Understanding Stroke

in West Virginia

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April 2004

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EXECUTIVE SUMMARY

General Facts

- Cerebrovascular disease, or stroke, is the third leading cause of death in the United States and the fourth leading cause of death in West Virginia.

- The American Heart Association estimates that more than 700,000 Americans suffer a stroke each year. A stroke death occurs every three minutes.

- Demographic risk factors for stroke include older age, especially for women, being an African-American, having a lower socioeconomic status, and having a family history of stroke.

- Other risk factors for stroke include hypertension, cardiac disorders, cigarette smoking, obesity, physical inactivity, elevated blood cholesterol and homocysteine levels, diabetes, binge drinking, diets lacking in adequate fruit and vegetable consumption, sickle cell anemia, sleep apnea, cocaine and amphetamine use, inflammation, stress, and anger.

- It is estimated that the economic costs of stroke in the United States in 2004 will be $53.8 billion. Two-thirds of this comprises direct health care costs such as hospital and nursing home care, physicians, drugs, and home health care and other medical durables. The remainder consists of indirect costs such as lost productivity due to morbidity and mortality.

West Virginia Statistics

Stroke Risk Factors

- One-third (33%) of adult West Virginians reported that they had high blood pressure in 2001, continuing an upward trend in this risk factor since 1992.

- Twenty-eight percent (28%) of adults in West Virginia reported that they were current smokers in 2002; however, youth smoking in the state decreased by 20% between 1999 and 2002.

- West Virginia had the highest prevalence of obesity in the nation (28%) in 2002; in 2001 the state ranked first in the percentage of adults who had been told their cholesterol was high (38%).

- In 2002, West Virginia was second only to Puerto Rico in the prevalence of diabetes (10%) among adults. Twenty-four percent (24%) of adult West Virginians reported no leisure-time physical activity, the continuation of a downward trend in this risk factor since a high of 45% was reported in 1994.

Stroke Hospitalizations

- There were 5,783 hospitalizations of West Virginia residents in West Virginia hospitals in 2001 that were due to stroke; women accounted for 62% of these.

- West Virginia's overall rate of 32.1 hospitalizations per 10,000 population in 2001 was higher than the national rate of 27.1. Both men and women were hospitalized for stroke at higher rates than in the nation as a whole.

- Total charges for in-patient hospitalizations for stroke have increased steadily since 1997, from $35 million in that year to $49 million in 2001.

Stroke Mortality

- There were 1,262 deaths from stroke in West Virginia in 2001, 482 men and 780 women. While stroke is the fourth leading cause of death among men, it is the third leading cause of death among women in West Virginia.

- West Virginia's 2001 age-adjusted rate of 59.8 deaths per 100,000 population was slightly higher than the United States age-adjusted rate of 57.9.

- The 2001 age-adjusted rate of stroke mortality among African-Americans in West Virginia was 74.4 deaths per 100,000, compared with a rate of 59.9 among the state's white population.

- Nearly one-fourth (23%) of stroke deaths among African-Americans in West Virginia in 2001 occurred prematurely, or before the age of 65; among whites, only 10% of stroke deaths were premature.

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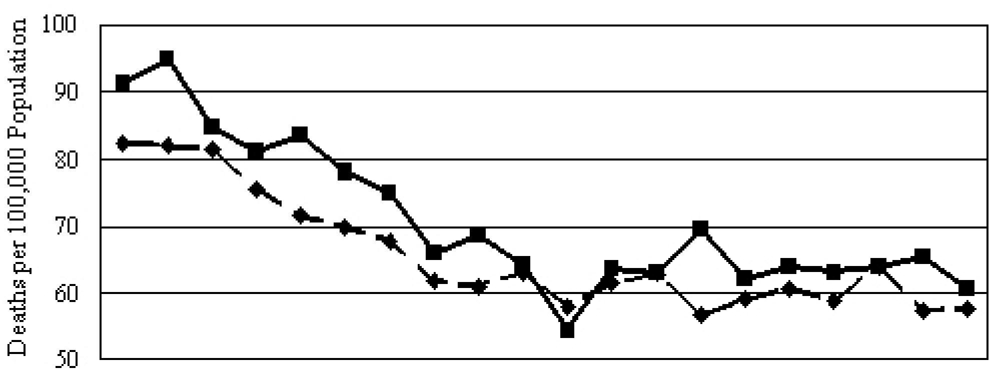
STROKE: AN OVERVIEW

