs for the participants who attended the unstructured program. We do not see any significant effect as a result of the physical activity from any of the programs on prescription drug and hospital utilization.

When the study was constructed, no control group was chosen to compare the results with the intervention group. This may create a hidden bias problem. One way to remove this undesired hidden bias is to have a control group. To do this another population with similar characteristics (sedentary, chronically sick older adults) could be observed without interfering in their sedentary lifestyle. If, for instance, this control groups' prescription costs increase 40 percent whereas the trial group's prescription costs increase 20 percent within the same time frame we can say that physical activity programs help, relatively, in decreasing prescription drug costs. Unfortunately in this study there is no control group to eliminate the hidden bias.

Another limitation of the study is its time frame. In this type of before and after analysis, if the treatment takes a long time to manifest itself, it may not be possible to see the effect of intervention in a short time period completely. Even though the participants were observed for five years (one inactive and four active years) the utilization data obtained from Sask Health are for just three years. When the fourth and fifth year data become available, the positive effect of physical activity programs on health care utilization may be observed more clearly.

Even though the results of this study reveal that physical activity programs may reduce health care utilization, no formal cost-benefit analysis was completed. Promoting and implementing a province or nation-wide physical activity program would cost a significant amount of money. In this scarce-budgeted health care environment, the policy should focus on the programs that would produce the highest marginal benefit / marginal cost ratio. Calculating estimated implementation costs of physical activity programs would help determine the cost-benefit ratio and compare the marginal benefit of physical activity programs with other alternative programs such as information sessions through various means of media, such as newspapers, TV, and radio. A future study can focus on this analysis.

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APPENDIX

Table A1. Health care utilization per patient (whole population)

	Inactive year		***First active Year***		***Second active year***		***Differences in means***		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**First versus inactive**	**Second versus inactive**	**Second versus first**
Physician ($)	416.86	332.61	431.72	450.15	605.21	633.80	14.86	188.35*	173.49*
Hospital (RIW)	0.0447	0.1403	0.0774	0.3016	0.0921	0.3659	0.0327	0.0474	0.0147
Drug ($)	404.95	446.13	499.10	507.90	537.52	568.48	94.15	132.57**	38.42

NOTES: N = 129, ***** *Statistically significant at α=0.01, ** Statistically significant at α=0.05*

Table A2. Health care utilization per patient (structured)

	Inactive year		*First active year*		*Second active year*		*Differences in means*		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**First versus inactive**	**Second versus inactive**	**Second versus first**
Physician ($)	384.10	264.21	336.49	308.97	616.63	716.08	-47.61	232.52	280.14*
Hospital (RIW)	0.0457	0.1408	0.0686	0.2983	0.1451	0.5210	0.0229	0.0994	0.0765
Drug ($)	402.47	483.30	457.49	498.78	461.44	450.66	55.02	58.97	3.95

*NOTES: N = 60, ***** Statistically significant at α=0.01*

Table A3. Health care utilization per patient (unstructured)

	Inactive year		*First active year*		*Second active year*		*Differences in mean**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**First versus inactive**	**Second versus inactive**	**Second versus first**
Physician ($)	445.35	381.98	514.53	532.57	595.29	557.69	69.18	149.94	80.76
Hospital (RIW)	0.0438	0.1409	0.0851	0.3064	0.0461	0.1090	0.0413	0.0023	-0.0390
Drug ($)	407.10	414.69	535.28	516.58	603.68	650.04	128.18	196.58	68.40

*NOTES: N = 69, * None of the differences is statistically significant at α=0.01*

Table A4. Regression results†

	Dependent Variables		
	Log (physician) Model 4 REE (z-stat)	**Log (drug cost) Model 5 FEE (t-stat)**	**RIW Model 6 FEE (t-stat)**
Constant	7.41	-14.17	16.72
	*(1.69)**	*(-0.94)*	*(2.85)***
Structured	-0.14	-0.02	0.09
	(-1.06)	*(-0.11)*	*(1.42)*
Unstructured	0.09	0.18	0.07
	(0.75)	*(1.05)*	*(1.05)*
Comorbidity	0.08		
	(1.03)		
Sex	0.53		
	*(2.76)***		
Age	-0.11	0.69	-0.52
	(-0.80)	*(1.51)*	*(-2.89)***
Age square	0.001	-0.01	0.004
	(0.97)	*(-1.61)*	*(2.85)***
Marital	-0.22		
	(-1.19)		
Residence	0.19	-0.01	-0.02
	(0.56)	*(-0.02)*	*(-0.08)*
Employment	0.02	0.55	0.22
	(0.13)	*(1.40)*	*(1.79)**
Income	0.002	-0.04	-0.02
	(0.04)	*(-0.37)*	*(-0.57)*
SBP	0.002	-0.01	-0.002
	(0.37)	*(-1.02)*	*(-1.02)*
DBP	-0.01	-0.01	0.01
	(-0.73)	*(-1.03)*	*(1.44)*
RHR	0.001	0.01	0.003
	(0.05)	*(0.83)*	*(1.00)*
Waist	0.01	0.01	-0.004
	*(1.95)**	*(0.90)*	*(-0.85)*
PCS-12	-0.01	-0.01	-0.002
	(-1.04)	*(-1.37)*	*(-0.70)*
MCS-12	-0.003	0.001	0.002
	(-0.43)	*(0.04)*	*(0.68)*
PASE	-0.001	-0.001	-0.001
	(-0.74)	*(-0.96)*	*(-1.61)*
Smoker	-0.11		
	(-0.24)		
Ex-smoker	0.24		
	(1.68)		
R-sq	--	0.16	0.10

