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Rehabilitation Utilization and the Marginal Cost of Ischemic Stroke in South Carolina

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REHABILITATION UTILIZATION AND THE MARGINAL COST OF ISCHEMIC STROKE IN SOUTH CAROLINA

by

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This study uses Medicare claims from 1997 and 2004 to examine two important health policy issues using patients with ischemic stroke as an example. We explore the differences in rehabilitation services utilization and expenditures for stroke prior to and after outpatient rehabilitation caps were enacted. We then examine the effect of using a total cost approach versus a marginal cost method to estimate the first year cost of stroke and stroke rehabilitation. We found the cap did constrain outpatient rehabilitation utilization and cost of rehabilitation services if examined only using Medicare Part B provider costs, but not when facility costs were also included. Use of a marginal costing approach was superior to average costing. Indeed, the average costing approach may be expected to inflate the estimated 2004 SC total cost due to stroke for Medicare patients by $3.6 billion, because this approach ascribes expenditures for comorbid conditions to stroke.

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1. INTRODUCTION

Stroke is the third most common cause of death in the United States (US) and South Carolina (SC), after heart disease and cancer (CDC, 2009). Even more challenging, stroke is the leading cause of long-term disability (Roger, Go *et. al.*, 2011a). The American Heart Association (AHA) estimates new or recurrent stroke incidence in the US annually at approximately 795,000 (Roger, Go *et. al.*, 2011a).

In 2010, it is projected that stroke related costs will reach an estimated 73.7 billion dollars in the US alone (CDC, 2009). Hospitalization costs from stroke in SC were estimated at $499 million in 2008 (SC Office of Chronic Disease Epidemiology and Evaluation, 2009) with additional indirect costs due to lost productivity to be estimated at another $190 million (Mackay J., 2010).

The National Heart, Lung and Blood Institute identified eleven US states (Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) with stroke death rates that were more than 10% higher than the US average (National Heart Lung and Blood Institute, 2009). Ten of the 11 states cluster in the southeastern US and are designated the “stroke belt” because of their higher incidence of stroke and stroke-related deaths (Casper, Wing *et. al.*, 1995; Howard & Howard, 1995; Howard, Evans *et. al.*, 1995). South Carolina has one of the highest stroke mortality rates (130 per 100,000) in the US and is considered to be a member of the “Stroke Belt” (SC Office of Chronic Disease Epidemiology and Evaluation, 2009). South Carolina and specifically Charleston, lies in the “Low Country” or low-lying coastal plains of S.C. which has the distinction of being part of the “stroke buckle” where stroke rates are the highest in the nation (Howard & Howard, 1995).

Ischemic stroke accounts for 87% of all strokes, with the remaining strokes falling into one of the hemorrhagic categories (Benesch, Witter *et. al.*, 1997; CDC, 2009). Interventions to treat acute ischemic stroke are now available and are increasingly being used which could effectively reduce mortality rates, however, long-term morbidity due to stroke-related impairments are expected to increase. These increases are likely to be further exacerbated by the aging population of baby boomers in the US

In addition to the impact of population aging and stroke morbidity rate increases on stroke rehabilitation needs, governmental policy changes may also play an influential role in the utilization and cost of post-stroke rehabilitation. The federal Balanced Budget Act of 1997 (BBA 1997) included a series of changes in Medicare regulations aimed at cost containment. One of the regulations in the BBA 1997 included a $1,500 annual cap on outpatient therapy services. The cap included an annual limit of $1,500 in occupational therapy service expenditures per Medicare participant, and a $1,500 cap on combined physical and speech-language therapy per annum, per participant. The effective date of this capitation program was January 1, 1999. Due to the tendency of the healthcare industry to adjust to major legislation before the legislation takes effect, it is likely that, even in the years after the effective date where there existed a moratorium on the rules being enforced, outpatient rehabilitation services utilization and rehab costs went down even though the needs likely increased. The effect of major federal health care policy changes have been seen outside of effective dates in the past, such as with the implementation of the diagnostic related group (DRG) based prospective payment system in the 1980s and 1990s (Schwartz & Mendelson, 1991).

Even with Medicare's attempts to contain costs, the total cost of chronic illness in the US continues to rise. Some speculate that the cost of treatment after ischemic Stroke will increase due to the decrease in mortality and subsequent increase in morbidity due to trend of stroke survivors living longer with stroke-related disabilities. These suppositions are very difficult to confirm or deny due to the variability in cost of illness research models and methods. However, because there has been an increase in the comorbidity in the elderly population, an understanding of marginal cost of stroke, over and above normal expected medical care, is the most valuable cost benchmark to follow over time. Furthermore, it is important to know what proportion of post-stroke health services is rehabilitation-related care, both for planning purposes and to establish evidence that will drive future federal regulation and policy.

Therefore, this study examined the cost of ischemic stroke in the state of South Carolina in order to improve our understanding of:

1) post-stroke rehabilitation service utilization and cost changes between 1997 and 2004, and
2) the 2004 marginal cost of stroke (a measure of the cost of stroke, over and above normal costs expected in a similar non-stroke population), and the proportion of marginal costs attributable to rehabilitation.

Our findings will contribute to improving baseline estimates of stroke and rehabilitation costs as well as to inform policy decisions related to Medicare financing.

AIM 1

To examine the cost and utilization of rehabilitation services (physical therapy (PT), occupational therapy (OT), speech language pathology (SLP)), before and after the 1997 Balance Budget Act.

Rationale of Importance

It is important to understand the effects of structural changes in governmental health care cost containment regulations (therapy caps) on the process of rehabilitation services utilization and outcome of cost.

AIM 2

To determine the cost of stroke-related healthcare and stroke-related rehabilitation care for South Carolina Medicare patients in 2004 and examine what proportion of the cost is rehabilitation-related.

Rationale of Importance

Cost of illness has been historically reported as direct total healthcare cost and has never been compared as a marginal cost difference with an equally ill, non-stroke, control group. Therefore the outcome of cost of illness has been historically misrepresented in a population that tends to have a great amount of healthcare costs that are related to comorbidities. The over-estimation caused by estimating cost of illness using total cost of care, results in an under-estimation of the impact and need for stroke rehabilitation.

2. THEORETICAL BACKGROUND

Stroke is a highly prevalent disease that can result in death or long-term debilitating impairments. Impairments can include: speech, swallowing, cognitive, and physical disability. At the same time some individuals experiencing a stroke do not survive. Studies show that stroke-related mortality appears to be on a downward slope, due in part to standardized treatment protocols for acute stroke treatment. This reduction in mortality from stroke is likely to result in an increase in the number of individuals with impairments requiring practitioners to transfer some of their research focus from acute treatment to long-term management of chronic stroke-related functional limitations.

As with other common chronic diseases, such as heart disease and cancer, mortality rate decreases are accompanied by greater requirements for chronic care and attention from the patient, caregivers, and the health-care community as a whole. What differentiates stroke from other chronic diseases is the magnitude of the impact of the disease on quality of life and productivity due to functional impairments.

Unfortunately society is required to assume much of the economic burden of stroke morbidity as many stroke survivors are over 65 years of age; and therefore, they receive primary healthcare support through Medicare. As more baby boomers reach the Medicare age range, we hope to experience what has been seen in this group until now, a generally healthier population. The baby boom generation is retiring later, or not at all, and being more productive than has been seen in earlier generations. This being said, the impact of post-stroke impairments in the baby boom generation may become an even greater burden on society unless advances in post-stroke rehabilitation practices and outcomes are realized. For these reasons it is imperative that we advance the research of rehabilitation which has fallen behind the multiple decades of research and knowledge gains in the medical management of stroke during acute care.

Rehabilitation professionals are striving to advance the understanding of which practices are best, in whom, when, and how much, without the benefit of knowing what is being done in the current practice of post-acute stroke care. There is little evidence to show how much rehabilitation stroke survivors are currently receiving even though clinical practice guidelines suggest a comprehensive team of rehabilitation specialists (physical therapists (PT), occupational therapists (OT), speech language pathologists (SLP), ect.) evaluate every individual who has survived a stroke. There is even less evidence to show that increases in rehabilitation contact hours results in greater productivity and quality of life, and less cost to society. In addition, the research community does not have a clear and consistent idea of the marginal cost of stroke and what portion of the cost is rehabilitation-related.

This evidence is needed to help benchmark changes that we will see in the future as well as to help guide research to answer the all-important, “who, when and how much” clinical questions as well as the “at what cost to patients and society" policy questions. Knowing these benchmarks will also provide evidence to support policies that will guide how much rehabilitation care is supported by the healthcare payment system. Good, long-term, evidence is currently needed to support the expected increase in spending in the short-term to recover much greater savings in the longer-term while also achieving optimal outcomes.

In the following sections, I will review the epidemiology of stroke and current mechanisms to receive and pay for rehabilitation services in the United States. This research was completed using South Carolina (SC) Medicare data, a state that bears a significant burden of stroke. I will also review current evidence for rehabilitation services post-stroke and I will also consider issues related to what is known about cost and access to rehabilitation after stroke, as well as the possible impact of health-care policy on clinical practice.

2.1. Stroke Population Statistics

It is estimated that 7,000,000 Americans have had a stroke, indicating a prevalence in the population of 3% (extrapolated to 2008 from NHANES 2005-2008 data) (Roger, Go *et. al.*, 2011a). The AHA estimates stroke prevalence in the US annually at approximately 795,000, with new strokes accounting in 610,000 of these (Roger, Go *et. al.*, 2011a). In 2007, approximately 1 in 18 deaths in the US were due to stroke (Roger, Go *et. al.*, 2011a). The actual number of deaths from stroke fell 18.8% from 1997 to 2007 in the US (Roger, Go *et. al.*, 2011a), likely due to an increase in controlling some of the major risk factors. However, the reduction in mortality due to stroke may result in an increase in the number of individuals living with the long-term complications of the disease. Stroke incidence remained relatively stable in the 1990s. However, since then data have shown that the incidence in stroke is declining in the white population, but not in blacks (Roger, Go *et. al.*, 2011a). It is estimated that every year 55,000 more women than men suffer from a stroke (Roger, Go *et. al.*, 2011a).

2.2. Stroke Etiology

Stroke is a clinical syndrome caused by a disruption of blood flow in the brain resulting from either a blockage in a blood vessel (ischemic stroke) or a rupture in a blood vessel (hemorrhagic stroke) (Mackay J., 2010). Bleeding in the brain (hemorrhagic), which damages surrounding tissue, or a blockage in a blood vessel in the brain (ischemic) which reduces blood flow, causes brain cell death resulting in stroke or a "brain attack". Some cells permanently die, and others are at risk of death, but may be saved if treated quickly (NINDS, 2011). It is estimated that 80-87% of all strokes are due to embolism (ischemic), 10% are due to intracerebral hemorrhage, and 3% are caused by subarachnoid hemorrhage (Demaerschalk, Hwang & Leung, 2010a; National Institutes of Health, NINDS, 2007; NINDS, 2011; Roger, Go *et. al.*, 2011a; Roger, Go *et. al.*, 2011a).

Common symptoms of stroke include: sudden numbness or weakness particularly on one side of the body; sudden confusion or problems speaking or understanding speech; sudden vision impairment; sudden dizziness, trouble walking, or loss of balance; and/ or sudden severe headache (NINDS, 2011). In many cases, more than one of these symptoms will be experienced at one time. Evidence suggests that the best chance to reduce permanent injury due to stroke is to seek medical assistance immediately (Demaerschalk, Hwang & Leung, 2010a; NINDS, 2011).

Incidence and mortality from stroke have declined greatly since the 1960's with the increased understanding and treatment of risk factors and improved clinical intervention for stroke (NIH - NINDS,). However, stroke remains the number one cause of serious disability in adults in the US today (NINDS, 2011).

Currently there is only one US Food and Drug Administration (FDA) approved treatment for ischemic stroke, intravenous infusion of recombinant tissue plasminogen activator (rt-PA) (Adams, del Zoppo *et. al.*, 2007; Demaerschalk, Hwang & Leung, 2010a). This treatment has been shown to improve neurologic recovery after ischemic stroke and reduce the incidence of impairment and disability (Adams, del Zoppo *et. al.*, 2007). In contrast, except for some surgical cases, there is no currently available clinical intervention for hemorrhagic stroke. In this study, I have elected to focus on ischemic stroke because there is current treatment for ischemic stroke and evidence suggests it is a likely contributor to reductions in mortality with subsequent increases in morbidity.

2.3. Recurrent Stroke

The risk of stroke also increases greatly once a person experiences a first stroke. Data from meta-analyses suggest that the short-term risk of recurrent stroke is ~3-10% two days after initial stroke and 9-17% at 30 days after initial stroke (Giles & Rothwell, 2007; Wu, McLaughlin *et. al.*, 2007). Brown et al. found that 2.5% of stroke survivors will experience a second stroke within one month of the initial stroke, 6.6% will experience a second stroke within six months and 11.8% will experience a second stroke within 12 months (Brown, Lisabeth *et. al.*, 2005). Despite the high likelihood of recurrent stroke, many individuals with a history of stroke frequently continue unhealthy lifestyles thereby increasing their risk of recurrent stroke (Cheng, Jolly *et. al.*, 2005; Hoenig, Nusbaum & Brummel-Smith, 1997; Qureshi, Suri *et. al.*, 2001).

2.4. Stroke Risk Factors

The major risk factors associated with stroke include: high blood pressure, atrial fibrillation, high cholesterol, smoking, poor diet, obesity, family history, lack of exercise, diabetes, and age (Mackay J., 2010; NINDS, 2011). Risk factors for stroke include both modifiable and non-modifiable factors. Non-modifiable risk factors which cannot be changed by an individual include gender, with women having a higher lifetime risk of stroke than men, due mostly to their longer life expectancy. An additional non-modifiable risk factor is age. The risk of having a stroke increases greatly with age. Another is race, with minorities having higher risk of stroke. An individuals' risk of having a stroke also increases if they have recently experienced a transient ischemic attack (TIA) (Roger, Go *et. al.*, 2011a). Individuals with a history of TIA have a 10 year risk of stroke of ~20% (Clark, Murphy & Rothwell, 2003).

Additional risk factors for stroke that are non-modifiable but in themselves may be modifiable with behavioral changes or medication use include: increased risk if a person has a history of congestive heart disease, heart failure, peripheral artery disease, hypertension, diabetes, atrial fibrillation, sickle cell disease, and dyslipidemia (Roger, Go *et. al.*, 2011a). The list of modifiable risk factors is similar to risk factors for other chronic diseases. They include obesity, smoking, and physical inactivity (Roger, Go *et. al.*, 2011a). Of these risk factors, having recently had a TIA, having high blood pressure (hypertension) or having atrial fibrillation has been shown to carry the greatest increased risk for stroke (Roger, Go *et. al.*, 2011a). Stroke risk factors become comorbidities which contribute to long and short term negative outcomes and cost of care for individuals with stroke.

2.5. Stroke Mortality

In a study of people ≥ 65 years of age from Medicare data, the 1-month case fatality rate was 12.6% for all strokes, 8.1% for ischemic, and 44.6% for hemorrhagic (Roger, Go *et. al.*, 2011a). Mortality rates due to stroke are higher in women than men, and in blacks versus whites while risk of stroke increases with age (Roger, Go *et. al.*, 2011a). When compared with the Northeastern US, the crude and age-standardized total and ischemic stroke death incidence rates are higher in the Southeast and Midwest (Roger, Go *et. al.*, 2011a).

2.6. Stroke Impairment and Disability

The US National Institutes of Health (NIH) estimates that 10% of people recover almost completely after stroke, 25% recover with mild impairment, 40% live with moderate to severe disability requiring special care, 10% are disabled enough to require long-term institutionalization, and 15% die shortly after having stroke (National Institutes of Health, NINDS, 2007). This equates to over 65% of stroke sufferers needing specialized stroke-related rehabilitation services. The need for these services increase costs in individuals with stroke.

The World Health Organization (WHO) in collaboration with the Center for Disease Control (CDC) publishes data related to the impact of stroke on disability adjusted life years (DALYS). In these publications they define DALYS as the "combined years of potential life lost due to premature death with years of productive life lost due to disability" (Mackay J., 2010). In the most recently published version of the CDC and WHO's combined report entitled "The Atlas of Heart Disease and Stroke", it is estimate that 8 DALYS per 1000 population in the US are lost due to stroke (Mackay J., 2010).

According to the AHA, based on 2005 Behavioral Risk Factor Surveillance System (BRFSS) data only 30.7% of those surviving a stroke receive outpatient rehabilitation services. The authors of this AHA report entitled, "Heart Disease and stroke Statitistics – 2011 Update" suggest that these 2005 findings indicated that,

> "the prevalence of stroke survivors receiving outpatient stroke rehabilitation was lower than would be expected if clinical practice guideline recommendations for all stroke patients had been followed" (Roger, Go *et. al.*, 2011a).

In a 2003 study of ischemic stroke survivors who were ≥ 65 years of age (based on Framingham Study data) there are a number of disabilities commonly seen after stroke. This study found that at 6 months following ischemic stroke, 50% of their sample had some amount of hemiparesis, 46% experienced cognitive deficits, 35% had symptoms of depression, 30% were unable to walk unassisted, 26% were dependent in activities of daily living (ADLs: Barthel < 60), 26% were institutionalized in a nursing home, 19% had aphasia, and 15% had sensory deficits (Kelly-Hayes, Beiser *et. al.*, 2003). All of these proportions were shown to be clinically and statistically significantly greater than seen in a control group, indicating a need for long-term rehabilitation therapy to address these deficits and improve symptoms.

2.7. Cost of Stroke in the US

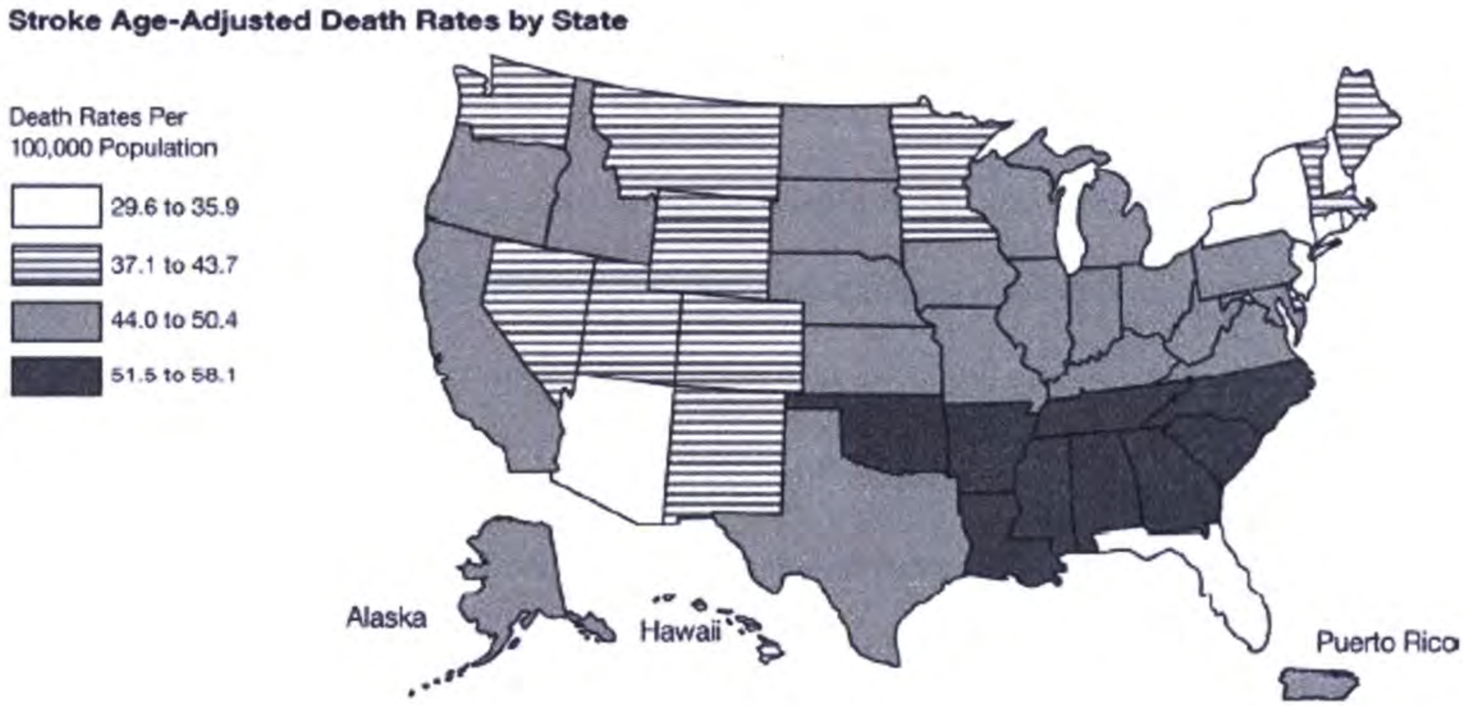
In 2010, it is projected that stroke related costs will reach an estimated $73.7 billion in the US alone (CDC, 2009). The AHA estimates total stroke costs in 2007 dollars (from Medical Expenditure Panel Survey (MEPS) data) at $40.9 billion (Roger, Go *et. al.*, 2011a). The variation between the Centers for Disease Control (CDC) and AHA estimates, even with a time differential of three years, is extremely broad. According to the Rochester Stroke Study, the thirty day post-event cost of a mild versus severe ischemic stroke was estimated at $13,019 and $20,346, respectively (data was from between 1987 and 1989 and severity was based on Rankin Scores) (Roger, Go *et. al.*, 2011a). These studies highlight the need for more consistent and accurate estimates of costs of illness. These cost estimates also did not differentiate between stroke-related costs with that of care for unrelated illnesses.

2.8. Stroke in South Carolina Stroke Belt

Since the 1940s there has been a significant geographic disparity in stroke mortality in the US, with higher rates seen in the southeast. This area is referred to as the "stroke belt". The National Heart, Lung and Blood Institute (NHLBI) identified eleven US states (Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) with stroke death rates that were estimated at 10-20% higher than the US average (National Heart Lung and Blood Institute, 2009; Roger, Go *et. al.*, 2011a). Ten of the 11 states cluster in the southeastern US and are designated the "stroke belt" because of their higher incidence of stroke and stroke-related deaths (Casper, Wing *et. al.*, 1995; Howard & Howard, 1995; Howard, Evans *et. al.*, 1995). The AHA lists only eight states to be members of the stroke belt, including North Carolina, South Carolina, Georgia, Tennessee, Mississippi, Alabama, Louisiana, and Arkansas (Figure 2-1.) (Roger, Go *et. al.*, 2011a).

South Carolina has one of the highest stroke mortality rates (130 per 100,000) in the US and is considered to be a member of the Stroke Belt (SC Office of Chronic Disease Epidemiology and Evaluation, 2009). South Carolina and specifically Charleston, lies in the "Low Country" or low-lying coastal plains of SC which has the distinction of being part of the "stroke buckle" where stroke rates are the highest in the US (Howard & Howard, 1995). Other states included in the stroke buckle are North Carolina and Georgia. The mortality rate from stroke in this region is estimated to be 40% higher than in the US in general (Howard & Howard, 1995). Also notable is a recently published report that indicates that South Carolina is one of 15 different states that has been defined as the "diabetes belt" where approximately 12% of residents have diabetes compared to 8.5% of the rest of the population (Barker, Kirtland *et. al.*, 2011). Diabetes is a major risk factor for stroke.