It is estimated that more than 700,000 Americans suffer a cerebrovascular event, or stroke, each year. Approximately 500,000 of these are first strokes, and 200,000 are recurrent attacks. On average, someone suffers a stroke every 45 seconds, and a stroke death occurs every 3.1 minutes (1). According to American Heart Association data, approximately 4,700,000 stroke survivors are alive in the United States today (2). Stroke is the leading cause of adult disability in the United States and the third leading cause of death nationwide. In West Virginia, stroke ranks as the fourth leading cause of death, after heart disease, cancer, and chronic lower respiratory disease; between 1,200 and 1,300 people die from stroke each year in the state.

> In West Virginia, between 1,200 and 1,300 people die from stroke each year; of these, about 62% are women.

Death rates from stroke declined markedly in the 1970s and 1980s in both the state and the country as a whole; however, this decline leveled off in the 1990s (3). Figure 1 illustrates the latter part of this trend, showing 20 years of stroke mortality rates in West Virginia among men and women. Rates among both men and women decreased in the state rather consistently until 1992, after which slight increases occurred.

Figure 1. Age-adjusted Mortality Rates* for Cerebrovascular Disease by Sex
West Virginia, 1982-2001



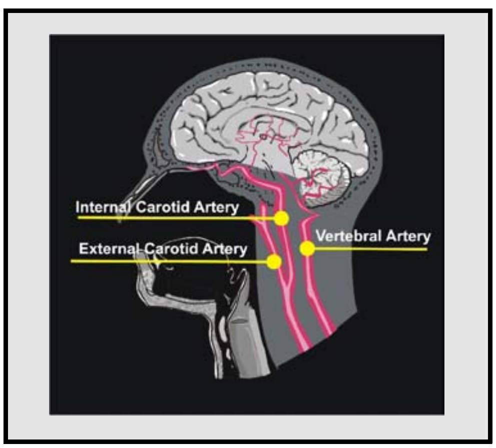
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
■ Male	91.4	94.8	84.9	81.	83.	78.	74.9	66	68.8	64.4	54.6	63.8	63.	69.	62.3	63.9	63.	63.9	65.4	60.6
◆ Female	82.	82	81.5	75.6	71.6	69.9	67.9	61.8	61.	63.	58.	61.	62.9	56.8	59.	60.8	58.8	64	57.4	57.6

Even though the mortality rate for stroke declined 12.3% from 1990 to 2000 in the United States, the actual number of stroke deaths rose nearly 10% (2) and stroke-related hospitalizations increased 19% (4). National projections for stroke mortality are bleak. A study funded by the National Institutes of Health (NIH) and published in *Stroke: Journal of the American Heart Association* (*Stroke*) in 2003 projected stroke deaths through 2032 (5). The analysis predicted that total stroke mortality in the United States would nearly double (an increase of 98%) over the next 30 years if reductions in stroke risk factors, especially among high-risk populations, are not achieved. The increase in stroke mortality is predicted to be highest among African-Americans (134%) and nonwhite, nonblack races (221%).

BRAIN ATTACK

Also known as a cerebrovascular accident (CVA) or a "brain attack," a stroke occurs when there is an interruption to or disruption in the blood flow to the brain. The brain accounts for about 2% of a person's total body weight; however, it continuously receives about 20% of the blood flowing through the body. Since the brain controls all of the body's actions, this blood flow is vital to provide a constant supply of oxygen and other nutrients to the brain cells. The reduced blood flow from a stroke causes a lack of oxygen and nutrients to the cells, and they begin to die. Once dead, brain cells cannot be revitalized or regrown.