*NOTES: † Models that are not supported by Hausman test, * Significant at 10 percent, ** Significant at 5 percent*

Table A5. Hausman Specification Test Results

	Chi-square test statistics	p-value	Decision
Log (physician) Model 1 versus Model 4	21.44	0.0910	Reject REE at 10percent confidence level
Log (drug cost) Model 2 versus Model 5	19.33	0.1134	Not reject REE
RIW Model 3 versus Model 6	19.84	0.1353	Not reject REE

Figure A1. Histograms of dependent variables (linear formats)

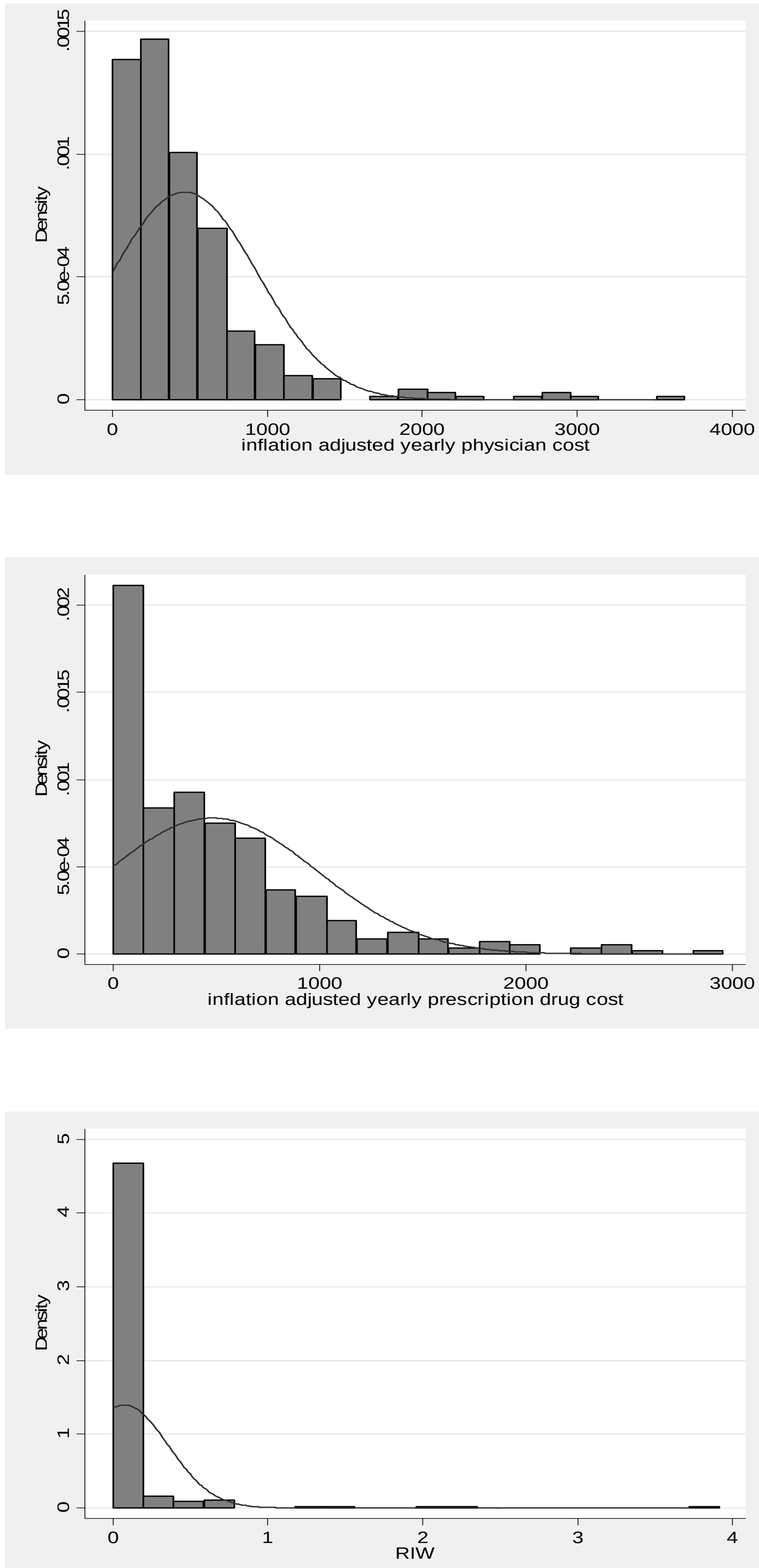

Figure A2. Histograms of dependent variables (log formats)