Figure 2-1.Age-adjusted Stroke Death Rates by State (Roger, Go *et. al.*, 2011a).



2.9. Rehabilitation for Stroke

Post-stroke rehabilitation services are needed to help improve functional limitations caused by debilitating illness. However, the timing and amount of services that are needed and for which population groups is not well understood. Nor is there a good understanding of what is being done in current practice and how much the current practice of rehabilitation after stroke is costing insurers and society as a whole. Quantifying current practice patterns and economic cost of rehabilitation care is essential in order to tackle the questions of "who, what, when, and how much is optimal" and for which patients. Without a baseline of current post-stroke rehabilitation practice patterns and an understanding of variability in care, the direction that research needs to take to support evidence based practice in rehabilitation science is unknown.

Rehabilitation use in stroke is an important and complex issue because it affects both health and costs in a interactive manner. Current rehabilitation practices are well described in an article by Conroy and colleagues entitled, "Hospital-Based Stroke Rehabilitation in the United States" (Conroy, DeJong & Horn, 2009). Once stroke patients have stabilized during acute hospitalization, they are usually discharged either to home where they often get either home-based or outpatient rehabilitation services, to a skilled nursing facility (SNF), also traditionally known as a nursing home, if they need more around-the-clock nursing care, or most commonly to an inpatient rehabilitation facility (IRF) (Conroy, DeJong & Horn, 2009). Each of these options will allow for a mix of standard rehabilitation services including , physical therapy (PT), occupational therapy (OT), or speech language pathology therapy (SLP).

Conroy et. al. indicates the driver of rules for rehabilitation after stroke is Medicare, because stroke is a low incidence disease that primarily occurs in the elderly. Since Medicare is the main mechanism funding healthcare for seniors and the disabled, it covers most people who have suffered a stroke (Conroy, DeJong & Horn, 2009). Furthermore, rules set by Medicare, both for clinical as well as time-line and financial requirements are usually adopted by other insurers.

The paper by Conroy and colleagues emphasizes the post-acute rehabilitation practices in IRFs. The average length of stay in an IRF is 15 days, with 70% of stroke patients being discharged home after their stay and 30% returning to acute care settings or to SNFs (Conroy, DeJong & Horn, 2009). SNFs generally provide 24 hour nursing care and 1 to 1.5 hours of PT, OT, and/or SLP therapy Monday through Friday. Medicare only pays for the first 100 days in a SNF, after which, if additional care is needed, the individual is either switched to Medicaid or private insurance whom Conroy notes do not generally cover rehabilitation services.

According to the rules of Medicare, an individual who has had a stroke and is in an acute care setting would be evaluated based on the "3 hour rule" for admission to an IRF. Under this rule, a patient has to either already be able to tolerate 3 hours of therapy (consisting of OT, PT, or SLP) a day or will soon reach that level of ability in order for the patient to be considered for transfer to an IRF. The rules for admission to an IRF and rehabilitation requirements once in an IRF are significant, resulting in limited access due to perception of need, chances for improvement, and likelihood of discharge to home.

2.10. Evidence for Rehabilitation Services Effectiveness

A consensus group from the American Heart Association published a set of comprehensive guidelines outlining recommendations for evidence based acute and post-acute stroke rehabilitation suggested that the strongest evidence exists to support the use of a well-organized, multidisciplinary team approach to post-stroke rehabilitation care (Duncan, Zorowitz *et. al.*, 2005). They also recommended that rehabilitation be started by the patient as soon as was medically possible or "early intervention" to facilitate positive outcomes. Although this group indicated a lack of consistency in defining or testing what "early intervention" really means. They commented that "current literature is too limited to allow an assessment of the relationship of specific types of non-inpatient rehabilitation services after stroke and functional outcome" (Duncan, Zorowitz *et. al.*, 2005).

The AHA consensus group gave a series of recommendations for practices that have been shown to improve a standard set of outcomes, including: functional status (including the FIM, ADLs and IADLs), re-hospitalization rates, community dwelling status, and mortality (Duncan, Zorowitz *et. al.*, 2005). In addition to the strong recommendation to offer all stroke patients organized, multidisciplinary team-oriented stroke unit care, the group gave many more specific recommendations. The guidelines included, utilization of the National Institutes of Health Stroke Scale (NIHSS) to assess stroke severity over multiple occasions, provision of early initiation of rehabilitation therapy, use of subcutaneous low-dose unfractionated heparin to prevent DVT/PE for patient with ischemic stroke and impaired mobility, assessment of all patients for swallowing (dysphagia) impairments, evaluation of all patients for proper nutrition and hydration, assessment of pain, assessment of all patients for cognitive and communication impairments, assessment of all patients for psychosocial problems particularly depression, assessment of all patients for ADLs and IADLs prior to discharge from acute settings, access to long term rehabilitation care for patients where need is indicated except for where poor prognosis for functional recovery suggest discharge to SNF is preferable (Duncan, Zorowitz *et. al.*, 2005).

A second group published a recommendation for best post-acute stroke rehabilitation upon reviewing the structure, process, and outcomes comparing different international systems of care (Donabedian, 1988; Teasell, Meyer *et. al.*, 2009). Teasell and colleagues noted that structures of care, such as use of specialized interdisciplinary stroke rehabilitation units and outpatient care programs have been shown to impact the process of care, but not stroke outcomes directly (Teasell, Meyer *et. al.*, 2009). They indicate that there is good evidence supporting the direct influence of processes of care on stroke outcomes related to changes in Functional Independence Measurement (FIM) scores, Length of Stays (LOS), mortality, and discharge destinations. They used the comparison between westernized countries as a mechanism to differentiate which process differences may positively or negatively impact overall outcomes, a similar method as is used in studies of small area variation, but on a large system scale.

The four processes that were specifically highlighted by this group are: 1) early time to admission into a stroke rehabilitation unit or program, 2) intensity of therapy over a shorter time period performing better than less intense therapy over a greater time period, 3) utilization of task-specific therapy being superior to restorative therapy, and 4) discharge planning being key to improved Activities of Daily Living (ADL) and patient satisfaction, particularly early supported discharge programs (ESD) for patients who have had mild to moderate strokes (Fisher, Gaynor *et. al.*, 2011; Teasell, Meyer *et. al.*, 2009). Rehabilitation for individuals with stroke has the potential to mediate costs due to stroke in the long term. However this might necessitate an increase in therapy utilization and intensity of treatment which may require increases in spending in the short term to gain savings in the longer-term.

2.11. The Economics and Utilization of Rehabilitation after Stroke

Stroke imposes a considerable economic burden on the US healthcare system, particularly ischemic stroke which accounts for 87% of stroke (Demaerschalk, Hwang & Leung, 2010b). In 2010, it was projected that stroke related costs would reach an estimated $73.7 billion in the US alone (CDC, 2009), which is a significant increase from the 2008 estimate of $65.5 billion (Adams, del Zoppo *et. al.*, 2007). Hospitalization costs from stroke in SC were estimated at $499 million in 2008 (SC Office of Chronic Disease Epidemiology and Evaluation, 2009) with additional indirect costs due to lost productivity to be estimated at another $190 million (Mackay J., 2010).

Healthcare costs continue to rise and are becoming a larger portion of the national gross domestic product. These costs have become a burden on the overall economic wellbeing of the nation resulting in more governmental policies aimed at healthcare cost-containment. The problem with these policies is their intent may not result in savings but in greater cost burdens in the longer-term as well as reductions in the quality of care. In a healthcare system as complicated as what we have in the US, any one change can have many unforeseen consequences that are often not understood until a significant negative impact is felt.

2.11.1. Cost of Stroke Rehabilitation

Previous studies estimating the cost of stroke have reported widely varying results. Costs likely differ depending on many factors, including the amount of rehab care given. Factors that may influence hospital length of stay and consequently cost of stroke include the type of stroke, stroke severity, and unmeasured comorbid conditions related to overall health status. What is missing from this literature entirely is an examination of the cost-effectiveness of different types of post-acute rehab care. This type of analysis can tie in the pragmatic cost with patient outcomes. This research is missing because the research community must reach a point of understanding how “gold-standard” post-stroke rehabilitation care is defined. Only then can different therapies be compared in their pragmatic cost-effectiveness to society. It is this great unknown in post-acute stroke care that is limiting the direction of research to improve long-term outcomes in this population.

Post-acute care (PAC) settings include inpatient rehabilitation facilities (IRFs), skilled nursing facilities (SNFs), home-based healthcare services from home health agencies (HHA), and hospital-based outpatient rehabilitation services (ORS). Medicare spending for post-acute care was estimated to encompass 15% of all Medicare spending in 2008 (Medicare Payment Advisory Commission (MedPAC), 2008). According to a study by Buntin et. al. on the cost and outcomes of post-acute care in Medicare patients after stroke, the cost of

IRF care after stroke is on average $10,121 per episode higher than SNF care and $24,219 per episode higher than home-based care (Buntin, Colla *et. al.*, 2010). These authors also found that IRF care resulted in reduced mortality and SNF care resulted in increased long-term institutionalization after stroke (Buntin, Colla *et. al.*, 2010). Therefore, while a number of studies have concluded that IRF care after stroke leads to better outcomes, these gains come at a considerably higher cost.

It is unclear if these gains are figments of differences due to disease severity and if these “proxy outcomes” can be directly related to functional improvements that are of primary concern in this population. It could be true that more severely disabled patients with the greatest chance for gains are most likely to get IRF care and more disability means greater room for improvement. It is easier to measure the impact of acute in outcomes like length of stay, mortality status, and discharge disposition. Post-acute outcomes tend to be more difficult to measure especially in larger populations and over long time periods. It is also important to separate out the cost of acute care from the cost of post-acute rehabilitation services. A more complete baseline view of utilization and cost will help to drive the direction of research needed to help answer some of these deeper, clinically relevant questions.

2.11.2. Stroke Rehabilitation Utilization

Post-acute care (PAC) includes a wide range of healthcare services that aim to restore recently hospitalized patients to the highest level of functioning possible and generally involves rehabilitation. It is estimated that 70% of stroke patients use PAC services after acute hospital discharge (Buntin, 2007). Depending on clinical presentation and/or perception of need and ability to benefit from PAC, medically complicated patients are discharged to IRFs, patients with age-related cognitive impairments tend to be discharged to SNFs, and healthier patients or in some cases patients unable to endure intensive rehabilitation schedules tend to be discharged home after acute stroke hospitalization (Buntin, 2007). When patients are discharged from inpatient stroke care they may or may not receive additional outpatient rehabilitation services. Thus, the cost of outpatient rehabilitation services will greatly depend on prior use of inpatient care and patient's perceived ability to benefit from rehabilitation services. If no outpatient care is received resulting in immediate cost savings, long-term residual disability may remain creating greater personal and societal economic burden.

It is understandable and expected that many clinical factors have an effect on use of post-acute care services. However, due to the lack of and depth of clinical research indicating which patient groups would benefit most from PACs including which types, time frames, and intensity of services benefits particular patient groups, many non-clinical factors likely influence who utilizes PAC after stroke (Buntin, 2007). Studies on access and use have shown that geographic distance to PAC services strongly influence use, and sex, race, and ethnicity differentially influence utilization of PACs in stroke populations (Buntin, 2007).

2.12. The Impact of Healthcare Policy on Stroke

The aforementioned non-clinical influences on the utilization of PACs after stroke, along with the lack of evidence on the appropriate trajectory of care after an acute event such as stroke, have led many healthcare policy observers to fear differential access to PACs. It is also possible that other financial factors including changes to Medicare payment structures may be influencing access (Buntin, 2007). Buntin and colleagues provide evidence that support these fears, by illustrating greatly varying use of IRFs, SNFs, and HHAs between 1997 and 2002 in the US which was a time of changing Medicare reimbursement policies that included the advent of the prospective payment system (PPS). What does appear evident is that no matter what the intent of changes to payment policies, there are always unintended consequences.

Besides the impact of the Medicare PPS on PAC facility usage, which some suggest was short lived and simply shifted care between different types of facilities (Buntin, 2007), the federal US Balanced Budget Act of 1997 (BBA 1997) implemented a cap on outpatient rehabilitation services. The BBA 1997 included a series of changes in Medicare regulations aimed at cost containment including a $1,500 annual cap on outpatient therapy services. The cap included an annual limit of $1,500 in occupational therapy service expenditures per Medicare participant, and a $1,500 cap on combined physical and speech-language therapy per annum, per participant. These amounts were increased in subsequent years to reflect inflation. While the original effective date of these caps was January 1, 1999, the caps have rarely been in effect or enforced (Table 2-1).

Table 2-1. Regulation Timeline of Outpatient Rehabilitation Caps

Year	Capitation Amount	Outcome
1998	-	Law not yet in effect
1999	$1,500	Implemented but under litigation (not enforced)
2000	-	Under Moratorium
2001	-	Under Moratorium
2002	-	Under Moratorium
2003	$1,590	Effective from September – December
2004	-	Under Moratorium
2005	-	Under Moratorium
2006	$1,740	Applied with Exceptions*
2007	$1,780	Applied with Exceptions*
2009	$1,810	Applied with Exceptions*
2008	$1,810	Applied with Exceptions*
2010	$1,860	Applied with Exceptions*
2011	$1,870	Applied with Exceptions*

*Exceptions automatic if a complex condition, other conditions require manual requests

Even though the enforcement of the outpatient rehabilitation services caps has been in flux since the passage of the BBA 1997, the policy change may have produced a structural change within the outpatient rehabilitation community in regards to the amount of hours of services commonly rendered. The influence of a policy prior to enforcement may be due to the tendency of the healthcare industry to adjust to major legislation before the legislation takes effect, because the healthcare system decision-makers anticipate legislative changes and respond proactively (Schwartz & Mendelson, 1991). This research predicts that outpatient rehabilitation services utilization and rehabilitation costs went down after the outpatient rehab caps date, even though beneficiary needs likely increased. The effect of major federal health care policy changes have been seen outside of effective dates in the past, such as with the implementation of the DRG based prospective payment system in the 1980s and 1990s (Schwartz & Mendelson, 1991).

2.13. Rehabilitation and Health Services Research

Theoretical models that describe and outline the process of disability caused by injury or illness allow scientists and clinicians a systematic means to communicate within and between disciplines. They also allow for greater directed inquiry into causes of disability and methods to illicit rehabilitation from those disabilities, as well as into the contributing factors that influence both of these processes. Over time, models to describe the disease process have changed and developed as health care practice has advanced and become more complex. These changes include the potential of system-wide policy changes and their cost implications as factors that may influence clinical and quality of life outcomes even though they are external to the patient. The study of the long term effects of stroke and their cost ramifications would benefit greatly from the perspectives gained through theoretical modeling.

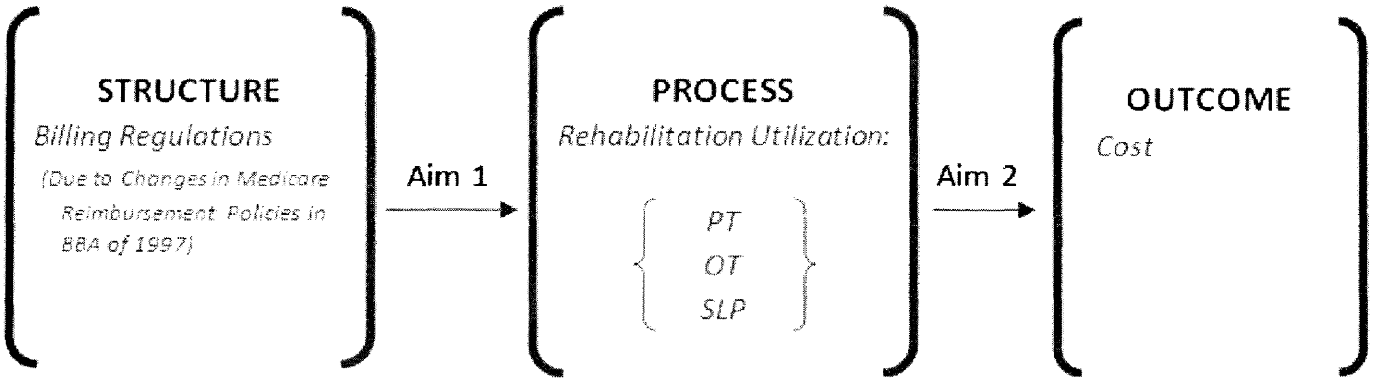
One of the earliest models that continue to drive health care research today, “the medical model” includes the central theme of the patient as the problem, with the central goal to cure the individual. Later rehabilitation models began to expand on earlier thinking to include personal and societal influences on health. An early rehabilitation model posed by Nagi expanded the medical model to include the thinking that biological changes can lead to impairments which may lead to functional limitations possibly causing disability (NAGI, 1964).

Today the rehabilitation model that most researchers agree has the most applicable themes allowing for the complexities of human health is the International Classification of Functioning, Disability and Health (ICF). The ICF allows for multi-directional movement between problems on the functional and body structure level affecting activity which may influence participation. This model also accounts for the possibility that each of these stages can be affected by the outside influences of personal characteristics and environmental factors. Environmental factors can include governmental or system-wide rules on cost structure.

In order to expand the medical or rehabilitation models that drive health care research to find solutions on the individual patient level, to the idea that population health may be affected by even more outside factors, we can utilize health services research models to direct structural or process level questions. In the late 1980s and early 1990s, Avedis Donabedian produced a theoretical Health Services Research (HSR) model on the relationship between health care structures, processes, and outcomes (Donabedian, 1988). Structure refers to all factors that may influence the physical environment or setting of health care delivery, such as policies and procedures, rules and regulations, buildings and equipment, and standards for performing interventions. This can range from how hospital facilities are laid out, to who is available at all times on a stroke team, to reimbursement practices. Process relates to how care is provided. Process includes effects of factors such as treatment guidelines, how a referral process is coordinated, the timing of hospitals' discharge of patients to home care or to other post-acute care settings, the type of therapy provided or how much therapy is given. Lastly, outcomes refer to how endpoints of care are measured, evaluated, and quantified, which may include patient preferences. Outcomes refer to both intermediate and ultimate outcomes. Intermediate outcomes include factors related to resource consumption such as cost, length of stay, or consumption of specific services. Ultimate outcomes are measures such as survival, quality of life, and health status. The model proposed by Donabedian is especially useful for organizing factors that related to a "health production" function, where the focus is on better understanding the effects of structural constraints, such as regulation, on the utilization of scarce resources, and on both intermediate and ultimate population outcomes. This model is not as well suited if the outcomes of interest are related to individual patients, but it is very accommodating of policy questions.

This research project used the Donabedian "Structure-Process-Outcome" HSR model as a framework for examining the effect of outpatient rehabilitation caps on the use of PT, OT, and SLP healthcare services (aim 1). The cap placed on outpatient rehabilitation services under the BBA of 1997 forces a process change in the care of patients with stroke. Legislative reimbursements limits fit the Donabedian model as a structure effect which may be expected to affect the process of rehabilitation care. This process change will affect the outcome measured as healthcare cost and also other outcomes such as quality of life which is not examined in the proposed research. The theoretical framework that guided this research study is depicted in Figure 2-2 below.

Figure 2-2. Applied Donabedian Structure-Process-Outcome Model



Structural changes in rehabilitation practices prompted by the Medicare reimbursement policy that occurred via the BBA of 1997 with the onset of outpatient rehabilitation caps fits well into Donabedian's paradigm that operationalizes constraints on practice settings in the healthcare system and their effect on the process of care. If rehabilitation practitioners expect to have limits on the reimbursement for the amount of care that they can administer to a Medicare beneficiary, it is conceivable that these limits may precipitate a change in the process of care, including a decrease in average rehab utilization. Additionally, if utilization is reduced due to changes in the process this may similarly affect the cost of care which is an economic outcome under the Donabedian model.

2.14. Summary

Stroke is a serious, prevalent, disease that is costly to society. Since stroke mortality is decreasing across the US but individuals are living longer after stroke, it is reasonable to conclude that long-term morbidity due to stroke is likely to increase, especially in SC where stroke incidence is high. With increases in people suffering from the long-term effects of stroke, quantifying rehabilitation services costs and utilization will help policymakers to plan for future needs and will begin to progress our understanding of best rehabilitation practices and future research needs.

Studies examining rehabilitation services utilization can benefit from the use of theoretical rehabilitation and health services models. These models can help to outline how structural changes in the healthcare system may influence processes and in turn healthcare outcomes. Federal regulatory caps on Medicare reimbursement of rehabilitation services are structural changes that may have an effect on health services utilization which lies in the area of process of care. The change in the amount of rehabilitation services received by an individual may, in turn, affect the cost of care, an economic outcome. In this study theoretical models were used to map the potential impact of the BBA of 1997 on rehabilitation services utilization and the related impact on the outcome of stroke and rehabilitation costs in the year after acute ischemic stroke.

3. METHODOLOGICAL BACKGROUND

It is important to recognize the type of health services research completed in this project requires a specialized set of methodological approaches in order to be performed in a reasonable and reliable manner. Challenges related to the retrospective analysis of long-term administrative billing data include difficulty specifying diagnoses, procedures, comorbidities, and disease severity.

3.1. Research Using Administrative Data

Administrative data, also known as billing data or archival data, are commonly used in research to examine health related questions. These data are readily available, inexpensive to obtain, available in a computer-readable database format, and cover large populations over long periods of time (Iezzoni, 1997; Iezzoni, 1994; Mitchell, Bubolz *et. al.*, 1994; Zhan & Miller, 2003).

The utility of administrative claims data for the evaluation of health care services and outcomes has been well established. Over the past 30 years, the analysis of retrospective administrative data has been used to examine practice variation (Wennberg et al. 1989; Shwartz, Ash *et. al.*, 1994), determine differences in access to care in minority groups (Desch et al. 1996), assess quality of care metrics (Lohr 1990; Iezzoni, 1997), estimate incidence of disease (McBean, Warren, and Babish 1994), and compare surgical outcomes and disease related outcomes and costs (Lubitz *et. al.*, 1993). Administrative claims data are part of the routine clinical reimbursement of health care services, allowing for availability of longitudinal data sets, with little cost, and easy accessibility. The use of these data to answer health services and outcomes related questions are essential, especially in situations where prospectively collected data are cost prohibitive or infeasible.

In summary, research designed to measure outcomes and best practices can be undertaken using inexpensive and efficient retrospective administrative data analysis. The cost-effectiveness of different post-stroke rehabilitation programs can be examined using administrative data. Consequently, significant gains in these previously under examined areas can be achieved in a relatively short period of time.

3.1.1. Medicare Billing Data

Beginning in the 1980s, researchers began to use administrative data from Medicare Parts A and B claims, merged on the individual beneficiary level, to study physician payment issues (Mitchell, Bubolz *et. al.*, 1994). However, it was not until 1985 that Medicare required providers to utilize a common medical procedure coding system that is still in use today. Since that time, researchers have used Medicare claims data to construct episodes of care-based analytical data files to answer many health services and outcomes related questions (Mitchell, Bubolz *et. al.*, 1994).

Medicare claims data are currently available in a set of related data files that are linkable through a non-identifiable unique patient code. This rich source of data can be used in the evaluation of medical care as these claims include information on all services provided to Medicare beneficiaries, including: hospital events (Part A, including hospitalization diagnoses, procedures, dates, costs excluding clinician charges and payments, discharge destination, etc.), supplemental insurance provider files (Part B, including clinician and specialty charges and payments and their associated diagnostic and procedure codes with dates of service), nursing home files (including related dates, charges, payments, etc.), home health service files (including related dates, charges, payments, etc.), outpatient visit files (including related diagnoses, procedures, dates, charges, payments, etc.), and durable medical equipment files (including related dates, charges, payments, etc.). A file commonly known as a “denominator” file is also included which gives demographic patient information (including age group, race, gender, and zip code) as well as month and year of death (if applicable). Files to trace data back to providers are also available. With the recent inclusion of prescription drug coverage under Medicare Part D, data files containing information regarding the use of prescription drug information are promised to be available in the near future but were not available in the current study’s data files.

The Centers for Medicare and Medicaid Services (CMS) require all providers to submit bills for payment using diagnosis and procedure codes that are standardized. Outpatient clinical visits are coded using Healthcare Common Procedure Coding System (HCPCS) which is based on Current Procedural Terminology codes (CPT). Hospitalization bills are based on diagnosis codes using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), although hospital bills will often contain multiple diagnosis (ICD-9-

CM) and procedure (CPT) codes for each episode (or line item). Since private insurers tend to follow the lead of CMS, the same coding practices are used for billing private insurers in the US as well. The ICD-9-CM coding system is also in use by many countries around the world. In fact, many other westernized countries have already adopted the next generation of coding, ICD-10-CM, which is scheduled to go into use in the United States on October 1, 2013.

3.1.2. Reasons to Utilize Medicare data in this Research

The benefits of utilizing billing data for epidemiological, clinical, or health services research are many; however, researchers must also be aware of a number of constraints and inherent weaknesses in this type of research. The positives of these data outweigh the negatives with regard to utilizing retrospective billing data to answer health services questions. This is particularly true in studies wishing to answer longer term questions that require cost and clinical data. This type of research can be very time consuming and costly when undertaken as a prospective study. Furthermore, in health services research, medical care practices and policies can change rapidly over time, which make it difficult to control possible time-related biases even when data is collected prospectively. Funding for this type of research has historically been limited in the US which makes the utilization of inexpensive, readily available data even more valuable to health services researchers wishing to examine healthcare practice patterns. The strengths of utilizing these readily available retrospective Medicare billing data sets include:

1. their size, or ability to provide large samples;

2. their longitudinal nature, or ability for researchers to follow patients over very long periods of time that are most often contiguous;
3. their availability at little expense; and
4. their representativeness of the population that covers most of the elderly (≥ 65 years of age) and the long-term disabled US population.

Some constraints of these data include: their lack of coverage of the privately insured US population; lack of representation in those under 65 years of age; limitations in the ability of the diagnosis codes to differentiate things such as initial event or repeat event, side of the body, clinical severity of disease or condition; and whether or not the event is a comorbidity or a complication of the condition under study. These data also do not contain other important clinical characteristics of care that might influence research results such as disease severity.

Utilizing Medicare data for research purposes can also include a set of unalterable challenges. One weakness is the variation of provider coding practices and the fact that coding is done for billing and not expressly for research purposes. Coding practices also change over time so longitudinal research based on these data must be done with care and with the awareness that issues might arise due to these changes. Also, the sheer size of Medicare data files takes knowledgeable and skilled programmers to properly manage and organize prior to analysis. Despite the challenges present when using these data, utilizing administrative billing data offers the best opportunity to answer the questions in this study.

3.1.3. Other Sources of Archival Data

Other sources of archival health data include data sets created via medical record abstraction or via patient derived data (Iezzoni, 1994). Patient derived data can be collected directly from patients either by interview or survey and may be retrospective or prospective in nature. Collection of these data can be time and cost prohibitive. These data are usually limited to clinical information and generally do not include related costs of care, which is needed to answer the questions posed in this study.

Some commonly used surveys that are expressly taken for healthcare research or disease surveillance include national surveys that are done by governmental or private agencies in regular time intervals. Survey data can be inexpensive and readily available, however survey data do not usually allow researchers to follow particular patients over a long period of time and rarely have cost data included with clinical information. They also tend to be limited by patient recall and subjectivity. Some examples of survey data sources are: the National Survey on Drug Use and Health (NSDUH), the BRFSS, the National Health and Nutrition Examination Survey (NHANES), the Medical Expenditure Panel Survey (MEPS), the National Health Interview Survey (NHIS), the National Survey of Sexual Health and Behavior (NSSHB), and the Annenberg National Health Communication Survey (ANHCS). These data sources have different associated costs, logistical complications, and feasibility implications (Iezzoni, 1994). More importantly, these main sources of survey data all have specific foci, none of which is amenable to addressing the questions of rehabilitation use and cost.

3.2. Estimating Cost of Illness

Understanding the cost of an illness is important to help inform decision-making related to resource allocation and policymaking, as well as to support cost effectiveness analysis of treatment interventions (Drummond, Sculpher *et. al.*, 2005). Governmental planners use disease cost estimates, along with incidence and prevalence estimates of diseases to help plan for the availability of budgetary dollars that pay for healthcare services, facilities, and staffing.

There are a wide range of strategies used to estimate disease cost depending on available data and on the goals of the study. One method begins by estimating total cost of illness based on ascribing unit cost to estimated incidence or prevalence rates (Evans, 1990). This method may underestimate costs because it will miss any effect that a disease may have on other conditions, such as depression or pain (Luengo-Fernandez, Gray & Rothwell, 2009). Furthermore, this costing method suffers from lack of evidence gained by use of patient-level data. Another common method of estimating cost of illness is to aggregate total direct medical costs on patient level population based data after an index medical event over a period of time. This is often referred to as "all-cause" costing or total healthcare cost. The aggregated "all-cause" costing approach will likely include health care costs related to any comorbid illnesses which are present or arise during the time period, and will therefore tend to overestimate costs attributable to the disease under study.

This research project uses a third method to estimate cost of ischemic stroke, marginal cost estimation, which may be expected to more accurately estimate true cost of care (Luengo-Fernandez, Gray & Rothwell, 2009). Marginal cost, also known as case-control cost comparison, is calculated by estimating the costs of resources used for care after an index event, using population based patient-level data, less the cost of a similar patient population who do not have the illness, over the same period of time. Arguably, this is one of the more precise ways to estimate overall cost-of-illness, especially in the case of stroke where most patients are older and have many comorbid conditions which tend to increase cost (Luengo-Fernandez, Gray & Rothwell, 2009).

3.2.1. Quality Metrics of Cost of Illness Studies

In an article entitled, "Costs of Stroke Using Patient-Level Data: A Critical Review of the Literature" by Luengo-Fernandez and colleagues, the authors specify that there are two ways to derive estimates of cost of illness, either by expert opinion, or analysis based on patient-level data (Luengo-Fernandez, Gray & Rothwell, 2009). They based their systematic review search on whether cost studies on cerebrovascular disease satisfied four criteria that signify quality research. Estimates based on patient-level data are preferred as they can be considered evidence based methods. However, all methods utilizing patient-level data are not equal as far as the validity, reliability, or generalizability of results.

The first quality metric described in the Luengo-Fernandez review article is the use of appropriate costing methodologies data (Luengo-Fernandez, Gray & Rothwell, 2009), and was based on a modified checklist developed by the British Medical Journal (Drummond & Jefferson, 1996). The authors define appropriate use of costing methodologies as those that included: whether or not the study objectives were clearly stated and justified; if the data collection contains descriptions of unit costs and resource use; as well as, if the methods used were appropriate; and if the analysis and interpretation of results were reasonable (Luengo-Fernandez, Gray & Rothwell, 2009).

The second quality research criterion described in this manuscript is based on if the study sample is representative of the overall population. The third criterion is concerned with whether or not the study takes into account the premorbid use of resources (Luengo-Fernandez, Gray & Rothwell, 2009). Accounting for the comorbidities of patients prior to the indexed illness is especially important when studying an elderly population since these patients tend to have a great deal of comorbidities and are more likely to consume a large amount of healthcare resources in addition to the illness under study. The last criterion used by these authors to assess study quality is whether or not the researchers report costs while taking into account patient characteristics, subtypes, severity, and disease etiology (Luengo-Fernandez, Gray & Rothwell, 2009).

During the seventeen year period of the Luengo-Fernandez and coauthors review of cost of stroke research studies (from 1990-2007), the authors identified

120 studies that meet their inclusion criteria: inclusion of cerebrovascular diseases (CVD), published in English, based in westernized countries, resource use derived using patient-level data, mean or median costs were reported, and study sample of at least twenty patients (Luengo-Fernandez, Gray & Rothwell, 2009). Of these studies, only 6 compared the costs of cerebrovascular (CV) patients with those with no history of CV events. Unfortunately, the authors did not indicate the specific references for these studies and did not provide a meta-table of study information. However, they reported that of the economic studies undertaken during the review time period, very few used appropriate cost-comparison techniques, where attributable or associated cost is estimated.

Luengo-Fernandez and colleagues concluded that disease costs estimates vary considerably based on differences in time periods and follow-up time horizons, geographic location, results based on charges versus unit cost, and inclusion of productivity loss costs (Luengo-Fernandez, Gray & Rothwell, 2009). The authors found a 10-fold difference in cost estimates between Eastern European studies and studies taking place in either the United Kingdom or the US (Luengo-Fernandez, Gray & Rothwell, 2009). However, differences in cost estimates within the US were even more disparate. In the 53 studies estimating stroke costs in the US, a 20-fold difference was found (cost range $7,309 – $146,149) (Luengo-Fernandez, Gray & Rothwell, 2009). So while the authors concur with many of the costing studies, that CVD poses a significant economic burden to societies, what might be the biggest “take-home” message is that the large variation in estimates may feed into the perception that these studies are not reliable which may hinder healthcare policy decision making.

In another recent systematic review entitled, “US Cost Burden of Ischemic Stroke: A Systematic Literature Review”, Demaerschalk and colleagues examined US studies focusing on the cost of ischemic stroke from 1995 to July 2008 (Demaerschalk, Hwang & Leung, 2010b). The authors of this study concluded that most US stroke cost studies focus primarily on short-term costs, particularly hospitalization. They also noted that no studies were identified where the cost of rehabilitation care was estimated (Demaerschalk, Hwang & Leung, 2010b). This systematic review article concludes by stressing the need for more studies that focus on the long-term costs of stroke, particularly rehabilitation services and indirect costs. They also note that more recent overall cost studies are needed since most studies that they found were analyzed using 1990s data (Demaerschalk, Hwang & Leung, 2010b).

3.2.2. Principles of Costing

In a publication by Evans entitled, “Principles Involved in Costing”, suggested that all attempts to calculate cost of illness should be done with care and take into account four important principal considerations (Evans, 1990). The first principle of costing that Evans gives is the determination of viewpoint taken in the analysis. Viewpoints in relation to economic studies can be taken from a number of perspectives, including those of the patient, hospital, insurance company, government, or society as a whole (Evans, 1990). Evans differentiates all analyses of costs to individual entities, such as the patient or the insurer, as "financial costs", while costs from the perspective of society as an "economic cost" (Evans, 1990).

The second principle of costing that Evans stipulates is the differentiation between direct and indirect costs. He defines direct medical costs as the "value of resources used to prevent, detect, treat and rehabilitate the health impairment or its effects"; while indirect costs are defined as "the output lost by patients, their relatives, and friends because of the impairment" (Evans, 1990). The inclusion of indirect costs in an economic evaluation of illness may be reasonable if the viewpoint of the study is from the societal or individual perspective. Otherwise, the inclusion of costs such as lost productivity may not be important from the perspective of an insurer or a hospital.

The third, and perhaps most import cost of illness principle, is the value of average cost versus marginal cost. Evans notes that "the cost of treating additional patients and the savings available because fewer patients require treatment cannot, in general, be equated to the average cost of treating existing patients". He contends that when one measures average cost, included in these costs are "operating costs" or "overhead costs", such as building maintenance or administrative staffing, which will occur whether or not a single additional patient becomes ill. From the perspective of cost-of-illness based on potential benefits of prevention, average costs will always overestimate the cost of adding one additional patient or the savings from one less patient because one fewer patient will not reduce the need to employ custodial or administrative staff or to maintain the building. This is the primary reason that marginal costs should be used when examining most cost of illness questions (Evans, 1990).

The last principle that Evans contends should be well understood prior to undertaking a costing study, is the value of discounting when costs occur at different time periods (Evans, 1990). This idea is based on the principle that a dollar spent today is more valuable than a dollar spent in the future, because the benefits of spending today will be felt much sooner. Similarly, from today's perspective, a dollar received today has more value than one received tomorrow. For this reason, all costing studies that take place or are interpreted from a perspective of multiple years should undergo discounting, where "future costs (and benefits) are discounted back to their present values" (Evans, 1990).

Evans offers insightful suggestions about the interpretation and general value of cost-of-illness studies. He clarifies that cost studies alone do not give enough evidence to directly guide public policy but provide baseline values needed to measure changes due to treatment interventions or healthcare system effects over time. Evidence of the effectiveness or efficiency of a particular intervention is needed in order to directly guide policy decisions. Incidence-based cost-of-illness estimates are valuable. However, to gauge the overall economic impact that a potential program or intervention may have one must consider outcomes. Other direct benefits of these types of studies include guidance to planners of future healthcare needs and provision of data for cost-effectiveness analyses.

3.3. Accuracy of ICD-9-CM Code Selection

In complex chronic conditions such as stroke, cost and outcomes research are usually performed using large retrospective administrative databases. However the utility of using these databases to examine stroke outcomes is limited by the reliability of administrative coding to correctly identify stroke patients. The current and most commonly used diagnosis coding mechanism in the US is the International Classification of Diseases, 9th revision, Clinical Modification system (ICD-9-CM) (Rinaldi, Vignatelli *et. al.*, 2003).

In 2001, Reker and colleagues examined studies from the 1990's that validated the accuracy of stroke ICD-9-CM codes, finding widely disparate methods and results (Reker, Hamilton *et. al.*, 2001). After examining other studies, Reker, et. Al., proceeded to undertake their own study of the "best" code group to select, using two strategies: 1) maximization of sensitivity (identification of patients with new stroke) and 2) maximization of specificity (limiting accidental inclusion of non-stroke patients) (Reker, Hamilton *et. al.*, 2001). In many cases only the Positive Predictive Value (PPV) is available in these studies as a measure of accuracy since many of these studies sample based on a stroke cohort, which under-represents non-stroke patients.

While the list of general ICD-9 codes for cerebrovascular disease shown in Table 3-1 (Rinaldi, Vignatelli *et. al.*, 2003) appear clearly defined, there are many sources of variation in hospital-specific coding practices, such as inter-coder reliability, poor clarity in medical charts, differences in data quality between hospitals or healthcare organizations, or lack of precision of the codes themselves (Rinaldi, Vignatelli *et. al.*, 2003; Wahl, Rodgers *et. al.*, 2010).

Table 3-1. ICD-9 Codes for Cerebrovascular Disease

ICD-9 Code	ICD-9 Classification Heading
430.xx	Subarachnoid hemorrhage
431.xx	Intracerebral hemorrhage
432.xx	Other and unspecified intracranial hemorrhage
433.xx	Occlusion and stenosis of precerebral arteries
434.xx	Occlusion of cerebral arteries
435.xx	Transient cerebral ischemia
436.xx	Acute, but ill-defined, cerebrovascular disease
437.xx	Other and ill-defined cerebrovascular disease
438.xx	Late effects of cerebrovascular disease

Additionally, some investigators will specify samples using only the first three digits in the ICD-9-CM codes and some indicate the need to restrict code selection to further sub-classification up to the fourth and fifth. Investigators must also consider whether or not to include diagnosis of stroke from only the primary diagnosis position in the data set or in the primary and collection of secondary diagnosis variables.

Extra caution should be taken in studies intending to estimate stroke incidence or prevalence rates since overestimation is likely to occur (Reker, Hamilton *et. al.*, 2001). When using administrative data to estimate incidence and prevalence using ICD-9-CM codes, it has been well documented that estimates can vary greatly depending on which codes are included (Reker, Hamilton *et. al.*, 2001). Different code sets should be used when deciding which ICD-9-CM codes are best for estimating disease burden versus if the study objective is to garner a patient cohort of individuals who have had a stroke. In the latter case, a method of specificity and PPV maximization is preferred.

Codes used to select stroke population samples should be well defined. For example, certain individual codes are reasonable to use if selection of specific stroke sub-types are intended, particularly those for intracerebral hemorrhage (431.x), or transient ischemic attack (435.x) (Reker, Hamilton *et. al.*, 2001). However, study findings differ as to the accuracy of the use of ICD-9-CM code 430.x in correctly identifying patients with subarachnoid hemorrhage (Kokotailo & Hill, 2005; Leone, Capponi *et. al.*, 2004; Reker, Hamilton *et. al.*, 2001; Tirschwell & Longstreth, 2002). If researchers have a large population based database available, and intend to sample a cohort of individuals with ***ischemic stroke*** for analysis of outcomes, the most consistently accurate ICD-9-CM codes which to use to garner the sample appear to be 434.xx and 436.x (Reker, Hamilton *et. al.*, 2001). When the intention is to use a set of ICD-9-CM codes to correctly identify a "high specificity ***all strokes***" cohort, Reker and colleagues confirm, in a well-designed large sample study, that codes 431.x, 434.xx, and 436.x in any diagnosis position result in good accuracy (Reker, Hamilton *et. al.*, 2001). Thus, when planning research using ICD-9-CM codes to identify patients with ischemic stroke, where the study question aims to minimize inclusion of patients incorrectly diagnosed with stroke, using ICD-9-CM diagnoses codes 434.xx and 436.x in the primary variable field for identification is best.

3.4. Taking into account Comorbidity and Severity of Illness

The importance of appropriately controlling for factors, such as disease severity and the presence of comorbid conditions when analyzing data from patients with stroke or other complex chronic conditions is well documented. Severity and comorbidity measures are used in a variety of situations from clinical trials, to epidemiologic studies, and cost-effectiveness analysis, where it is important to be able to control for disease severity in order to properly quantify the true difference in outcomes between comparison groups. Without accounting for differences in comorbidities and disease severity when analyzing retrospective cohort or case-control data, a researcher may not be sure if differences found between groups are attributable to the problem under study or are simply due to population differences.

3.4.1. Measuring Comorbidity

There are many indices of comorbid conditions that have been developed and used for analysis of a variety of health related outcomes. An example of such an index that was developed to control for comorbid conditions in the analysis of hospital data is the Charlson Morbidity Index (CMI). The CMI is an excellent model of the value that an index can provide due to its utility of controlling for health-related population differences when analyzing administrative data repositories. The CMI was originally developed to abstract medical diagnoses from inpatient medical records and combine them into a single index to be used as an independent covariate in the analysis of hospital outcomes and a proxy measure of a patients' 1-year mortality probability (Charlson *et. al.*, 1987).

Since the development of the CMI, there have been cross-walks from diagnoses on medical records, to ICD-9-CM diagnosis codes that are available from hospital billing data (Deyo et al. 1992, Elixhauser et al. 1998). The ability of the CMI to be translated from its original diagnosis categories and weights, to ICD-9-CM diagnosis codes, has made it the single most commonly used morbidity index in the analysis of both prospective and retrospective data for many different types of disorders and diseases. In contrast, there are no established indices of stroke severity for use with administrative data. This project utilized similar principles to cross-walked a set of codes to estimate stroke severity. This set of codes will be studied in-depth for reliability and validity in future research.

In a Medline search of research conducted since 1997, the CMI was used in 573 published research projects to help control for extraneous factors that might affect the outcomes or costs being studied. In order to assess differences in groups, all other possible independent factors that may affect the outcome being studied must be controlled for within the analysis. Severity of illness and comorbid conditions are the two main factors, outside of demographic descriptors, that are used to account for these independent predictors of health related outcomes.

For example, if it is a researchers' goal to estimate the 1-year attributable cost of a post-stroke condition such as the communication disorder aphasia in

Medicare patients who have suffered an ischemic stroke using state provided Medicare hospital billing data, we would need to add up the total costs for each patient who suffered a stroke in the targeted time period and analyze if the average annualized health-related cost in the patients who have had aphasia due to stroke, differs from those who did not have aphasia. In order to be confident that our cost difference is due to aphasia we would need to make sure that our two groups, aphasics and non-aphasics, had equal comorbidities as well as equal stroke severity. If we are not able to control for comorbid conditions and level of stroke severity, we could not be sure that the cost difference was due to having aphasia or to one group having poorer health than the other.

3.4.2. Measuring Disease Severity

In complex chronic conditions such as stroke, cost and outcomes research are usually performed using large retrospective administrative databases. However the utility of using these databases to examine longer-term stroke outcomes is limited by the lack of an availability of a stroke severity measure. This hinders proper evaluation of rehabilitation related outcomes among individuals varying significantly in severity due to our inability to control for severity of illness. In order to assess differences in groups, the analysis must include adjustments for all other independent factors that may affect the outcome being studied.

In studies involving ischemic stroke related outcomes the most commonly used severity measures in the United States are the NIHSS or the modified Rankin Scale (mRS). These scales are inconsistently collected in hospital medical records and usually require capture in a systematic prospective manner in order to be used in clinical trials or other similar studies. Unfortunately even within the vast amount of retrospective data derived from administrative databases; there is currently not a good measurement of stroke severity that can be used as an independent predictor of outcome or as a means for matching patients.

The development of a stroke severity index that can be derived from administrative data would allow researchers to answer a vast array of longer-term stroke outcomes and rehabilitation related questions. We could better detect differences in post-acute access to physical, occupational, or speech-language therapy programs; answer questions related to predictors of re-stroke; and compare costs of treatment programs and outcomes among groups with differing stroke severity. All of these questions could provide the evidence needed to direct future clinical research questions, resource allocation, and policy decision making.

Since both an individual's severity of illness and the presence of comorbidities can potentially influence overall probability of continued morbidity or death, analyses for patient outcomes research must adjust for these factors to properly account for variation of health status within patient cohorts. A selection of codes to use to account for stroke severity in this analysis has been previously reported in an applied cost of illness study (Ellis, Simpson *et. al.*, 2012). Based on an examination of evidence presented in previous research a series of codes were selected based on their diagnostic relationship with the NIHSS. These codes include: dysarthria (784.5), aphasia (784.3), dysphagia (787.2), hemianopia (368.4x), sensory impairment (782.0), neglect (781.8), memory loss (780.93), and hemiplegia (342.xx) (Ellis, Simpson *et. al.*, 2012). These ICD-9-CM codes were selected for their ability to map back to the key components of the NIHSS which include: 1) Level of Consciousness, 2) Aphasia Visual Impairments (hemianopia – partial, complete, bilateral), 3) Facial Palsy, 4) Motor Arm, 5) Motor Leg , 6) Limb Ataxia, 7) Sensory impairment, 8) Dysarthria , and 9) Neglect.

Additional diagnoses and procedures with related codes have been used as factors related to stroke severity in previous studies: 1) mechanical ventilation (CPT codes 94656, 94657; ICD-9 code 96.7x), 2) placement or revision of a gastrostomy tube (CPT codes 43750, 43760, 43761, 43832, 43246; ICD-9 code 43.11), 3) hemiplegia and hemiparesis (ICD-9 code 342.xx), 4) residual neurologic deficits (ICD-9 codes 345.40-345.51 and 345.50-345.91 for epilepsy, 348.1 for anoxic brain damage, 348.3x for encephalopathy, 780.3x for convulsions, and 784.3 for aphasia) (Smith et al. 2005, Lee et al. 2010).

Current research in the areas of rehabilitation service utilization in stroke care is limited by the inability to control for stroke severity which will be greatly enhanced by a well designed stroke severity measure for use in administrative data. The stroke severity index used in the current research, in combination with the CMI, will provide the strongest analytical control available for the analysis of retrospective billing data when looking for differences in stroke-related outcomes.

3.5. Controlling for Selection Bias

Selection bias is the bias associated with an unbalanced selection of individuals under study. Szklo and Nieto remark that selection bias is particularly problematic in case-control studies which is the study designed used for aim 2 of the current research study. They define selection bias as, "…a systematic error in the ascertainment of the study subjects – cases or controls in case-control studies, …(that) results in a tendency toward distorting the measures expressing the association between exposure and outcomes" (Szklo & Nieto, 2007).

The objective of randomization in studies on health is to obtain groups that are balanced, or comparable, in terms of observed and unobserved group characteristics. If this balance is not achieved it may not be clear whether a difference observed on a certain outcome of interest is due to the "treatment" under study or is the result of underlying differences between the groups. Even in randomized studies, balance between groups is analyzed for residual bias.

However, when using large retrospective observational data sets to assess health outcomes, randomization prior to data collection is not possible. Therefore, other methods, often referred to as "pseudo-randomization methods", must be used in order to balance groups. One well developed and largely accepted method to accomplish this task is the utilization of propensity score techniques.

Propensity Score (PS), as described by the founders of the method, Rosenbaum and Rubin, is "the conditional probability of assignment to a particular treatment given a vector of observed covariates" (Rosenbaum & Rubin, 1983). The first step in using this technique is estimating the likelihood (i.e. the propensity score) that each individual in the sample would have received “the treatment” given a set of their personal characteristics. This is done by estimating the probability of inclusion in the group (i.e. having a stroke) given a set of covariates, such as age, gender, race, history of hypertension, etc., by using a logistic regression. Rosenbaum and Rubin stipulate the importance of thinking of PS methods as a study design tool that approximates randomization, rather than an analysis tool (Rosenbaum & Rubin, 1983; Rosenbaum & Rubin, 1985; Rubin, 1997).

Once the propensity scores have been estimated for each individual they can be used in the analysis of interest, i.e. “comparing treatment group effects”, in three different ways: 1) by matching the controls to the cases by similarity in propensity score, 2) by using the propensity score to stratify the analyses, 3) by using the propensity score as a covariate in the final multivariable model in order to control for possible confounding effect. Interestingly, while the third method has been used by many researchers, it is not the correct way to employ a technique that was developed to approximate randomization, i.e. garner similarly balance comparison groups. Controlling for an individuals’ likelihood of being in the treatment group does not ensure that groups are balanced on observed covariates and is considered an “inferior or mistaken” method to use according to Donald B. Rubin, a developer of the method (Rubin, 2004). For this reason, only the first two methods to employ the use of propensity scores in observational studies will be discussed in the following sections.

3.5.1. Propensity Score Stratification Methods

The method of stratification by propensity score has been used since the development of the measure. This is particularly due to the simplicity of application and the limitation of computing resources in the early years of using propensity scoring methods in observational research studies. Once the logistic regression has been used to estimate a propensity score for each study subject, the most common PS stratification approach takes the range of the propensity scores from the minimum value to the maximum value and divides it into five equally sized strata and these strata are then used to match similar controls to cases (Austin, 2009). Once this stratification variable is developed, it is used as a continuous covariate in the multivariable analysis of interest along with the original covariates that were used in the logistic regression model development of the PS. It has been demonstrated that using this stratification method eliminates approximately 90% of the bias due to the measured confounders and is a very good way to control for selection bias caused by observed baseline characteristics (Rosenbaum & Rubin, 1983).

3.5.2. Propensity Score Matching Methods

One must carefully select a well-matched control group, using proven techniques, when estimating marginal cost. It is also important to understand why marginal cost is a superior method to estimate cost of illness when compared to other costing strategies. Recent studies comparing the ability of propensity score matching, i.e. matching a case with a control or a number of controls based on an algorithmic set distance, have indicated a superior ability of propensity score matching to balance groups in observational studies, over the older stratification methodology (Austin, 2009). There are a number of mathematical algorithms with which matching can be performed with today's computing power, although the most commonly used is “nearest neighbor matching” using a “greedy algorithm”. Besides deciding which algorithm to use, the researchers must also consider the structure, i.e. 1 case to 1 control paired matching, 1 case to many controls matching, or optimal full matching which allows all controls to be matched to cases but does not ensure an equal number of matched controls to cases (Gu & Rosenbaum, 1993). The distance metric used between case and control pairing must also be considered. Lastly, one must also consider if the matching of cases to controls will be done with or without replacement.

In an applied example comparing propensity score methods, Austin and Mamdani concluded that using a greedy-match algorithm with caliper distance set to a maximum width of 0.2 standard deviations of the logit of the estimated propensity score and a 1 case to 1 control matching scheme, without replacement, resulted in superior overall performance and eliminated systematic differences between treatment groups when compared to stratification methods or using PS as a controlling covariate (Austin & Mamdani, 2006). In a second theoretical simulation study comparing some of these matching practices, the authors concluded that a more computationally complex form of optimal matching, using total distance between all controls to one case, rather than nearest neighbor matching criterion, did not improve the balance between groups (Gu & Rosenbaum, 1993). When considering the structure of matching (1:1

versus 1:m versus complete optimal matching), practical considerations are important when examining whether or not to match controls to cases with or without replacement. Whether selecting to match with or without replacement of controls, one must consider the complexity of statistical techniques needed when using "with replacement" since this creates situations where there are many within match group dependencies (Austin, 2009).

3.6. Summary

There are methodological issues that must be considered in order to maximize the potential of the research when utilizing retrospective billing data to examine HSR questions. A cost and time efficient way to examine health services utilization and cost of illness is to analyze long-term, readily available administrative data. Methods to control for population differences, such as estimating and controlling for comorbidities and disease severity, are essential to ensure that conclusions reached are valid and unbiased. It is important to choose procedural and diagnosis codes carefully when constructing cohorts using this type of data, otherwise individuals may be erroneously included or excluded which may introduce bias. It is also important to control selection bias by utilizing techniques such as propensity score matching during analysis of this type of data.

Calculating the cost of stroke is important to help inform policy decision-making for future resource allocation, as well as to support cost-effectiveness studies. Marginal cost is one of the best methods to calculate cost of illness, particularly in populations with more comorbidity such as the in elderly. It is essential to have a similar comparison group when estimating marginal cost and the best method for which to garner well matched groups in this type of research is to use propensity score matching methods.

Therefore, the purpose of this study is to examine the effect of Medicare outpatient rehabilitation caps enacted in the Balanced Budget Act of 1997 on the utilization of post-acute stroke rehabilitation services and their associated costs. This research project also estimated the total versus marginal cost of ischemic stroke in South Carolina in 2004 and the proportion of those costs that were post-acute rehabilitation services related. These estimates provide an important benchmark for which to compare future estimates and may help provide inputs to better estimate Medicare funding needs. They also allow healthcare professionals, researchers, and policymakers to recognize the difference between estimating the total annual cost of healthcare for patients with an acute event versus the marginal cost of healthcare due to the acute event. Particularly in illnesses that predominately occur in the older Medicare population, the difference between measuring cost of illness as total cost of care versus marginal will likely be much more extreme than what would be expected in a younger population that uses fewer healthcare services each year.

4. METHODS

This study was designed to examine the utilization and cost of rehabilitation services in Medicare patients with ischemic stroke in the state of South Carolina in order to improve our understanding of:

1) rehabilitation services utilization and cost changes in 1997 versus 2004, and
2) the 2004 marginal cost of stroke, over and above normal costs expected in a similar non-stroke population, and the proportion of marginal costs attributable to rehabilitation.

The aims and hypotheses of this study are as follows:

AIM 1

To examine the cost and utilization of rehabilitation services (PT, OT, SLP), before and after the 1997 Balance Budget Act.

Hypotheses

H1: Rehabilitation utilization (measured as proportion π over cap) among those who receive rehab after stroke is greater in 1997 than 2004.

H_0: $\pi_{\text{over cap (provider) 1997}} = \pi_{\text{over cap (provider) 2004}}$

H_a: $\pi_{\text{over cap (provider) 1997}} \neq \pi_{\text{over cap (provider) 2004}}$

H2: Rehabilitation cost (μ payments) among those who receive rehab after stroke is greater in 1997 than 2004.

H_0: $\mu_{\text{rehab cost 1997}} = \mu_{\text{rehab cost 2004}}$

H_a: $\mu_{\text{rehab cost 1997}} \neq \mu_{\text{rehab cost 2004}}$

Rationale

It is important to understand the effects of structural changes in governmental health care spending regulations (therapy caps) on the process of rehabilitation services utilization and outcome of cost.

AIM 2

To determine the cost of stroke-related healthcare and stroke-related rehabilitation care for South Carolina Medicare patients in 2004 and examine what proportion of the cost is rehabilitation related.

Hypotheses

H1: The 1-year cost of stroke healthcare services (μ payments) is greater than the cost of care (μ payments) of the matched control Group.

H_0: $\mu_{\text{cost of care (2004 stroke group)}} = \mu_{\text{cost of care (2004 control group)}}$

H_a: $\mu_{\text{cost of care (2004 stroke group)}} \neq \mu_{\text{cost of care (2004 control group)}}$

H2: The 1-year cost of rehabilitation services (μ payments) is greater than the cost of rehabilitation care (μ payments) of the matched control Group.

H_0: $\mu_{\text{cost of rehabilitation-related care (2004 stroke group)}} = \mu_{\text{cost of rehabilitation-related care (2004 control group)}}$

H_a: $\mu_{\text{cost of rehabilitation-related care (2004 stroke group)}} \neq \mu_{\text{cost of rehabilitation-related care (2004 control group)}}$

H3: The proportion (π) of the marginal cost of stroke that is rehab-related is greater than the proportion (π) of rehab-related care using total cost of stroke, in 2004.

H_0: $\pi_{\text{marginal rehab-related cost/marginal cost 2004}} = \pi_{\text{total rehab-related cost/total cost 2004}}$

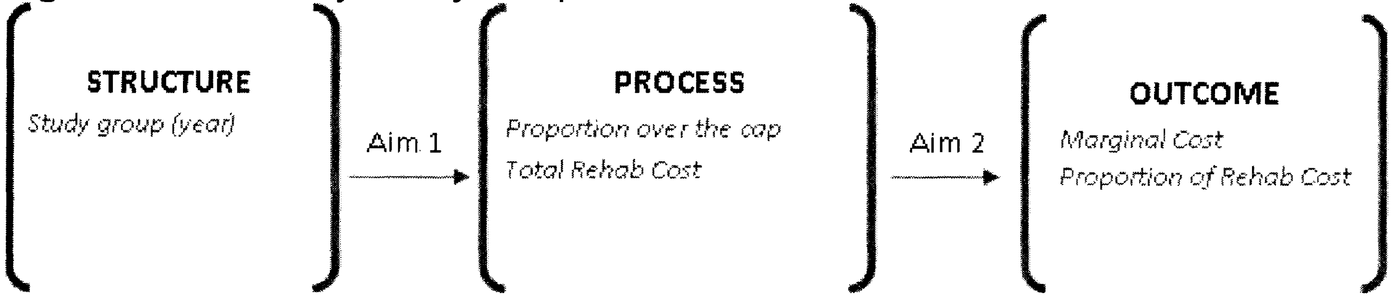
H_a: $\pi_{\text{rehab-related cost/marginal cost 2004}} \neq \pi_{\text{rehab-related cost/total cost 2004}}$

Study Rationale

Cost of illness has been historically reported as direct total healthcare cost and has never been compared as a marginal cost difference with an equally ill, non-stroke, control group. Therefore the outcome of cost of illness has been historically misrepresented in a population that tends to have a great amount of care costs that are related to comorbidities. The over-estimation caused by estimating cost of illness using total cost of care results in an under-estimation of the impact and need for stroke rehabilitation.

The primary endpoints that were used to support the examinations of aims 1 and 2 of this research are embedded in an applied theoretical view of the Donabedian Structure-Process-Outcome model in Figure 4-1 below.

Figure 4-1. Primary Study Endpoints Related to Theoretical Framework of Aims



4.1. Study Design

Aim 1 of this study uses a retrospective cohort design where Medicare beneficiaries with index ischemic stroke in 1997 are followed until death or up until 1 year after stroke, whichever comes first. The 1997 stroke cohort is compared with a similarly selected and followed cohort having an index ischemic stroke in 2004. Aim 2 of this study utilizes a retrospective case-control research design. SC Medicare data from 2004 are used to select a set of ischemic stroke cases. Each stroke case is matched with two non-stroke controls from the same year. Cases and controls are followed for a year or until death, whichever comes first. Matching controls to case is performed using propensity score techniques in order to control for potential selection bias.

A retrospective longitudinal cohort of patients with a primary diagnosis of ischemic stroke was extracted from the SC Medicare hospital discharge Standard Analytic File (SAF) database that contained data for the years 1996, 1997, 1998, 2003, 2004, and 2005. Aim 1 cohort groups are expressed as the "early cohort", referring to the group of 1997 ischemic stroke patients, and the "late cohort" describing the 2004 ischemic stroke patients. Patients were excluded if their index stroke date did not take place in the appropriate index year, either 1997 or 2004. Any patients less than 65 years of age at the time of the hospital admission for their index stroke were also excluded. Stroke patients with missing race information or with a primary diagnosis of ischemic stroke that resulted in hospitalization in the six months prior to index stroke were also excluded. Lastly, patients who expired while in the hospital for their index ischemic stroke were excluded.

Ischemic stroke patients were selected from the 2004 Medicare SAFs in a similar manner in aim 2 as for aim 1. The same exclusions were used in aim 2 as is described in aim 1 except that individuals who died in hospital for their index stroke were not excluded in this analysis.

4.2. Data Sources

The data used in this study were provided by the SC Office of Research Services (ORS) from a state-wide cohort of Medicare participants from SC which was made available to the researchers as part of the EXCEED grant (South Carolina EXCEED Project funded by AHRQ under DUA #16339 EDG#4081) to examine health disparities in minority populations. This study has been reviewed and approved by the institutional review board for human subjects at the Medical University of South Carolina.

The current research project utilized six years worth of data, spanning a ten year time period, of administrative Medicare billing data. SAFs include data collected by the Centers for Medicare and Medicaid Services regarding charges and payments for health care services provided to Medicare beneficiaries. Medicare SAFs include two sets of files used by providers for billing; durable medical equipment (DME) and part B provider bills (also known as carrier files), and five facility billing files including; inpatient, outpatient, home health, skilled nursing, and hospice (ResDAC, 2011). Since spending in hospice was negligible and utilization of rehabilitation in hospice does not generally occur, this file was not used in this study.

Provider billing includes DME claim files that include final action claim data submitted to Medicare by durable medical equipment suppliers. Part B provider billing files also fall under provider billing. They contain final action claims data submitted by non-institutional providers. Examples of part B providers include; physicians, physician assistants, social workers, nurse practitioners, independent clinical laboratories, ambulance providers, independent physical and occupational therapists, and free-standing ambulatory surgical centers (ResDAC, 2011).

Facility billing includes final action claims data submitted to Medicare from inpatient hospital providers and skilled nursing facilities for reimbursement of facility costs. Facility costs can include services provided by clinical providers who are employed by the facility. Home health agency (HHA) claims file contains data submitted by HHA providers. Facility billing also includes outpatient claims files which contain final action claims submitted by institutional outpatient providers such as; hospital outpatient departments, rural health clinics, renal dialysis facilities, outpatient rehabilitation facilities, comprehensive outpatient rehabilitation facilities, and community mental health center (ResDAC, 2011).

This type of data has been widely used by researchers to study outcomes, epidemiology, and health services rates of utilization among elderly and permanently disabled patients in the US. SC Medicare data from hospital, home health, outpatient, skilled nursing, durable medical equipment, and Part B provider files were merged together and linked using encrypted beneficiary identification numbers. Costs for each patient were aggregated over the study time period.

4.3. Measurement of Variables

Appendix A provides an overview of the variables supplied in the original Medicare data, as well as derived variables that were used in this study. Some important variables that were derived for this research, include indicator variables of "early" (1997 index stroke) or "late" (2004 index stroke) stroke cohort (aim 1), case versus control group indicator (aim 2), and indicator of being over or under the outpatient rehabilitation services cap enacted in the BBA of 1997 (aim 1).

To classify stroke severity, a proxy index of severity for administrative data was created using the same criteria that is described in previously published research (Ellis, Simpson *et. al.*, 2012). Stroke severity was defined as mild if patient had no major stroke-related diagnoses (aphasia, dysarthria, dysphagia, sensory impairment, hemianopia, neglect, memory loss or hemiplegia) during index hospitalization, moderate if at least one stroke-related diagnosis was coded (excluding hemiplegia), and severe if hemiplegia or two or more stroke-related diagnoses were coded.

4.4. Data Set Construction: Aim 1

Beneficiaries' data were linked from different claims files via encrypted beneficiary identification numbers at the individual level and followed longitudinally in two groups. The first cohort included patients who had a primary diagnosis of acute ischemic stroke requiring hospitalization in 1997 and the second cohort of patients included those diagnosed with a primary ischemic stroke in 2004 that required hospitalization. Each cohort was followed for the remaining time period of available data. The six months prior to stroke for each cohort was used to construct the Charlson comorbidity Index up until and including index stroke for each patient and were also used to exclude individuals with previous ischemic strokes. This ensures that the index stroke is not a recent re-stroke and provided a clearer cohort of incident ischemic stroke sufferers with a well-defined comorbidity measurement.

The patient population of interest in this study includes patients hospitalized with newly diagnosed acute ischemic stroke in either the year 1997 or 2004. Patients were selected based on the presence of a primary diagnosis of AIS via the most consistently accurate and highly specific ICD-9-CM codes of 434.xx or 436.x in the hospital impatient claims file (Reker, Hamilton *et. al.*, 2001). Patients were excluded from the cohort if they met the following exclusion criteria: not enrolled in Medicare in 1996 or 2003, less than 65 years of age, indication of previous stroke, not having at least one physician claim in the year following stroke unless discharged dead during index hospitalization, or if race data is missing.

The two groups were then be used to compare early (1997) versus late (2004) rehabilitation services utilization and cost of physical therapy (PT), occupational therapy (OT), and speech or swallowing therapy (SLP). Billing codes were used to identify indicators of rehabilitation use (Appendix B), stroke severity, and comorbid conditions.

ICD-9-CM diagnosis, Healthcare Common procedure coding system (HCPCS), and CPT codes were used to identify indicators of rehabilitation services use. The following table (Table 4-1) discussed by Zorowitz and colleagues, outlines codes that have be used in a past study to define general indicators of rehabilitation therapy services use (Zorowitz, Chen *et. al.*, 2009) and were used as an initial starting point to help designate rehabilitation use.

Table 4-1. Zorowitz et. Al. Rehabilitation Code Selections

Settings	Code Type	Code	Description
Hospital Inpatient	ICD-9-CM DRG	V57xx 462	Care involving use of rehab. procedures Rehabilitation
Hospital outpatient and primary care	CPT	92506, 92507, 92508	Evaluation or treatment of speech, language, voice, communication and/or auditory processing
		97001, 97002, 97003, 97004, 97010-97039	Physical therapy evaluation Occupation therapy evaluation Application of a modality to one or more areas including, but not limited to thermal, acoustic, light mechanical or electric energy
		97110-97546 97703, 97750 97780, 97781, 97799	Therapeutic procedures one or more areas Tests of measures of physical performance Other physical medicine/rehabilitation services/procedures
	HCPCS	G0129	Occupational therapy requiring the skills of a qualified occupational therapist, furnished as a component of a partial hospitalization treatment program, per day
	ICD-9-CM	V57xx	Care involving use of rehab. procedures
Skilled Nursing Facilities	ICD-9-CM	V57xx	Care involving use of rehab. procedures
	RUG	First three digits: FHA, FHB, RHC, RLA, RLB, RMA, RMB, RMC RUA, RUB,	Low/medium/high rehabilitation Very high/ultra high rehabilitation

		RUC, RVA, RVB, RVC	
Home Health Agency	HCPCS	G0151-G0153	Physical, occupational, speech and language in home health setting (each 15 minutes)
		S8990	Physical or manipulative therapy performed for maintenance rather than restoration
		S9128, S9129, S9131	Speech, occupational, physical therapy at home (per diem)
	ICD-9-CM	V57xx	Care involving use of rehab. procedures

This project examined outpatient billing for PT, OT, and SLP services due to the potential effects of BBA of 1997 caps specifically on these services. The following is a list of CPT codes commonly used by these service groups (Table 4-2). To distinguish between the service type, Medicare requires these billing codes be entered with the modifier "GN" for services delivered under an outpatient speech-language pathology plan of care; "GO" for services delivered under an outpatient occupational therapy plan of care; or, "GP" for services delivered under an outpatient physical therapy plan of care. These modifiers were found in 2004 date but did not exist in years before the BBA of 1997 was enacted, and was therefore not available in 1997. Outpatient rehabilitation modifier codes were used to help designate line items in 2004 data but were found to be little used. Therefore, rehabilitation codes were also used to define line item bills as rehabilitation-related even if they did not have modifier codes attached. A list of all rehabilitation codes used to define rehabilitation line items is included in Appendix B.

Table 4-2. Outpatient PT, OT, and SLP Billing (CPT or HCPCS) Codes

Clinical Service	Codes	Description
SLP	92506	Evaluation of speech, language, voice, communication, and/or auditory processing
	92507	Treatment of speech, language, voice, communication, and/or auditory processing disorder; Individual
	92508	Treatment of speech, language, voice, communication, and/or auditory processing disorder; group, 2 or more individuals
	92526	Treatment of Swallowing dysfunction and/or oral function for feeding
	92610	Evaluation of oral and pharyngeal swallowing function
	92626	Evaluation of auditory rehabilitation status; first hour
	92627	Evaluation of auditory rehabilitation status; each additional 15 minutes (List separately)
PT	97001	Physical Therapy Evaluation
	97002	Physical Therapy Re-evaluation
	97110	Therapeutic procedure, one or more areas, each 15 minutes; therapeutic exercises to develop strength and endurance, range of motion and flexibility
	97112	Neuromascular reeducation of movement, balance, coordination, kinesthetic sense, posture, and/or proprioception for sitting and or standing activities
	97116	Gait Training (includes stair climbing)
	97124	Massage, including effleurage, petrissage and/or tapotement (stroking, compression and percussion).
	97140	Manual Therapy Techniques (eg. mobilization/manipulation, manual lymphatic drainage, manual traction), one or more regions, each 15 minutes
	97150	Therapeutic procedure(s), group (2 or more individuals).
OT	97003	Occupational Therapy Evaluation
	97004	Occupational Therapy Re-evaluation
	97140	Manual therapy
	97535	Self-care management training
	G0129	Occupational therapy requiring the skills of a qualified occupational therapist, furnished as a component of a partial hospitalization treatment program, per day
	G0152	Services performed by a qualified occupational therapist in the home health or hospice setting, each 15 minutes
	G0160	Services performed by a qualified occupational therapist, in the home health setting, in the establishment or delivery of a safe and effective therapy maintenance program, each 15 minutes
	S9129	Occupational therapy, in the home, per diem
	G0158	Services performed by a qualified occupational therapist assistant in the home health or hospice setting, each 15 minutes

Once line item rehab utilization had been identified for each individual, they were combined to estimate rehabilitation services utilization and cost. Total rehabilitation costs were summarized using means and medians and were later used to examine their relative proportion to marginal versus total stroke costs.

4.5. Data Set Construction: Aim 2

The data set constructed for aim 2 utilized the 2004 index stroke cohort from aim 1 as stroke cases without excluding patients who died in the hospital during index stroke. A large pool of non-stroke Medicare beneficiaries from the same year was used from which to draw the control population. Propensity score matching was performed to match two controls to each case. Total medical care costs were then aggregated for all controls in the same manner as was done for the stroke cases.

4.6. Statistical Analysis Methods: Aim 1

Means and standard deviations were calculated to describe continuous data for each stroke cohort in aim 1. Frequencies and percents were calculated to describe categorical data. To test for differences in stroke rates, demographic and outcome variables between the two stroke groups, chi-square statistics were used to test for differences in proportions non-parametric. While Wilcoxon/Mann-Whitney U statistics were used to test for differences in medians (or ranks). Graphing was used as needed to test assumptions as well as to display results. Univariate statistical comparisons between groups provide a good initial indication of potential significant differences in individual variables. They do not, however, adjust for potential confounding covariates commonly influential in nonrandomized studies and thus must be examined further by using multi-variable analysis methods when group differences are found.

Frequencies and percents were calculated to describe rehabilitation services utilization in each of the stroke groups ("early" versus "late"). To test for differences in whether or not the proportion of patients over the outpatient rehabilitation cap was different between the early and late groups, chi-square statistics were calculated. When differences between groups were found, logistic regression was used to control for covariates that differed between the groups and that were potentially related to the outcome. Covariates included in initial models were: age, gender, race, Charlson morbidity score, and number of days alive in the year after index stroke. Covariates not found to significantly contribute to each model were removed one at a time and the models were then re-fit to the data. Final models and covariates are discussed in the results chapter.

Generalized linear modeling techniques were used to test the hypotheses that the total and outpatient provider costs of rehabilitation-related care were different between early and late groups. To correct for the non-normal distribution of Medicare costs, gamma distributed generalized linear models using a logarithmic transformation (Montez-Rath, Christiansen *et. al.*, 2006) were analyzed using the PROC GENMOD module in the SAS statistical software (version 9.2; SAS Institute, Inc., Cary, NC). The use of a gamma distributed generalized linear model with a log transformed link function has been shown to be a good method to estimate healthcare cost distributions that are generally right-skewed, especially when the log transformed dependent variables do not have heavy tails or excessive heteroscedasticity such as was found to be true in these data (Manning, Basu & Mullahy, 2005).

Multicollinearity between covariates was assessed using Pearson correlation coefficients. No collinearity was found in these data (all p-values > 0.25). Clinically relevant variables were used to determine which covariates were initially included in the models to control for population differences. Covariate adjustment was used to control for differences in cost that may be attributed to other factors. Covariates that were tested for potential confounding in model estimates of rehabilitation payments included age, gender, race, Charlson morbidity score, and number of days alive in the year after index stroke. Final models and covariates are discussed in the results chapter.

Manual backwards selection regression methods were used to decide which covariates remained in the final models using smallest Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) values, and covariate p-values to judge model fit. Variables with p-values greater than 0.20 were removed from the models if the AIC and BIC values became smaller than in the previous model containing the covariate. All analyses were performed using SAS statistical software (version 9.2; SAS Institute, Inc., Cary, NC), and statistical significance was determined at the 0.05 level.

4.7. Statistical Analysis Methods: Aim 2

The marginal cost of stroke-related healthcare and stroke-related rehabilitation care was defined as the cost of caring for patients with stroke after index stroke hospital admission that is over and above the cost of general medical care in the non-stroke control group over the same time period. Total Medicare payments and total rehabilitation services payments were calculated using means and unadjusted differences between groups were tested using non-parametric Wilcoxon Scores (same as Mann-Whitney U Scores). The marginal cost of stroke-related rehabilitation was calculated by subtracting the average total rehabilitation services payments for the controls, from the average total rehabilitation services payments for the stroke cases. Generalized linear models controlling for covariate differences were not used for this analysis because models would not converge and fit properly due to the large number of patients with no rehabilitation payments. However, because adjusted estimate results for total Medicare payments were so similar to their unadjusted results, the inability to utilize adjusted models in this case is not a major concern.

Generalized linear modeling techniques were used to estimate average annualized total Medicare payments for stroke cases and controls and to test for differences between the stroke case and control groups. The 1-year marginal cost of stroke-related healthcare was calculated by subtracting the estimated total Medicare payments for the controls from the estimated total Medicare payments for the stroke cases.

To correct for the non-normal distribution of Medicare costs, gamma distributed generalized linear models using a logarithmic transformation (Montez-Rath, Christiansen *et. al.*, 2006) were analyzed using the PROC GENMOD module in the SAS statistical software (version 9.2; SAS Institute, Inc., Cary, NC). The use of a gamma distributed generalized linear model with a log transformed link function has been shown to be a good method to estimate healthcare cost distributions that are generally right-skewed, especially when the log transformed dependent variables do not have heavy tails or excessive heteroscedasticity such as was found to be true in these data (Manning, Basu & Mullahy, 2005).

Multicollinearity between covariates was assessed using Pearson correlation coefficients. No collinearity was found in these data (all p-values > 0.25). Clinically relevant variables were used to determine which covariates were initially included in the models to control for population differences. Covariate adjustment was used to control for differences in cost that may be attributed to other factors. Covariates that were tested for potential confounding in model estimates of rehabilitation payments included age, gender, race, Charlson morbidity score, and number of days alive in the year after index stroke. Final models and covariates are discussed in the results chapter.

Manual backwards selection regression methods were used to decide which covariates remained in the final models using smallest Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) values, and covariate p-values to judge model fit. Variables with p-values greater than 0.20 were removed from the models if the AIC and BIC values became smaller than in the previous model containing the covariate. All analyses were performed using SAS statistical software (version 9.2; SAS Institute, Inc., Cary, NC), and statistical significance was determined at the 0.05 level.

Propensity score (PS) methods were employed to match cases to controls. The first step in this process was to perform logistic regression analysis to estimate the propensity of being "allocated to the stroke group". A propensity score for each individual was calculated and appended onto the analysis data set. Known components related to the risks of having a stroke were included as covariates in the logistic regression model (Brookhart, Schneeweiss *et. al.*, 2006). Covariates used in the PS model included age, gender, race, Charlson comorbidity score, and the following stroke risk factors (as monitored in billing records from the six months prior to index study start date): diabetes, heart failure, heart attack, atrial fibrillation, and hypertension as well as five interaction terms of gender by each risk factor. Final model selection was based on hypothesis testing of balance between groups of all the covariates included in the propensity score logistic regression models, model with largest r-square value, and satisfied reduction of the absolute standardized differences in means between the matched and unmatched data for all covariates (<0.25).

Propensity score methods using a greedy-match algorithm with caliper distance set to a width of 0.1 standard deviations of the logit of the estimated propensity score and a 1 case to 2 control matching scheme, without replacement, was used to match cases with controls in the final analytical data set. Simulation studies have shown this method to result in superior overall performance that eliminates systematic differences between treatment groups (Austin & Mamdani, 2006; Austin, 2009).

5. RESULTS

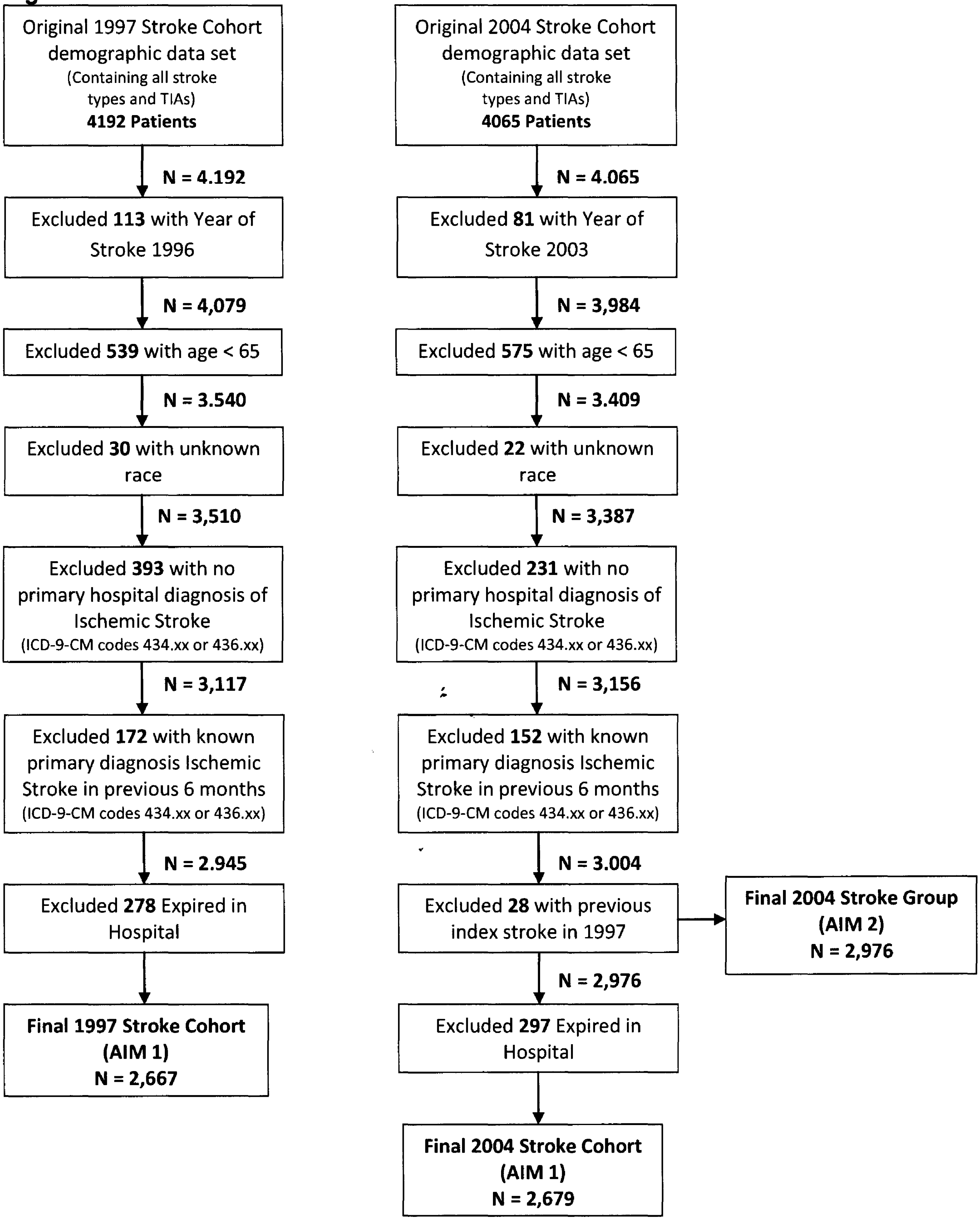
5.1. Aim 1 Results

5.1.1. Study Cohort Groups Identification and Descriptive Characteristics

1997 Stroke Group

4,192 patients initially eligible for the "early cohort", who were hospitalized for all stroke and ischemic events in 1997, were identified for this aim in a 1997 stroke cohort file provided by the SC ORS. Of these patients, 113 (2.7%) had their index stroke in 1996 and were excluded from this analysis. Of the remaining 4,079 patients, 539 (12.9%) were also excluded as they were under the 65 year age required for study inclusion; 30 (0.7%) patients had unknown race; 393 (9.4%) had a primary hospital diagnosis other than the ischemic inclusion codes 434.xx or 436.xx; 172 (4.1%) patients had claims in the prior 6 months indicating a prior ischemic stroke diagnosis; and an additional 278 (6.6%) patients had expired while in hospital for the index stroke and were therefore excluded because they were never eligible to receive post-acute outpatient rehabilitation services. This left a patient sample of 2,667 in the final 1997 ischemic stroke cohort. The process of exclusion is depicted in Figure 5-1.

Figure 5-1. Ischemic Stroke Cohorts Identification



2004 Stroke Group

The 2004 "late cohort" consisted of 4,065 SC Medicare patients who were hospitalized for stroke and ischemic events in 2004 in a 2004 stroke cohort file provided by the SC ORS. Of these patients, 81 (2.0%) had their index stroke in 2003 and were excluded from this analysis. Of the remaining 3,984 patients, also excluded were 575 (14.1%) who were under the 65 year age required for study inclusion, 22 (0.5%) patients with unknown race, 231 (5.7%) who had a primary hospital diagnosis other than ischemic inclusion codes 434.xx or 436.xx, 152 (3.7%) patients with claims in the prior 6 months indicating prior ischemic stroke diagnosis, 28 (0.7%) with a previous index stroke in 1997 and who were already included in the 1997 cohort, and an additional 297 (7.3%) patients who expired while in the hospital for index stroke and were never eligible to receive post-acute outpatient rehabilitation services. This left a final patient sample of 2,679 in the final 2004 ischemic stroke cohort. The exclusion categories are provided in Figure 5-1.

Group Comparisons

The 1997 and 2004 stroke cohorts did not differ significantly with respect to gender, proportion that died in the year post stroke, the average number of days alive in the year after stroke, or average Charlson morbidity score (Table 5-1). However, the 2004 cohort had a statistically significant higher average age (77.9 versus 76.8 years, p-value<0.0001), by just over a year, than the 1997 cohort (Table 5-1). This statistically significant finding may not be of clinical significance, but rather be a mathematical phenomenon commonly seen in large samples where small differences may be statistically significant, but not clinically important. The later cohort had a slightly higher proportion of Caucasians than the earlier group (71.8% versus 68.8%, p-value=0.02). Interestingly, the 2004 stroke cohort had a smaller average index hospital length of stay than the 1997 group, by less than one day (6.8 versus 7.6 days, p-value<0.0001), which may reflect the general trend toward shorter hospital stays over time for many illnesses observed nationwide in the past 15 years (Bueno, Ross *et. al.*, 2010; Clarke & Rosen, 2001; Kominski & Witsberger, 1993).

The 2004 cohort also comprised of a higher proportion of individuals who received rehabilitation services after the acute index hospitalization and who had a higher average number of rehabilitation bills in the year following their index stroke. These rehabilitation related outcomes are not baseline measures rather they are directly related to the primary outcomes of this study but were included in Table 5-1 for description only. It is important to note that use of post-acute rehabilitation increased from 20.5% in 1997 to 48.6% in 2004 in SC Medicare beneficiaries who had an ischemic stroke (Table 5-1). This increase in utilization of rehabilitation services of 28.1% (p-value <0.0001), is illustrated in Figure 5-2. Also important to note is the increase in the average number of rehabilitation bills from 1.4 in 1997 to 4.5 per patient in 2004 (p-value <0.0001) (Table 5-1). Not only did the rehabilitation bills increase but the standard deviation in the number of rehabilitation bills increased almost three fold (Table 5-1). This indicates a larger variation in the amount of care provided and may reflect high utilization of health care services by a small proportion of individuals.

Table 5-1. Demographics and Characteristics of Ischemic Stroke Patients

	Overall (n=5,346)	**1997 Stroke Group (n=2,667)**	**2004 Stroke Group (n=2,679)**	**p-value***
Age (approximate)†	77.4 (±6.8)	76.8 (±6.8)	77.9 (±6.9)	**<0.0001**
Male^	2102 (39.3)	1070 (40.1)	1032 (38.5)	0.22
Caucasian^	3759 (70.3)	1834 (68.8)	1925 (71.8)	**0.02**
Died yr post-stroke^	1332 (24.9)	659 (24.7)	673 (25.1)	0.74
Days Alive year post-stroke†	308.0 (±111.0)	308.8 (±109.9)	307.2 (±112.1)	0.62
Charlson Morbidity Score†	3.1 (±1.6)	3.1 (±1.6)	3.1 (±1.6)	0.11
Length of Stay (days)†	7.2 (±6.3)	7.6 (±6.5)	6.8 (±6.0)	**<0.0001**
Receiving Rehabilitation^	1849 (34.6)	546 (20.5)	1303 (48.6)	**<0.0001**
# of Rehab. Bills†	3.0 (±10.2)	1.4 (±5.0)	4.5 (±13.3)	**<0.0001**

† Mean (±SD)
^ N (%)
*p-values were calculated using non-parametric Wilcoxon Scores for continuous measures, Chi-square or Fisher's Exact for categorical measures (as appropriate).

5.1.2. Characteristics of Stroke Patients Receiving Rehabilitation Services

Of the 2,667 ischemic stroke patients in the 1997 group, 546 had at least one post-acute index hospitalization bill with a rehabilitation services procedure or diagnosis code included. Thirteen hundred and three of the 2,679 patients in the 2004 cohort had one or more post-acute rehabilitation bills. These sub-groups are the main focus of the hypotheses in aim 1, patients using rehabilitation services in the year after their index stroke (Table 5-2). Within the cohorts of patients receiving rehabilitation services, there are a number of demographic variables and study characteristics that are unequal between the groups. The 2004 group had a higher average age, a lower proportion of males, and a greater number of days alive in the year after stroke. The groups did not differ in race, morbidity, proportion that died in the year after stroke, or in the length of index hospital stay (Table 5-2).

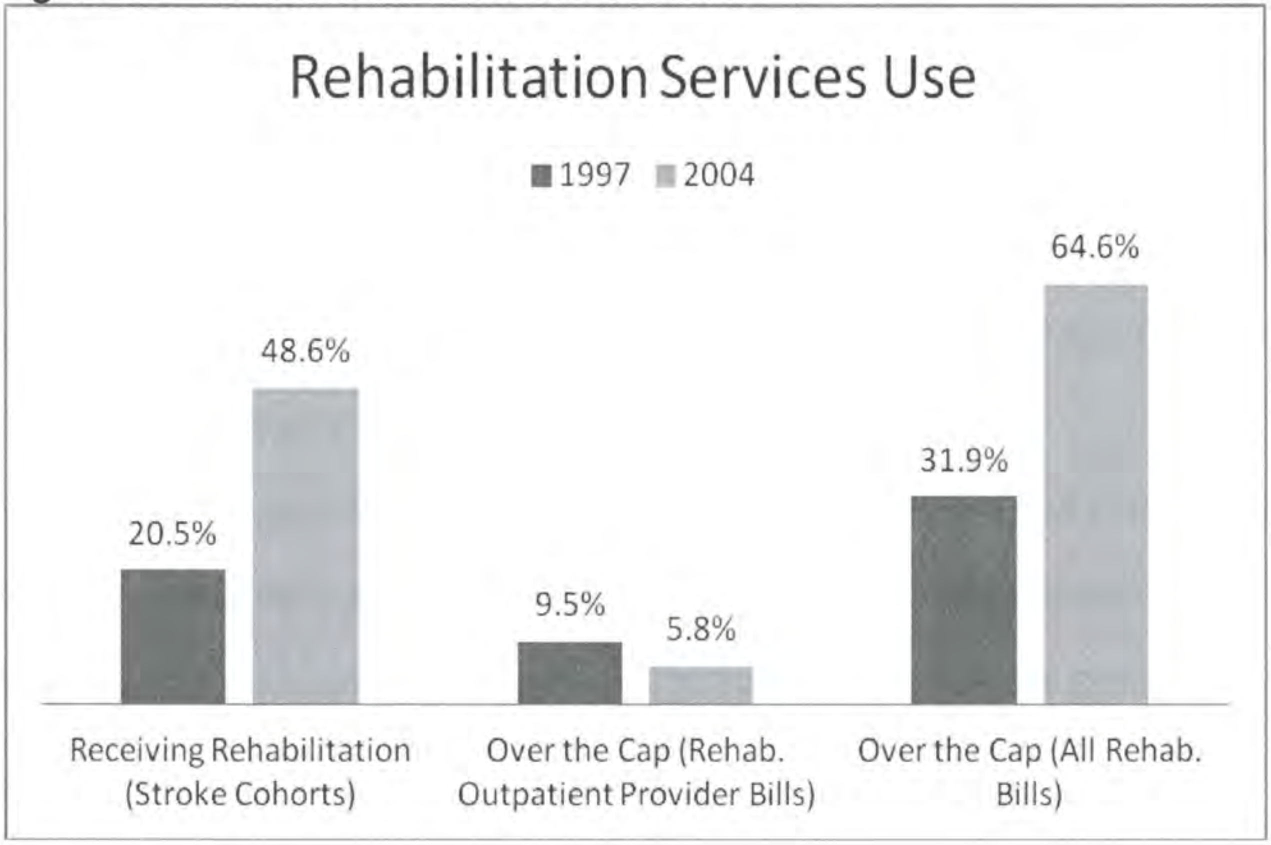
Table 5-2. Demographic and Characteristics of Ischemic Stroke Patients Using Rehabilitation Services

	Overall (n=1,849)	**1997 Cohort (n=546)**	**2004 Cohort (n=1,303)**	**p-value***
Age (approximate)†	77.1 (±6.7)	75.8 (±6.6)	77.6 (±6.6)	**<0.0001**
Male^	806 (39.6)	241 (44.1)	482 (37.0)	**0.004**
Caucasian^	1298 (70.2)	381 (69.8)	917 (70.4)	0.80
Died year post-stroke^	347 (18.8)	90 (16.5)	257 (19.7)	0.13
Days Alive yr post-stroke†	328.5 (±87.6)	331.7 (±86.4)	327.2 (±88.1)	**<0.0001**
Charlson Morbidity Score †	3.1 (±1.6)	3.2 (±1.5)	3.1 (±1.6)	0.06
Length of Stay (days)†	7.2 (±6.0)	7.1 (±5.5)	7.2 (±6.2)	0.51
Over the Cap (all outpatient bills)^	1016 (55.0)	174 (31.9)	842 (64.6)	**<0.0001**
Over the Cap (outpatient provider)^	127 (6.9)	52 (9.5)	75 (5.8)	**<0.004**

† Mean (SD)
^ N (%)
*p-values were calculated using non-parametric Wilcoxon Scores for continuous measures, Chi-square or Fisher's Exact for categorical measures (as appropriate).

In unadjusted models assessing the proportion of individuals with rehabilitation charges above the total outpatient rehabilitation cap, 32.7% (p<0.0001) more individuals were above the cap in 2004 (capped level of $3,180) than in 1997 (cap level $3,000) (Table 5-2). However, when examining only the Medicare Part B provider bills the opposite was found to be true. In the 1997 cohort, 9.5% of stroke patients had Part B expenditures above the total cap while only 5.8% exceeded the cap in 2004 (p-value <0.004) (Table 5-2). This may be reflecting a shift in how outpatient rehabilitation services were being billed. These differences are shown in Figure 5-2.

Figure 5-2. Rehabilitation Services Utilization



5.1.3. Rehabilitation Services Utilization

The findings from the univariate analysis for rehabilitation utilization results did not change when examined using multivariable logistic regression models when controlling for clinically relevant covariates: age, gender, days alive in the year post-stroke, and level of stroke. In 2004, South Carolina ischemic stroke patients over the age of 65 who were hospitalized for their stroke, and who received some type of rehabilitation services after their index hospitalization, had 3.7 (p-value <0.00001) times the odds of exceeding the total $3,180 outpatient rehabilitation services cap than those in the 1997 Medicare cohort (based on the level set the following year at $3,000). If only the outpatient Medicare Part B provider bills were used to assess the odds of exceeding the cap, the opposite result was found. The odds of the 2004 cohort exceeding the cap, using only the provider bills, are 0.60 (p-value <0.007) the odds of being above the cap in 1997.

When examining rehabilitation services utilization after ischemic stroke from the provider cost perspective, average payments were higher or remained similar between the two cohorts (Table 5-3). In order to account for inflation, 1997 Medicare payments were adjusted to 2004 dollars by using the Consumer Price Index medical care services estimates provided by the Bureau of Labor Statistics (Consumer Price Index, 2012).

Total rehabilitation costs per patient were greater in 2004 than in 1997, even after adjusting the data for inflation. Estimated 1-year adjusted total rehabilitation payments were $9,606 in 2004 compared with $5,691 (inflation adjusted) in 1997 (p-value <0.001) (Table 5-3). While utilization of any rehabilitation services after ischemic Stroke increased by 32.7% from 1997 to 2004, the average cost increased by just under $4,000. Although not statistically significant, the estimated cost of rehabilitation services for Medicare Part B provider billing appears to decrease slightly over this time period (p=0.12) (Table 5-3). Among patients receiving rehabilitation services, total 1-year Medicare payments fell from 1997 to 2004 by $3,987 (p<0.001) (Table 5-3).

Table 5-3. Rehabilitation Services Medicare Payments for Stroke Patients Receiving Rehabilitation†

	Overall (n=1849)	1997 Cohort (n=546)	1997 Adj. Cohort$ (n=546)	2004 Cohort (n=1303)	p-value*
Total Medicare Payments	33,882 (23921)	29,632 (20362)	39,707 (27285)	35,663 (25028)	<0.0001
Estimated Total Medicare Payments#			39,565	35,578	<0.001
Total Rehab. Payments	7,127 (10193)	3,776 (7945)	5,060 (10646)	8,530 (10695)	0.02
Estimated Total Rehab. Payments^			5,691	9,606	<0.0001
OT	1,029 (3089)	602 (2953)	806 (3659)	1,208 (3204)	0.0004
PT	2,478 (4854)	994 (3099)	1,332 (4153)	3,100 (5301)	<0.0001
SLP	569 (2366)	264 (1806)	354 (2420)	697 (2555)	0.0002
PT & SLP	3,047 (5985)	1,258 (4377)	1,686 (5865)	3,797 (6397)	<0.0001
General (unspecified)	3,050 (6265)	1,916 (4524)	2,568 (6063)	3,525 (6810)	0.20
Provider Rehab. Payments	847 (4023)	769 (1476)	1,031 (1978)	879 (4696)	<0.0001
Estimated Provider Rehab. Payments$			1,052	833	0.12

† All payments are in US$ and are reported as mean (SD); charges have been rounded to the nearest dollar.

$ 1997 payment amounts adjusted to 2004 US$ using Consumer Price Index series CUUR0000SAM2 annual medical care services 1.34 adjustment (Bureau of Labor Statistics)

*p-values for univariate comparisons were calculated using non-parametric Wilcoxon Scores for continuous measures,

p-value for estimated total Medicare payments were calculated using multivariable Log linked Gamma Distributed Generalized Linear Model, controlling for race and number of days alive in year post stoke.

^ p-value for estimated total rehabilitation payments were calculated using multivariable Log linked Gamma Distributed Generalized Linear Model, controlling for race, age approximation, number of days alive in year post stoke, and stroke severity.

$ p-value for estimated outpatient rehabilitation payments were calculated using multivariable Log linked Gamma Distributed Generalized Linear Model, controlling for gender, race, and number of days alive in year post stoke.

5.2 Aim 2 Results

5.2.1 Characteristics of the 2004 Stroke Cohort and the Matched Control Group

The 2004 Ischemic stroke cohort used in aim 2 of this study is very similar but not identical to 2004 group used in aim 1. Figure 5-1 shows the flow diagram of how the stroke groups were selected. The aim 2 ischemic stroke cases were selected identically to the approach used in aim1 until the final exclusionary step where subjects who died in-hospital after their index stroke were either excluded, as was completed in aim 1, or not excluded, as was completed in the present aim.

The primary purpose of aim 1 was to evaluate post-acute stroke rehabilitation, which requires all subjects to be alive after acute treatment in order to have the opportunity to receive rehabilitation services. In aim 2, the goal is to estimate the 1-year marginal cost of stroke for all ischemic stroke patients over age 65, including those that die during initial hospitalization. For this reason, the stroke group in aim 2 of this study differed slightly in sample size and population composition to that of aim 1. Two thousand nine hundred and seventy six ischemic stroke cases were matched to a cohort of 5,952 controls on age, gender, race, Charlson morbidity score, and the following stroke risk factors (as monitored in billing records from the six months prior to index study start date): diabetes, heart failure, heart attack, atrial fibrillation, and hypertension using a PS matching procedure. Potential control patients were excluded if billing data for their indexed year, or prior six months, contained ischemic stroke diagnosis codes. In addition to the nine covariates listed above, five interaction terms of gender by each risk factor were also included in the propensity model in order to help achieve an improved gender balance. Controls were selected from a group of 17,924 potential Medicare beneficiaries that met the same inclusion criteria used to select the ischemic stroke cohort. A, two controls to one stroke case, matching scheme was performed based on propensity score similarity via a computerized matching algorithm as discussed in the methods section.

Table 5-4. Demographics and Characteristics of 2004 Ischemic Stroke Patients and Matched Controls

	Overall (n=8928)	**2004 Stroke (n=2976)**	**2004 Controls (n=5952)**	**p-value***
Age (Approximate)†	78.2 (±6.8)	78.1 (±6.9)	78.3 (±6.8)	0.14
Male^	3510 (39.3)	1149 (38.6)	2361 (39.7)	0.33
Caucasian^	6374 (71.4)	2148 (72.2)	4226 (71.0)	0.24
Charlson Morbidity Score†	2.1 (±1.7)	2.1 (±1.7)	2.0 (±1.6)	0.10
Receiving Rehabilitation^	2438 (27.3)	1303 (43.8)	1135 (19.1)	**<0.0001**
Died Year Post-Index Date^	1975 (22.1)	967 (32.5)	1008 (16.9)	**<0.0001**
Days Alive Yr Post-Index Date†	309.1 (±115.2)	279.2 (±136.1)	324.0 (±99.8)	**<0.0001**
Stroke Risk Factors (prior 6 months)				
Diabetes^	3018 (33.8)	991 (33.3)	2027 (34.1)	0.48
Heart Failure^	2606 (29.2)	851 (28.6)	1755 (29.5)	0.38
Heart Attack^	767 (8.6)	280 (9.4)	487 (8.2)	0.06
Atrial Fibrillation^	2423 (27.1)	832 (28.0)	1591 (26.7)	0.22
Hypertension^	7512 (84.1)	2476 (83.2)	5036 (84.6)	0.09

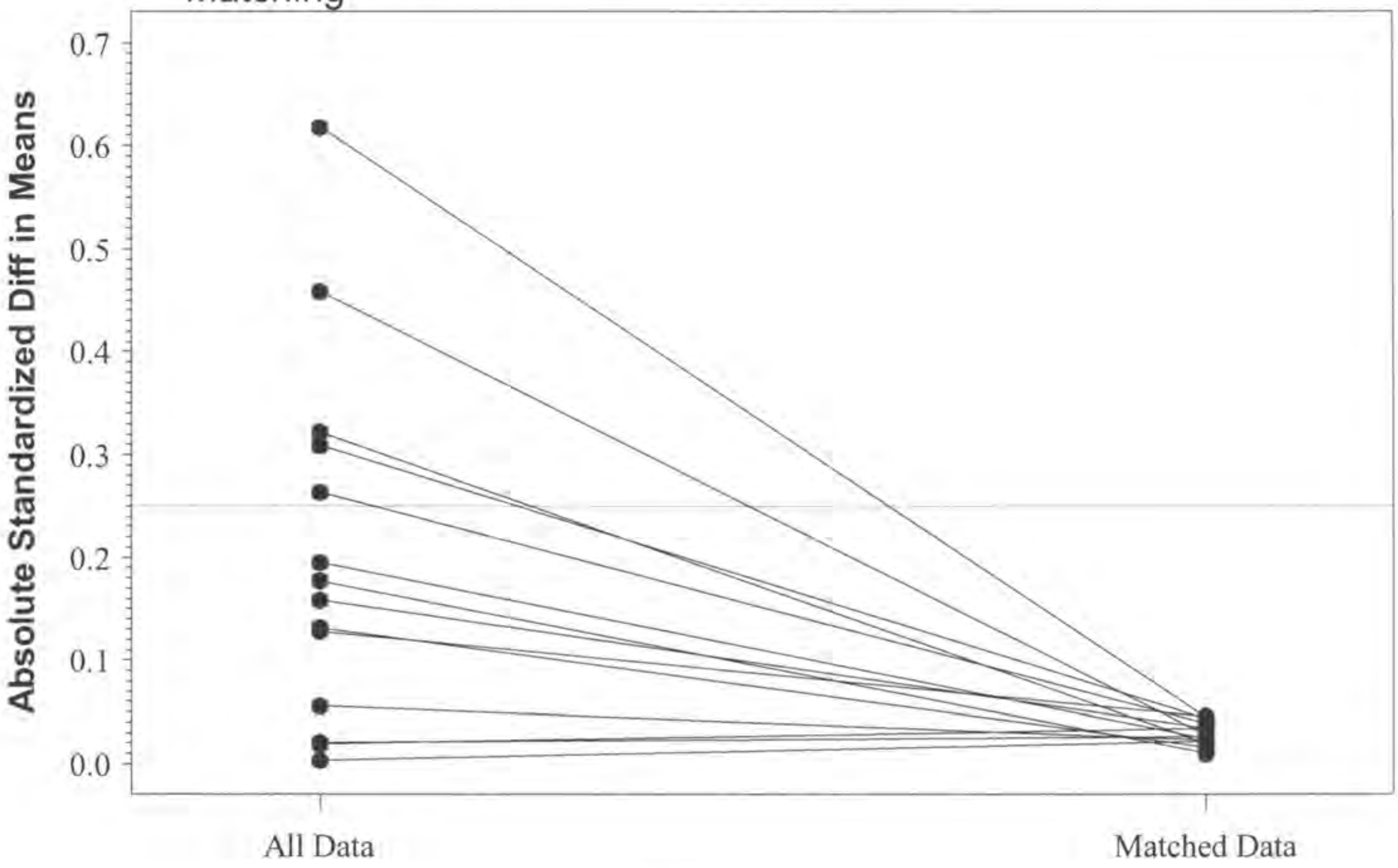
† Mean (±SD)
^ N (%)
*p-values were calculated using non-parametric Wilcoxon Scores for continuous measures, Chi-square or Fisher's Exact for categorical measures (as appropriate).

5.2.2 Propensity Score Matching Results

Each of the propensity score matched covariates resulted in statistically equal groups on these known potentially biasing factors. Unadjusted outcomes such as, average number of days alive in the year after index study start date (stroke date for the stroke cohort and randomly selected 2004 medical bill date for the control group), proportion receiving any rehabilitation services in the year after index date, and proportion who died in the year after index study date, were all higher in the stroke cohort versus the control group (p-values <0.0001) (Table 5-4).

A plot of the absolute standardized differences in means, as seen in Figure 5-3, offers a good representation of whether selection bias of known factors has been reduced by matching on propensity score (Stuart, 2010). Balance (i.e. reduction in standardized mean differences between stroke cases and selected controls) for each covariate that was used in the logistic regression model of propensity, is improved when differences are reduced after matching to no greater than 0.25 (Rubin, 2001). Figure 5-3 illustrates that the standardized differences in means for each of the fourteen covariates included in the propensity model is reduced to less than the 0.25 recommended level after matching. This resulted in a reduction in selection bias on all known covariates after matching which is the intended goal of propensity score matching (Rosenbaum & Rubin, 1983). An added benefit of this matching approach was a reduction in the selection bias of other unmeasured factors that are correlated with the known covariates used in this matching algorithm. This gives confidence that we have a well matched observational study design that is unlikely to have much selection bias.

Figure 5-3. Standardized Difference of Means of PS Covariates Before and After Matching



5.2.3 Marginal Cost of Stroke in SC

The estimated average healthcare cost in the first year after ischemic stroke in 2004 was $27,330 (Table 5-6). Average estimated healthcare costs in the control group was significantly lower at $18,276 (p-value <0.0001) (Table 5-6). Therefore, the marginal cost of stroke, defined as the cost of healthcare for an average individual who has had and ischemic stroke, over and above the normal average cost seen in a similar group who have not suffered a stroke, was the difference between these group estimates, or $9,054 (Table 5-6).

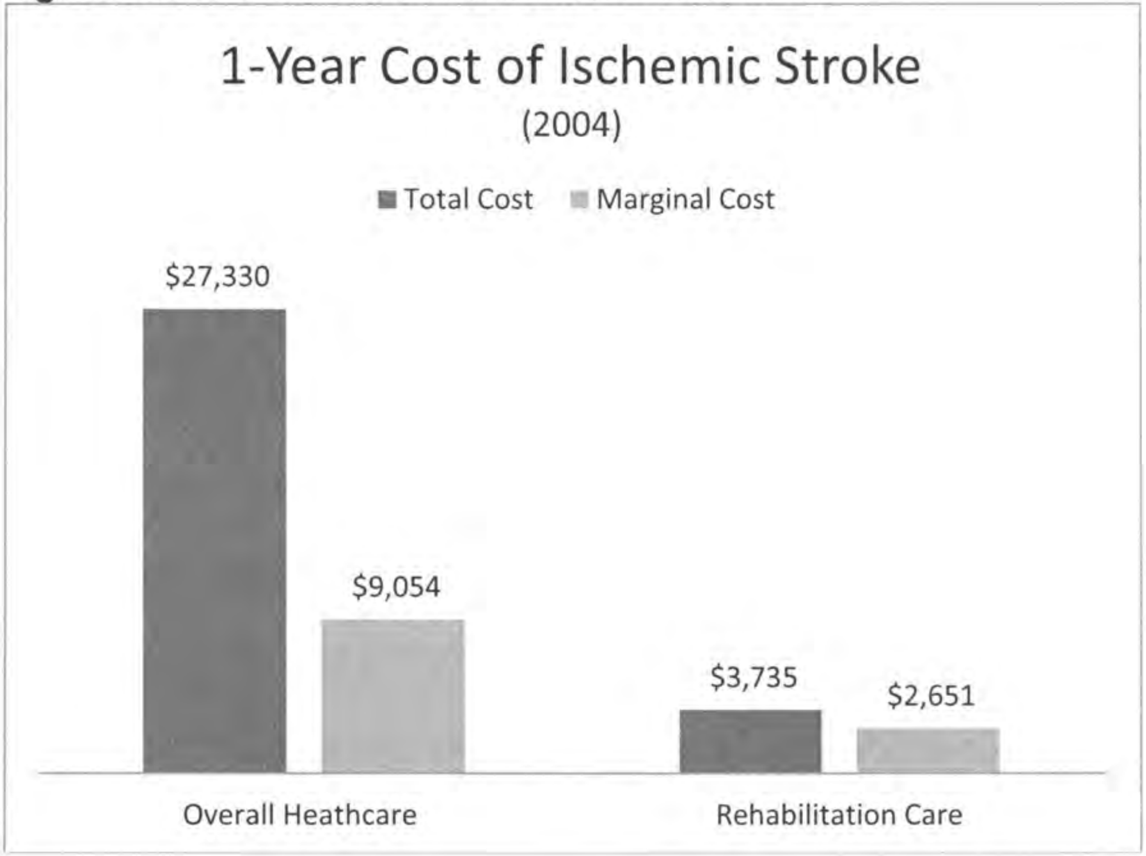
Table 5-6. Rehabilitation Services Medicare Costs for 2004 Stroke Cohort and Matched Controls†

	Overall (n=8928)	2004 Stroke (n=2976)	2004 Controls (n=5952)	p-value*
Total Medicare Payments	21,220 (28267)	27,329 (23913)	18,165 (29745)	<0.0001
Estimated Total Medicare Payments#		27,330	18,276	<0.0001
1-year Marginal Cost of Stroke-Related Healthcare		**$9,054**		
Total Rehabilitation Services Payments	1,968 (5887)	3,735 (8245)	1,084 (3958)	<0.0001
1-year Marginal Cost of Stroke-Related Rehabilitation		**$2,651**		

† All payments are in 2004 US$ and are reported as mean (SD); payments have been rounded to the nearest dollar.
*p-values for univariate comparisons were calculated using non-parametric Wilcoxon Scores for continuous measures,
p-values for estimated payments were calculated using multivariable Log linked Gamma Distributed Generalized Linear Model.

The average cost of rehabilitation after stroke in 2004 was $3,735, significantly more than average rehabilitation services cost for the controls (p-value <0.0001) (Table 5-6). The difference between the rehabilitation costs in these two groups is the 1-year marginal cost of stroke-related rehabilitation care, or $2,651 (Table 5-6.). Both the average total healthcare cost differences and rehabilitation cost differences are illustrated in Figure 5-4.

Figure 5-4. 1-Year Cost of Ischemic Stroke in SC



The proportion of the marginal cost of stroke that is rehabilitation-related was greater than the proportion of rehabilitation-related care using total cost of rehabilitations services and total cost of healthcare (29.3% versus13.7% respectively, p-value=0.004).

6 DISCUSSION

This research examines rehabilitation services utilization and healthcare cost during the year after acute ischemic stroke in South Carolina. More specifically, how the caps on outpatient rehabilitation services required by the US Balance Budget Act of 1997 impacted utilization and cost by comparing stroke cohorts from before and after the legislation was enacted. The one-year attributable healthcare costs of ischemic stroke was also examined by calculating the marginal estimated healthcare Medicare payment difference between a 2004 ischemic stroke cohort and a propensity matched 2004 non-stroke control group. This latter question is innovative because the marginal cost of illness has never been published for an elderly stroke cohort, and marginal cost is the preferred method of cost of illness estimation for many purposes; specifically, it is an essential input for cost-effectiveness studies for this disease group.

One of the objectives of this research was to estimate the proportion of healthcare dollars spend on rehabilitation services in the year after ischemic stroke. Estimates of rehabilitation expenditures are extremely varied and are often underestimated due to the fact that they are estimated as a proportion of annual total healthcare expenditure, rather than as a proportion of the marginal cost attributable to a specific illness. Because the type of data available to answer these questions is retrospective observational billing data, special methods must be used to properly minimize selection bias. Also, because costs are being estimated, statistical methods should be used that can effectively model skewed distributions that are commonly associated with healthcare costs.

There are four primary findings from this research. First, the BBA of 1997 outpatient rehabilitation services caps did constrain the costs of Medicare Part B provider services when rehabilitation bills were examined. However, the second finding was that all other rehabilitation services billing contained within outpatient facility charges continued to rise significantly over the study time period. Third, findings related to the second study aim clearly demonstrated that the total cost of healthcare after ischemic stroke significantly overestimates the cost of stroke as an illness because the marginal cost of stroke in this elderly population is attenuated by healthcare costs related to comorbidities. Fourth, estimates of the proportion of healthcare dollars spent on rehabilitation services using total annual healthcare expenditures, rather than marginal costs, underestimates the proportion of rehabilitation services used after stroke. The proportion of dollars spent on stroke-related rehabilitation services is better estimated by calculating marginal stroke-related healthcare costs rather than total healthcare costs. This is because the amount of expenditures incurred for other non-stroke related healthcare needs in this older population is quite large. These findings and related issues are discussed below, followed by a discussion of the limitations of this study, future directions, and opportunities in this line of research.

6.1 Aim 1 Discussion

The first aim of this study examined the cost and utilization of rehabilitation services before and after the 1997 BBA. The proportion of stroke patients exceeding the cap in 2004 after the 1997 BBA was enacted, was lower (5.8 %) than those in 1997 (9.5%) had there been a cap at that time (p-value=0.004). These numbers, however, do not reflect the total spending on rehabilitation services outside of hospital settings. They represent only the portion of rehabilitation services that are billed to Medicare via Part B outpatient provider files.

Rehabilitation services can also be billed via home health facility, outpatient facility, and skilled nursing facility billing. When we examined the proportion of individuals exceeding the cap among both the outpatient provider and facility files, there was a greater proportion of stroke patients in 2004 (64.6%) than in 1997 (31.9%) who exceeded the cap (p-value <0.0001). The same relationship was found when examining the 1-year cost of rehabilitation services after acute ischemic stroke among patients who are eligible for these services. The estimated average 1-year Medicare payments for rehabilitation services, when examining only the Part B outpatient provider bills, did not differ between the cohorts (p=0.12), and, in fact, decreased slightly from $1,052 in 1997 (after adjustment for inflation) to $833 in 2004. However, when examining rehabilitation costs using all available outpatient Medicare bills, the average estimated payments greatly increased (p-value <0.0001) from 1997 when it was $5,691 to $9,606 in 2004 after inflation adjustment.

These results suggest that billing practices may have changed in response to the outpatient rehabilitation services caps enacted by the BBA of 1997. Rehabilitation services billing may have shifted from Part B provider bills to being more frequently included in facility charges. In fact, the average number of bills containing an indication of services performed by a PT, OT, or SLP increased greatly over this time period from 1.4 in 1997 to 4.5 per patient in 2004 (p-value <0.0001).

Not only did the number of rehabilitation bills increase but we observed a greater variation in billing as indicated by the standard deviation in the number of rehabilitation bills increasing almost three fold. This indicates a larger variation in the amount of care provided and may reflect a high utilization of health care services by a small proportion of individuals which has been noted in numerous reports (Andersen & Newman, 2005; McKinsey and Company, December 2008) to be a major contributing factor of the exponential growth of US healthcare expenditures. It should also be considered a warning that potential disparities in access to care could be increasing.

In addition, the number of stroke patients receiving some amount of rehabilitation services after acute ischemic stroke has greatly increased during this time period. The proportion of patients using rehabilitation services after their stroke increased from 20.5% in 1997 to 48.6% in 2004. This increase in utilization of rehabilitation services of 28.1% (p-value <0.0001), reflects an important indication that practice is moving toward compliance with recommendations that all stroke survivors receive at least one evaluation visit with a PT, OT, and SLP clinician, and that the unit cost or appropriate utilization of rehabilitation services may not be the best legislative focus for cost containment.

No matter what special rules are enacted, healthcare administrators will find ways to legally bill Medicare for needed provider services. The focus of healthcare cost containment may be better served by reducing the large amount of services used by a small portion of the population. The increase in variation of the amount of units of rehabilitation services used in the year following ischemic stroke indicate that just over 2% of Medicare beneficiaries consume more than 30 rehabilitation services billing units in the year after their 2004 stroke, while this proportion of high-use behavior in 1997 resulted in the top 2% consuming only 10 or more rehabilitation units. The cap on outpatient rehabilitation per person annual spending enacted under the BBA of 1997 has also contributed untold time and related expenditure on legislative, private sector, and public research efforts to lobby, debate, and study the issue with little or no supporting evidence that the cap is fair or satisfies the goal of cost containment.

From 1998 through 2000, Olshin, Ciolek, and Hwang report that Medicare Part B expenditures for therapy services dropped by 10.3% (Olshin, Ciolek & Hwang, 2002). The findings in this study are not directly comparable to what we found as a decrease of 14.7% in Part B expenditures from 1997 (adjusted) to 2004. However, because our time frame was longer than the Olshin, Ciolek and Hwang report it is reasonable that the decrease found in our study is greater but still in the same direction as this government sponsored research (Olshin, Ciolek

& Hwang, 2002). When we adjusted our estimates for gender, race, and the number of days alive that year, the difference was no longer statistically significant. The Olshin, Ciolek and Hwang group report on all Medicare beneficiaries while ours include only those diagnosed with ischemic stroke. Some limitations of the Olshin et. al. report is that the authors do not test for a statistically significant difference and do not address rehabilitation services that are billed under other facility based bills, such as home health or nursing home. Another reason for the difference in findings between the current research and the Olshin report may be because the government report is based on a national sample.

Indeed, according to US congressional committee members' response to the analysis performed by Olshin, Ciolek and Hwang, the Computer Sciences Corporation (CSC) results were considered insufficient for informing health policy, written in a report from the US government accountability office (GAO) in 2005 (Grassley, Baucus *et. al.*, 2005). In the GAO report, "Little progress made in targeting outpatient payments to beneficiaries needs", the congressional GAO authors stated that "the [CSC] contracted analysis of claims data does not show any particular conditions or diseases as more likely than others to be associated with payments exceeding the therapy caps" (Grassley, Baucus *et. al.*, 2005). They go on to suggest that even for conditions such as stroke, claims data analysis shows that the length of treatment varies widely (Grassley, Baucus *et. al.*, 2005). This is one of the reasons why the current in-depth study, focused specifically on stroke patients, may contribute substantially to informing health policy.

In the most recent analysis by Ciolek and Hwang, the authors remark that the initial problems with reduced access to outpatient rehabilitation services seen in the early years of the caps appears to no longer be notable once the exceptions process was put in place (Ciolek & Hwang, 2008). Our conclusions are similar to this report in that it appears that once the healthcare system had time to adjust to the legislation it was able to provide services in different locations. Thus, access issues do not appear to be a problem in the current study, consistent with Ciolek and Hwang. Use of rehabilitation services by larger proportions of the Medicare population continue to increase.

In a study published by the CDC based on 2005 BRFSS survey data, 30.7% of stroke survivors received outpatient rehabilitation (CDC, 2007). This estimate is much lower than found in the current study, where 48.6% of SC Medicare patients who survive hospitalization after ischemic stroke receive rehabilitation services. In additional to other limitations of BRFSS data related to survey sampling, the lower estimate in the BRFSS survey may be due to the fact that those data are based on subjective recall and only represent non-institutionalized individuals which excludes anyone in nursing home or inpatient rehabilitation facilities at the time of the survey. Also, rehabilitation rates may vary from the national sample to the current South Carolina based study data.

Nevertheless, these estimates continue to indicate that there may still be a concern that clinical practice guidelines recommend outpatient rehabilitation for the majority of stroke survivors (Adams, Brott *et. al.*, 1994; Adams, del Zoppo *et. al.*, 2007). It is quite unlikely that the more than half of stroke patients who do not receive rehabilitation services do not need, at a minimum, rehabilitation assessment. We suspect that these patients simply are unable to negotiate the entry points into the rehabilitation system. This may be a serious problem for patients with low health literacy, without family support in negotiations, and with cognitive impairments that make them poor advocates for themselves.

6.2 Aim 2 Discussion

The second aim of this study examined the 1-year difference in healthcare costs between a group of SC Medicare beneficiaries who had suffered an ischemic stroke in 2004 and a propensity score matched control group of 2004 non-stroke SC Medicare beneficiaries. In 2004, the estimated marginal cost of stroke-related healthcare in the year after ischemic stroke in SC was $9,054. This amount reflects the difference between the annualized healthcare cost of the stroke group of $27,330 less the healthcare costs of the propensity score matched non-stroke control group of $18,276 (p-value <0.0001). Similarly, the 2004 marginal cost of stroke-related rehabilitation services in the year after ischemic stroke was $2,651, resulting from a statistically significant difference between the average annualized total rehabilitation services cost for the stroke group of $3,735 and the control group of $1,064 (p-value <0.0001). Both the average total healthcare cost differences and rehabilitation cost differences are illustrated in Figure 5-4.

While these amounts are substantial and both clinically and statistically significant, they are lower than is commonly quoted as the annual cost of care after stroke. A 1996 publication by Taylor, Davis and colleagues is the most commonly cited cost of stroke paper with 559 publications referencing this research (accessed May 2012) . The Taylor study continues to be referenced annually in the stroke cost section by the most well-known review publication on stroke statistics, "Heart Disease and Stroke Statistics—2011 update: A report from the American Heart Association" (Lloyd-Jones, Adams *et. al.*, 2009; Lloyd-Jones, Adams *et. al.*, 2010; Roger, Go *et. al.*, 2011b; Rosamond, Flegal *et. al.*, 2007; Rosamond, Flegal *et. al.*, 2008), even though this research is based on 1990 data and uses antiquated methodology. This is likely true because there have been no more recent, population-based studies on the cost of stroke.

The authors of the Taylor study estimated the 1990 annual direct cost of ischemic stroke in the 65-74 year age group to be $17,823 ($35,197 in 2004 dollars) versus the annual healthcare expenditures for their control group of $2,825 ($5,579 in 2004 dollars) (Taylor, Davis *et. al.*, 1996). This study reports the annual direct marginal cost of ischemic stroke of $14,998 in 1990 dollars ($29,618 in 2004 inflated dollars) which is much higher than we found in the current research. Differences between the current research and that undertaken by Taylor and colleagues in their 1997 publication are related to differences in the methods used to estimate these dollar amounts and in changes in healthcare practice patterns.

A significant trend toward shorter hospital average length of stay has been frequently reported in the literature. In this case, the Taylor study reports that 70% of the first year of medical costs can be account for by the initial hospitalization; however, the article does not report the average length of stay. In the current study, initial hospital costs only account for 35% of the first year of total healthcare costs. This reflects a change in practice patterns of shorter average hospital stays from the 1980s to today (Bueno, Ross *et. al.*, 2010; Clarke & Rosen, 2001; Kominski & Witsberger, 1993). Shorter length of stay would result in lower first year healthcare cost estimates in later studies, however these reductions may be counteracted by inflation adjustment over time.

The Taylor et. al. study includes a 5% Medicare sample of the 1990 US population, while the current study uses all SC Medicare patients with ischemic strokes in 2004. Taylor et. al. also used an average cost to charge ratio for all admissions to estimate stroke costs while the current research used actual Medicare payments. Estimates based on cost to charge ratios for all admissions can skew costs because stroke costs may not follow general hospital cost to charge trends. While the current research uses actual payments made by Medicare to the provider and does not make any assumptions in the costing methods. Also, the Taylor research used a 1 in 1,000 randomly selected, non-matched control group from the general US Medicare population. This practice would likely under estimate the control groups' healthcare expenditures because the average Medicare population is more likely to be healthier than a control group matched on an equally at-risk population. This, outdated matching approach, would result in inflated marginal cost estimates. This study addresses the potential selection bias caused by unmatched controls by using propensity score matching to match the stroke cases to controls, which results in a more conservative and reasonable marginal cost estimate. An added benefit of the matching approach used in the current study was a reduction in the selection bias of other unmeasured factors that are correlated with the known covariates used in this matching algorithm. This gives confidence that the observational study is well matched and is unlikely to contain much selection bias.

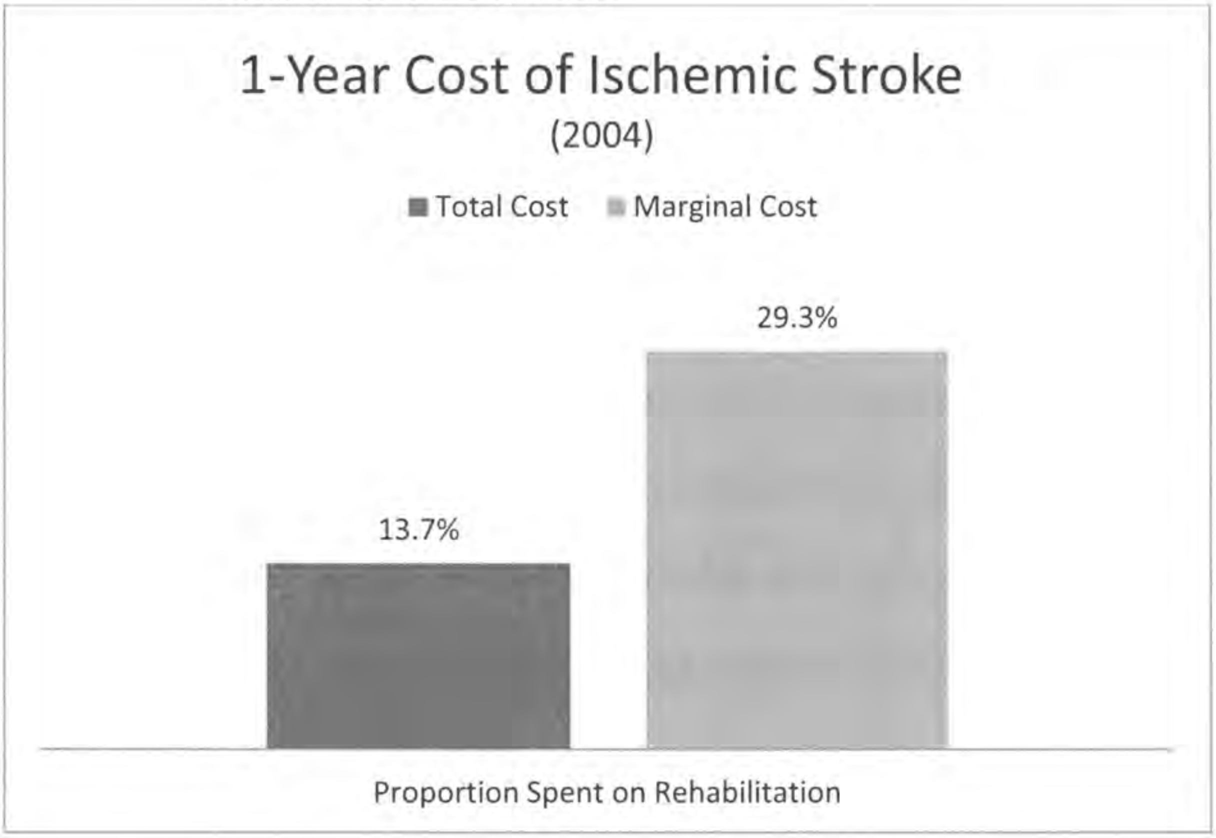
In a seminal study by Samsa and colleagues, the 2-year cost and survival after cerebral infarction was estimated based on 1991 data (Samsa, Bian *et. al.*, 1999). This publication, which has been cited 130 times (accessed May 2012), reports the first year cost of first ever ischemic stroke in the over 65 Medicare population as $29,444 (in 1991 dollars) (Samsa, Bian *et. al.*, 1999). The Samsa estimate is very similar to the current study's 1-year cost estimate of $27,330, but the current study is based on 2004 Medicare payments while theirs is calculated using 1991 data. The Samsa study estimated total average cost rather than marginal cost. In 1991 the average length of hospital stay after acute stroke was considerably longer than it was in 2004, resulting in inflated estimates when compared to current practice. Their estimates also used cost-to-charge ratio adjusted Medicare charges for all facility bills, rather than payments, which has an unknown effect on the costs incurred by Medicare. So while this is a good study on the cost of ischemic stroke using a comparable population the estimates provided by Samsa et. al. are no longer applicable to the current healthcare system and do not take into account the cost of the non-stroke care that surviving stroke patients are likely to incur even if they did not have a stroke.

The Samsa study exemplifies the inflated estimation of costs that result from reporting total healthcare cost instead of marginal cost of care, particularly in the group examined in this study. Older individuals tend to have significant healthcare costs outside of the particular major illness being studied, which make it essential to take into account other costs when estimating the costs attributable to a single disease.

In a more recent study by Brown et. al., epidemiological modeling was performed to estimate the cost burden of ischemic stroke from 2005 through 2050 (Brown, Boden-Albala *et. al.*, 2006). The authors suggest that they use marginal cost in their projections for hospital and nursing home expenditures; however, they reference the Samsa paper for these amounts which are not based on marginal cost. Also, the research published by Brown and colleagues is not population based, but is modeled by using previously published results from studies covering many different time periods, using different methodology. Furthermore, it is not clear if and how the authors adjust for inflationary trends which add to questions raised on the quality of their research estimates.

The use of total annualized healthcare expenditures to estimate the cost of a certain illness may also contribute to underestimation of certain portions of the cost attributable to specific healthcare services. For instance, within the 2004 stroke cohort, the proportion of total healthcare costs spent on rehabilitation services is 13.7%, as illustrated in Figure 6-1. However, if one uses the 2004 marginal costs of stroke and rehabilitation services due to stroke, the proportion of costs attributable to rehabilitation services is 29.3%. Since our goal is to specify costs of care that are specifically due to ischemic stroke, the marginal cost is the better method of estimation of these costs because they exclude the expected cost of non-stroke related healthcare that patients would have used if they did not have a stroke. Thus, as illustrated in Figure 6-1, the estimation of the proportion of dollars spent on rehabilitation care after stroke is undervalued by two-fold unless marginal cost estimation is used. This error can be found in the commonly referenced estimates by Taylor and colleagues, based on 1991 data, which state that 70% of first-year post-stroke costs are accounted for by inpatient hospital costs (Taylor, Davis *et. al.*, 1996). Not only is this proportional estimate based on total annualized healthcare costs, but it is also from a time period where hospital length of stay was considerably longer and therefore more expensive than what is true in healthcare today.

Figure 6-1. Proportion of the 1-Year Cost of Ischemic Stroke Spent on Rehabilitation Services



Ciolek and Hwang reported in 2006 that outpatient therapy services payments for rehabilitation totaled $4.07 billion in 2006 (Ciolek & Hwang, 2008). Of these PT accounted for 75%, OT for 18.4% and SLP 6.6% (Ciolek & Hwang, 2008). They observed that the relative proportion of services by therapy type was consistent with prior years. These estimates were based on data from 4,419,907 individuals for a mean expenditure per person $921 (Ciolek & Hwang, 2008) which corresponds closely to the findings for the per person annual expenditure of our 2004 control group of $1,084. The slightly higher number found in the 2004 control group could be due to the exclusion of individuals under 65 years of age which were not excluded in the Ciolek and Hwang report. The Ciolek and Hwang reported 2004 expenditures, provided in Figure 2 page 8 of the 2006 report indicates a mean expenditure of $1,000 per individual (Ciolek & Hwang, 2008).

The close correlation of the findings between Ciolek and Hwang and the current study indicate that the findings in this study have high external validity.

Based on stroke estimates from the current study, 1-year total healthcare cost to SC Medicare in 2004 of beneficiaries having ischemic stroke was $81,334,080 and total annualized 2004 SC Medicare rehabilitation costs due to ischemic stroke was $11,115,360 (Table 6-1). However, if quoting marginal rather than total cost, the annualized stroke-related healthcare costs to SC Medicare in 2004 were $26,944,704 (Table 6-1). This reflects a potential $54.4 million over-estimation of Medicare expenditures that were not due to ischemic stroke. Similarly, the marginal cost of stroke-related rehabilitation care in 2004 in SC Medicare patients having ischemic stroke was $7,889,376, resulting in a $3.2 million over-estimation if total rehabilitation costs are quoted (Table 6-1).

Table 6-1. Cost of Ischemic Stroke to Medicare in SC and the US

	2004 SC Stroke Costs	2012 Projected SC Stroke Costs	†2012 Projected US Stroke Costs	2004 SC Rehab-Related Stroke Costs	2012 Projected SC Rehab-Related Stroke Costs	2012 Projected US Rehab-Related Stroke Costs
Total Cost	$81.3 M	$109.5 M	$7,319.3 M	$11.1 M	$15.0 M	$1,000.3 M
Marginal Cost	$26.9 M	$36.3 M	$2,424.8 M	$7.9 M	$10.6 M	$710.0 M
Differential	$54.4 M	$73.2 M	$4,894.5 M	$3.2 M	$4.4 M	$290.0 M

* Cost estimates are based on costs and incidence rates using the 2004 Stroke Group from this study and are rounded to the nearest tenth of a million $US dollar
# The number of 2004 Medicare beneficiaries used to estimate SC costs to Medicare was taken from Kaiser Family Foundation State Health Facts website (www.statehealthfacts.org, accessed on 05/25/2012)
† 2012 $US dollars cost projections were calculated using 2004 estimates inflated by Consumer Price Index series CUUR0000SAM2 annual medical care services adjustment (Bureau of Labor Statistics)

When these 2004 SC Medicare stroke cost estimates are inflated using the Consumer Price Index for healthcare services to make 2012 dollar projections, 2012 SC Medicare annualized stroke-related healthcare and rehabilitation care costs would be over-estimated by $73.2 million and $4.34 million, respectively (Consumer Price Index, 2012) (Table 6-1). When SC stroke rates and costs estimated in this study are used to predict Medicare costs for all US ischemic stroke patients, 2012 total stroke costs are predicted to be $7.32 billion compared with 2012 marginal stroke-related healthcare costs of only $2.42 billion, resulting in an over-estimation of stroke-related expenditures of $4.89 billion (Table 6-1). Similarly, utilizing total cost instead of marginal cost figures to predict stroke-related rehabilitation care costs of 2012 Medicare beneficiaries would result in an over-estimate of $290 million (Table 6-1)..

There are many policy issues related to the use of inflated estimates for stroke. When it is generally felt that commonly quoted figures related to incidence rates, prevalence rates, proportional estimates of certain services and cost estimates are inflated, the public, including those in the research community, begin to become immune to the numbers. The research community may believe that it is okay to inflate cost estimates in order to help support arguments for increased funding. However this practice may negatively affect funding for other important research since there are limited dollars to support health-related research efforts. Furthermore, when advocacy and governmental groups quote these inflated estimates they lose credibility with the public and their ability to make good policy decisions are diminished.

For this reason it should be imperative for the research community to report reasonable findings so that funding agencies can properly designate research dollars in a balanced manner, commensurate with the degree to which the healthcare issue affects society. A good example of this is the lower funding for post-acute stroke rehabilitation research compared with acute stroke treatment due to the antiquated belief that hospital costs account for the largest percentage of stroke-related costs.

6.3 Limitations

There are several limitations in the analysis of SC Medicare claims data. There is an inherent limitation of using administrative claims to ascertain diagnoses and identify resource use and costs with complete accuracy, because these data are not purposely collected for clinical research but are collected for the distinct purpose of making healthcare payments. It is possible that signs or symptoms related to stroke may not have been captured in the claims, and that ischemic stroke patients not diagnosed with 434.xx and 436.xx ICD-9-CM codes under the primary diagnosis category would be missed by this analysis. Similarly, the measurement of rehabilitation and general resource use in these data depends on the design and implementation of the Medicare fee-for-service plan and its scope of coverage which may change over time. Medicare reimbursement rules and healthcare practice patterns that change over time may also make these 2004 based results less generalizable to current times. The use of SC estimates from this research may not be representative of stroke costs and rehabilitation utilization in other states and in the US since healthcare practice patterns and costs vary geographically. In addition, the interpretation of rehabilitation resource use and the assignment of associated costs are challenging.

Due to the lack of availability of clinical information in these claims data, the classification of rehabilitation was based on the inclusion of specific rehabilitation related codes in the ten diagnosis code and four procedure coding columns provided in the data files. Provider billing systems will often allow for a much longer list of these codes when interpreting medical records into billing data in the clinical setting. So it is reasonable to assume that some diagnoses or procedures related to stroke and rehabilitation would not be included in the Medicare data.

Clinical outcomes are not available in billing data and costs can be significantly influenced by clinical factors such as stroke severity. In response to this concern, we developed and used an un-validated coding-related stroke severity measure designed to mimic the NIH stroke scale in our multivariable analyses. Also, as becomes clear in aim 2 of this study, when using billing codes to identify rehabilitation resource use, the reason for such use is directly related to the index stroke. Stroke patients may also receive rehabilitation for other comorbidities which would then be erroneously counted as stroke-related unless being accounted for in a marginal use or cost analysis that uses a similarly distributed control group.

An additional challenge was presented by the way Medicare bills are aggregated in the data. Facility based bills, such as those listed in outpatient, home health, and skilled nursing files, do not provide line-item specific information. For example, a single bill from a skilled nursing facility can include one payment for all charges incurred over a 30-day period since Medicare's prospective payment system generally only reimburses these as a single allowable amount. So while this bill may have procedure and diagnosis codes that include rehabilitation services, the actual cost of that service is not differentiated within the payment amount. This differs with Part B provider bills which are coded on a line-item basis, so each bill will directly reflect the payment for the service that is specified in the procedure or diagnosis codes.

In addition, we intended to examine differences in payments for provider types (PT, OT, SLP) but had to abandon this analysis because ICD-9, CPT, and HCSPCS coding use in the data was too inconsistent to differentiate clearly between provider types (Appendix B). For example, the most commonly used CPT/HCSPCS code in the data, "97110 - Therapy Procedure", is used by both PT and OT professionals. The coding differentiation between provider types improved slightly between 1997 and 2004 but remained too general to allow for clear delineation between providers. In theory, modifier codes that designated the outpatient rehabilitation services practitioner, ("GO" for OT, "GP" for PT, and "GN" for SLP) were added by Medicare after the BBA 1997 and are required to be used for all outpatient rehabilitation services billing. However, fewer than 10% of bills containing rehabilitation codes actually included modifier designations in the better coded 2004 Stroke cohort (Appendix B). Thus, the use of these modifier codes is not well enough implemented to support the identification of the type of professional rehabilitation service provider. For that reason we primarily examined payments for rehabilitation using total rehabilitation services costs rather than provider specific costs.

Because the goal of the research conducted in aim 1 was to characterize the utilization and cost of rehabilitation in patients who might be affected by the caps implemented by the BBA of 1997, rehabilitation cost estimates are for ischemic stroke patients who survive their acute stroke hospitalization and who are identified as receiving any rehabilitation services outside of their initial hospitalization. For this reason, patients who died during the acute hospitalization or those not identified as receiving rehabilitation services in the year after stroke, were excluded. Had these patients been included in the cost analyses, the estimated Medicare costs may have differed.

Lastly, this study evaluated the burden of caring for stroke patients from the perspective of the Medicare system. Additional costs such as premiums, deductibles, co-insurance, self-paid items, prescription drugs, and indirect stroke-related expenses were not included in the cost estimates.

6.4 Future Directions and Opportunities

The first research aim of this study compares rehabilitation utilization and cost before and after the BBA of 1997 enacted caps on outpatient rehabilitation services. It provided strong evidence that the caps impacted the cost of rehabilitation services that are billed via Medicare Part B provider services, but that rehabilitation costs continue to rise when billed in facility settings. Furthermore, the current research shows that while the use of rehabilitation services after hospitalization for ischemic stroke continue to increase, contrary to current practice guidelines, greater than 50% of eligible Medicare patients do not receive rehabilitation services after their stroke. It will be important to examine the population who do not receive rehabilitation services for disparities in access to care. It will also be important for future research to examine what types of stroke impairment are most likely to result in clinician referral for post-stroke rehabilitation care.

The second aim of this study estimated the marginal cost of ischemic stroke in SC in the 2004 Medicare population over age 65. While healthcare costs for stroke patients were found to be significantly greater than in the matched controls, the marginal cost difference between the two was just under $10,000. This amount may be surprising in its relative smallness when compared to common estimates quoted in past research, but is largely due to the fact that the estimate is based on marginal cost difference and not on total healthcare dollars spent. Furthermore, the current studies stroke-related healthcare cost estimate is based on a comparison with the annual healthcare costs of an equally at-risk matched control group.

In order to generalize these findings, a similar study based on a national sample should be performed and also be undertaken using more recent data. An additional analysis should also be performed to update national and global lifetime cost of stroke estimates that would be valid to replace the 25 year old data estimates published by Taylor and colleagues (Taylor, Davis *et. al.*, 1996).

Another future direction for this research is to be able to link healthcare costs for stroke and rehabilitation with clinical outcomes using different post-acute treatment paradigms. Lastly, estimates of the marginal cost of other illnesses should be performed. Marginal cost of illness methodology is particularly important to use for chronic diseases. For example, in the case of diabetes, a chronic disease associated with a great deal of comorbidities over a long period of time, it is important to generate diabetes-related cost estimates compared with a well-matched control group to produce practical estimates of healthcare costs that are due to diabetes rather than other illness.

7 CONCLUSIONS

In the first part of this study, we used Medicare claims from patients with ischemic stroke in South Carolina in1997 and 2004 to examine two important health policy issues related to cost control and cost estimation. We explore the differences in the proportion of outpatient rehabilitation services cost that fall over the cap enacted in the Balance Budget Act of 1997. We then examined if the cap resulted in a reduction in expenditures for stroke prior to and after outpatient rehabilitation caps were enacted. Next we looked at the effect of using a total cost approach versus a marginal cost method to estimate the first year cost of stroke and stroke rehabilitation.

We found that the utilization of rehabilitation services after ischemic stroke rose sharply between 1997 and 2004. We also found that the BBA 1997 caps did constrain the proportion of individuals over the outpatient rehabilitation caps in 1997 versus 2004 and that costs of rehabilitation services were similarly constrained but only if these outcomes were examined using Medicare Part B provider bills, not when facility costs were also included.

Lastly, we found that using a marginal costing approach to estimate healthcare costs due to ischemic stroke was important in the Medicare population compared to using total average costing techniques, in order to accurately attribute healthcare costs to stroke. Indeed, the average total costing approach may be expected to inflate the estimated 2004 SC total cost due to stroke for Medicare patients by $3.6 billion, because this approach ascribes expenditures for comorbid conditions to stroke.

Healthcare policy makers should consider other approaches than capping for controlling costs, and be wary of burden of illness estimates that employ average total costs for patients who may be expected to have substantial comorbid disease.

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APPENDICES

Appendix A. Medicare Data Dictionary of Variables

Variable List		
#	Variable	Label
16	ADMD	Date of Admission
146	Adj_Sum_rehab_GEN_pmt	Total Rehab Payments adjusted to 2004 dollars, General
142	Adj_Sum_rehab_OT_pmt	Total Rehab Payments adjusted to 2004 dollars, OT
140	Adj_Sum_rehab_PT_pmt	Total Rehab Payments adjusted to 2004 dollars, PT
144	Adj_Sum_rehab_SLP_pmt	Total Rehab Payments adjusted to 2004 dollars, SLP
110	Adj_Total_Charges	Total Charges adjusted to 2004 dollars, Total
111	Adj_Total_Payments	Total Payments adjusted to 2004 dollars
150	Adj_Total_Rehab_Carrier_pmt	Total Rehab Payments adjusted to 2004 dollars, Carrier
148	Adj_Total_Rehab_pmt	Total Rehab Payments adjusted to 2004 dollars
122	Adj_rehab_pmt_amt_genCA	Total Rehab Payments adjusted to 2004 dollars, General Carrier
121	Adj_rehab_pmt_amt_otCA	Total Rehab Payments adjusted to 2004 dollars, OT Carrier
120	Adj_rehab_pmt_amt_ptCA	Total Rehab Payments adjusted to 2004 dollars, PT Carrier
119	Adj_rehab_pmt_amt_slpCA	Total Rehab Payments adjusted to 2004 dollars, SLP Carrier
31	Aphasia	Dichotomous variable 1=has Aphasia code in SDx, 0=no Aphasia code in SDx
152	Carrier_Over_Cap	Dichotomous indicator total rehab carrier charges over the cap, 1=yes, 0=no
128	CharAFib	Dichotomous variable 1=has Afib code , 0 otherwise
125	CharCHF	Dichotomous variable 1=has CHF code, 0 otherwise

Variable List		
#	Variable	Label
126	CharDiab	Dichotomous variable 1=has Diab code, 0 otherwise
127	CharMI	Dichotomous variable 1=has MI code, 0 otherwise
129	Charhichol	Dichotomous variable 1=has Hi Chol code
130	Charhypertens	Dichotomous variable 1=has Hypertension code, 0 otherwise
133	CharlsScore	Charlson Comorbidity Score
134	Cohort	Dichotomous variable 1=1997 group, 2=2004 Group
17	DISD	Date of Discharge
114	DME_zero	Indicator of Durable Medical Equipment payment of zero
12	DaysAlive_yearpoststroke	Continuous number of days alive in the year after stroke
15	DeathDate	Date of Death using middle of the month (15th) imputation
13	Died_yearpoststroke	Dichotomous variable 1=died in year post, 0= did not die in year post stroke
32	Dysarthria	Dichotomous variable 1=has Dysarthria SDx code, 0=no Dysarthria SDx code
33	Dysphagia	Dichotomous variable 1=has Dyphagia SDx code, 0=no Dysphagia SDx code
115	HH_zero	Indicator of Home Health payment of zero
34	Hemianopia	Dichotomous variable 1=has Hemianopia SDx code, 0=no Hemianopia SDx code
38	Hemiplegia	Dichotomous variable 1=has Hemiplegia SDx code, 0=no Hemiplegia SDx code
116	Hosp_zero	Indicator of Hospital payment of zero
20	Last_follow_date	Last date in study (either end of follow-up year or date of death)
37	MemLoss	Dichotomous variable 1=has Memory Loss code, 0=no Memory Loss code
118	NH_zero	Indicator of Nursing Home payment of zero

Variable List		
#	Variable	Label
36	Neglect	Dichotomous variable 1=has Neglect SDx code, 0=no Neglect SDx code
117	OP_zero	Indicator of Outpatient payment of zero
21	PDx	Primary Diagnosis Code (ICD-9_CM)
132	Prior_time_max	Number of maximum prior days available in 6 months before index date
22	SDIAG1	Secondary Diagnosis Code 1 (ICD-9_CM)
23	SDIAG2	Secondary Diagnosis Code 2 (ICD-9_CM)
24	SDIAG3	Secondary Diagnosis Code 3 (ICD-9_CM)
25	SDIAG4	Secondary Diagnosis Code 4 (ICD-9_CM)
26	SDIAG5	Secondary Diagnosis Code 5 (ICD-9_CM)
27	SDIAG6	Secondary Diagnosis Code 6 (ICD-9_CM)
28	SDIAG7	Secondary Diagnosis Code 7 (ICD-9_CM)
29	SDIAG8	Secondary Diagnosis Code 8 (ICD-9_CM)
30	SDIAG9	Secondary Diagnosis Code 9 (ICD-9_CM)
35	SensImp	Dichotomous variable 1=has Sensory Impairment code, 0=no Sensory Impaiment code
2	Stroke	Aim 2 group indicator variable, 1=stroke case, 0=control
39	Stroke_Severity	Categorical Stroke Severity Score
145	Sum_rehab_GEN_pmt	Total payments rehab, General
141	Sum_rehab_OT_pmt	Total payments rehab, OT
139	Sum_rehab_PT_pmt	Total payments rehab, PT
143	Sum_rehab_SLP_pmt	Total payments rehab, SLP
108	Total_Charges	Total charges over study time period
151	Total_Over_Cap	Dichotomous indicator total rehab charges over the cap, 1=yes, 0=no

Variable List		
#	Variable	Label
109	Total_Payments	Total payments over study time period
153	Total_Payments_1997	Total payments over study time period
149	Total_Rehab_Carrier_pmt	Total payments carrier files
147	Total_Rehab_pmt	Total payments rehab
3	age_group	Categorized Age Group
4	ageaprox	Continuous Age Approximation (set as central point of age group)
8	black	Indicator of black race
113	carrier_zero	Indicator of Carrier (Part B) payment of zero
11	dd	Categorized discharge disposition
9	deathind	Died during study, 1=yes, 0=no
135	expired_inhosp	Dichotomous indicator expired in hospital, 1=yes, 0=no
1	id	Study subject identifier code
18	los	Hospital Length of Stay
6	male	Indicator of male gender, 1=yes, 0=no
44	num_CA_bills	Number of bills, Carrier
59	num_DME_bills	Number of bills, DME
62	num_HH_bills	Number of bills, Home Health
95	num_NH_bills	Number of bills, Nursing Home
80	num_OP_bills	Number of bills, Outpatient
77	num_hosp_bills	Number of bills, hospital
137	num_rehab_CAbills	Number of rehab bills, Carrier
136	num_rehab_bills	Number of rehab bills
43	pmt_amt_CA	Payment amount, Carrier
58	pmt_amt_DME	Payment amount, DME
61	pmt_amt_HH	Payment amount, HH
94	pmt_amt_NH	Payment amount, NH

Variable List		
#	Variable	Label
79	pmt_amt_OP	Payment amount, OP
76	pmt_amt_hosp	Payment amount, Hospital
41	prior_hosp	Indicator of prior hospitalization, 1= yes 0=no
40	prior_stroke	Indicator of prior stroke, 1= yes 0=no
7	race	RACE
138	rehab	Indicator of any rehab, 1= yes 0=no
68	rehab_num_ICD571ptHH_bills	Number of rehab bills stemming from code 571, for PT HH
101	rehab_num_ICD571ptNH_bills	Number of rehab bills stemming from code 571, for PT NH
86	rehab_num_ICD571ptOP_bills	Number of rehab bills stemming from code 571, for PT OP
71	rehab_num_ICD572otHH_bills	Number of rehab bills stemming from code 571, for OT HH
104	rehab_num_ICD572otNH_bills	Number of rehab bills stemming from code 571, for OT NH
89	rehab_num_ICD572otOP_bills	Number of rehab bills stemming from code 571, for OT OP
74	rehab_num_ICD573slpHH_bills	Number of rehab bills stemming from code 571, for SLP HH
107	rehab_num_ICD573slpNH_bills	Number of rehab bills stemming from code 571, for SLP NH
92	rehab_num_ICD573slpOP_bills	Number of rehab bills stemming from code 571, for SLP OP
65	rehab_num_ICD57genHH_bills	Number of rehab bills stemming from code 571, for GEN HH
98	rehab_num_ICD57genNH_bills	Number of rehab bills stemming from code 571, for GEN NH
83	rehab_num_ICD57genOP_bills	Number of rehab bills stemming from code 571, for GEN OP
47	rehab_num_genCA_bills	Number of rehab Carrier bills, General
53	rehab_num_otCA_bills	Number of rehab Carrier bills, OT

Variable List		
#	Variable	Label
50	rehab_num_ptCA_bills	Number of rehab Carrier bills, PT
56	rehab_num_slpCA_bills	Number of rehab Carrier bills, SLP
67	rehab_pmt_amt_ICD571ptHH	CLM_PMT_AMT
100	rehab_pmt_amt_ICD571ptNH	CLM_PMT_AMT
85	rehab_pmt_amt_ICD571ptOP	CLM_PMT_AMT
70	rehab_pmt_amt_ICD572otHH	CLM_PMT_AMT
103	rehab_pmt_amt_ICD572otNH	CLM_PMT_AMT
88	rehab_pmt_amt_ICD572otOP	CLM_PMT_AMT
73	rehab_pmt_amt_ICD573slpHH	CLM_PMT_AMT
106	rehab_pmt_amt_ICD573slpNH	CLM_PMT_AMT
91	rehab_pmt_amt_ICD573slpOP	CLM_PMT_AMT
64	rehab_pmt_amt_ICD57genHH	CLM_PMT_AMT
97	rehab_pmt_amt_ICD57genNH	CLM_PMT_AMT
82	rehab_pmt_amt_ICD57genOP	CLM_PMT_AMT
46	rehab_pmt_amt_genCA	CLM_PMT_AMT
52	rehab_pmt_amt_otCA	CLM_PMT_AMT
49	rehab_pmt_amt_ptCA	CLM_PMT_AMT

Variable List		
#	Variable	Label
55	rehab_pmt_amt_slpCA	CLM_PMT_AMT
66	rehab_totchg_ICD571ptHH	CLM_TOT_CHRG_AMT
99	rehab_totchg_ICD571ptNH	CLM_TOT_CHRG_AMT
84	rehab_totchg_ICD571ptOP	CLM_TOT_CHRG_AMT
69	rehab_totchg_ICD572otHH	CLM_TOT_CHRG_AMT
102	rehab_totchg_ICD572otNH	CLM_TOT_CHRG_AMT
87	rehab_totchg_ICD572otOP	CLM_TOT_CHRG_AMT
72	rehab_totchg_ICD573slpHH	CLM_TOT_CHRG_AMT
105	rehab_totchg_ICD573slpNH	CLM_TOT_CHRG_AMT
90	rehab_totchg_ICD573slpOP	CLM_TOT_CHRG_AMT
63	rehab_totchg_ICD57genHH	CLM_TOT_CHRG_AMT
96	rehab_totchg_ICD57genNH	CLM_TOT_CHRG_AMT
81	rehab_totchg_ICD57genOP	CLM_TOT_CHRG_AMT
45	rehab_totchg_genCA	Total charges amount Carrier, General
51	rehab_totchg_otCA	Total charges amount Carrier, OT
48	rehab_totchg_ptCA	Total charges amount Carrier, PT
54	rehab_totchg_slpCA	Total charges amount Carrier, SLP
5	sex	Gender

Variable List		
#	Variable	Label
14	stroke_date	Date of Stroke or index date (for control subjects)
10	stroke_date04	Date of Stroke in 2004 (if any)
123	stroke_date97	Date of Stroke in 1997 (if any)
19	stus_cd	PTNT_DSCHRG_STUS_CD
42	totchg_CA	Total charges for carrier files
57	totchg_DME	totchg_DME
60	totchg_HH	CLM_TOT_CHRG_AMT
93	totchg_NH	CLM_TOT_CHRG_AMT
78	totchg_OP	CLM_TOT_CHRG_AMT
75	totchg_hosp	CLM_TOT_CHRG_AMT

Appendix B. Billing Codes used to Identify Rehabilitation Services

1997 HCPCS/CPT Rehabilitation Codes

PT or OT Codes (General)	
HCPCS/CPT	Description
95831	Massage
95851	Manual Therapy
97010	Supervised application of hot or cold packs
97012	Supervised application of traction
97014	Supervised application of electrical stimulation
97016	Supervised application of vasopneumatic devices
97018	Supervised application of paraffin bath
97020	Supervised application of microwave
97022	Supervised application of whirlpool
97024	Supervised application of diathermy
97026	Supervised application of infrared
97028	Supervised application of ultraviolet
97032	Application of electrical stimulation
97033	Application of iontophoresis
97034	Application of contrast baths
97035	Application of ultrasound
97036	Application of hubbard tank
97039	Application of unlisted modality
97110	Therapeutic procedure (15 mins)
97112	Neuromuscular reeducation
97113	Aquatic therapy
97116	Gait Training
97122	Traction
97124	Massage
97139	Unlisted therapeutic procedure
97150	Therapeutic Procedure (group)

97250	Myofascial release/soft tissue mobilization
97260	Manipulation
97261	Manipulation each additional area
97265	Joint mobilization
97504	Orthotics fitting and training
97520	Prosthetic training
97530	Therapeutic activities, direct
97535 (OT)	Self care/ home management training
97537 (OT)	Community/work re-intergration
97542	Wheelchair management
97545	Work hardening/conditioning (initial 2 hrs)
97546	Work hardening/conditioning (additional 1 hr)
97703	Checkout for orthotic/prosthetic use
97750	Physical performance test or measurement
97770	Development of cognitive skills
97799	Unlisted physical medicine/rehabilitation service

SLP Codes	
HCPCS/CPT	Description
92506	Evaluation for speech, language, voice, communication, etc.
92507	Treatment of speech, language, voice, communication, etc.
92508	Treatment of speech, language, voice, communication, etc. (group)
92525	Evaluation of swallowing and oral function for feeding
92526	Treatment of swallowing dysfunction and/or oral function for feeding

1997 and 2004 ICD-9-CM Therapy Services Codes

Code	Description
General Codes	
V57	Code Group: Care involving use of rehabilitation procedures
V57.0x	Breathing Exercises
V57.4	Orthoptic training
V57.8x	Other specified rehabilitation procedure
V57.9	Unspecified rehabilitation procedure
PT Codes	
V57.1	Physical therapy
OT Codes	
V57.2x	Occupational therapy and vocational rehabilitation
SLP Codes	
V57.3	Speech-language therapy

2004 Outpatient Provider HCPCS Codes with PT modifier

HCPCS /CPT	Frequency	Description
95831	1	Muscle Testing
95851	5	Range of Motion Measure
97001	75	PT Evaluation
97002	19	PT Re-evaluation
97003	4	OT Evaluation
97010	6	Hot/Cold Packs
97012	63	Traction
97022	3	Whirlpool
97024	1	Diathermy
97032	155	Electrical Stimulation
97033	11	Iontophoresis
97035	124	Ultrasound
97036	1	Hubbard Tank
97110	1163	Therapy Procedure
97112	217	Neuromuscular Re-education
97116	82	Gait Training
97124	30	Massage
97140	102	Manual Therapy
97150	45	Therapy Procedure (Group)
97530	206	Therapy Activities
97535	36	Activity of Daily Living Training
97542	2	Wheelchair Management
97750	9	Physical Performance Test
G0283	10	Electrical Stimulation
Total	2370	

2004 Coded as PT without Modifier Code

HCPCS/CPT	Description
97001	PT Evaluation
97002	PT Re-Evaluation
97110	Therapy Procedure
97112	Neuromuscular Re-education
97116	Gait Training

2004 Outpatient HCPCS Codes with OT Modifier Code

HCPCS/CPT	Frequency	Description
97003	17	OT Evaluation
97004	3	OT Re-Evaluation
97010	3	Hot/Cold Packs
97032	4	Electrical Stimulation
97033	14	Iontophoresis
97035	7	Ultrasound
97110	114	Therapy Procedure
97112	47	Neuromuscular Re-education
97140	11	Manual Therapy
97150	1	Therapy Procedure (Group)
97530	33	Therapy Activities
97533	3	Sensory Integrative Techniques
97535	19	Activities of Daily Living Training
A4556	1	Electrodes
G0283	25	Electrical Stimulation
Total	302	

2004 Coded as OT without Modifier Code

HCPCS/CPT	Description
97003	OT Evaluation
97004	OT Re-Evaluation
G0129	Occupational therapy services (per day)
G0152	Services of an OT in home health or hospice (15 mins)
G0158	Services of an OT in home health or hospice (15 mins)
G0160	Services performed by an OT in maintenance prog. (15 mins)
S9129	OT, in the home, per diem

2004 Coded as PT or OT without Modifier Code (General)

HCPCS/CPT	Description
97124	Massage
97140	Manual Therapy
97150	Therapy Procedure (Group)
97530	Therapy Activities
97532	Cognitive skills development
97533	Sensory Integrative Techniques
97535	Activities of Daily Living Training
97537	Work Reintegration Training
97542	Wheelchair Management
97545	Work conditioning or hardening (initial 2 hrs)
97546	Work conditioning or hardening (additional 1 hr)

2004 Outpatient HCPCS Codes with SLP Modifier Code

HCPCS /CPT	Frequency	Code Meaning
92506	1	Evaluation SLP
92610	1	Evaluation Swallowing
92612	1	Flex Scope Swallowing
96115	8	Neurobehavioral Status Exam
Total	11	

2004 Coded as SLP without Modifier Code

HCPCS/CPT	Description
92506	Evaluation SLP
92507	Treatment of speech, lang., voice, comm., or aud. disorder
92508	Treatment of speech, lang., voice, comm., or aud. Disorder (group)
92526	Treatment of swallowing dysfunction
92610	Evaluation Swallowing
92612	Flex Scope Swallowing
92626	Evaluation of auditory rehabilitation status (1 hr)
92627	Evaluation of auditory rehabilitation status (15 mins)