There are four main blood supplies to the brain, the **carotid arteries** and the **vertebral arteries**. The carotid artery splits into external and internal arteries near the top of the neck, with the external carotid supplying blood to the face and neck and the internal carotid going into the skull. Within the skull, the internal carotid branches into two large arteries (the anterior cerebral and middle cerebral arteries) and several smaller arteries. Together these arteries supply blood to the front two-thirds of the brain.



The vertebral arteries travel up to the brain on either side of the spinal column and join to form the basilar artery near the brain stem at the base of the skull. The vertebral-basilar system supplies blood to the cerebellum and the brain stem before branching into two posterior cerebral arteries; these supply blood to the back third of the brain.

The fact that there are only four main blood supplies to the brain makes it crucial that these arteries are healthy. Any blockages or weaknesses in an artery can result in a stroke, leading to major brain damage or even death.

TYPES OF STROKE

There are two major types of stroke: **ischemic stroke** and **hemorrhagic stroke**. Ischemic strokes account for approximately 88% of total strokes (1) and occur when blood flow is stopped or reduced due to an obstruction in an artery. Hemorrhagic stroke, less frequent but the deadlier of the two types, occurs when a blood vessel ruptures or leaks and there is bleeding into or around the brain. Ischemic strokes are usually caused by either a **cerebral thrombosis**, which happens when a blood clot or plaque build-up forms in an artery bringing blood to the brain, blocking the blood flow, or the more deadly **cerebral embolism**, which occurs when a blood clot that has formed in another part of the body (usually the heart) has broken free and become lodged in an artery leading to the brain.

The two most common types of hemorrhages in the brain are (1) **intracerebral hemorrhage (ICH)**, when a blood vessel ruptures and bleeds within the brain itself, and (2) **subarachnoid hemorrhage (SAH)**, which occurs when a blood vessel ruptures on the surface of the brain, between the inner and middle layers of the tissue covering the brain. Intracerebral hemorrhage accounts for about 9% of all strokes (1) and is more common than subarachnoid hemorrhage among people over the age of 60. SAH accounts for the remaining 3% of all strokes (1).

A **transient ischemic attack** (TIA), also known as a "little stroke" or mini-stroke, occurs when there is a short-lived interruption of blood flow to the brain. Approximately 80% of TIAs are caused by a blockage in an artery, either a blood clot or plaque (6). The remaining 20% of TIAs are the result of minor bleeding in the brain due to a leaking aneurysm or vascular malformation. TIAs generally last less than an hour and do not result in permanent brain damage; they can be followed by a major stroke, however, if the cause is not treated, so should be considered a warning of potential serious illness.

TEMPORAL AND SEASONAL VARIATION IN STROKE

Researchers used data from the Framingham Heart Study, a 40-year period of surveillance, to ascertain seasonal and temporal patterns of initial strokes among that cohort of 5,070 people (7). Their results indicated a significant association between winter and cerebral embolic strokes among women but not among men. No such association was found for hemorrhagic stroke. The most frequent day for stroke occurrence was Monday for intracerebral hemorrhage among both men and women. For subarachnoid hemorrhage, Sunday and Monday were significantly more frequent for men and Friday and Saturday for women. The morning hours (8:00 AM to noon) were more likely to be associated with all stroke subtypes.

Data from the Finnish Stroke Register from 1982-92 (15,449 stroke events) were analyzed for seasonal influence; the findings showed a 12% greater incidence of ischemic stroke among men and 11% greater incidence among women in winter than in summer (8). For intracerebral hemorrhage, there was a 28% greater likelihood and 33% greater likelihood of occurrence during winter than during summer. No significant differences by season were found for subarachnoid hemorrhage.

Oberg et al. examined data involving 72,779 veterans hospitalized for stroke at any Veterans Affairs hospital from 1986-95 (9). They found that the peak occurrence of ischemic stroke among this male population was in mid-May, even after controlling for region (i.e., climate) and race. No seasonal effect was found for hemorrhagic stroke.

STROKE OCCURRENCE

SYMPTOMS OF STROKE

The symptoms of stroke depend on what part of the brain is affected and how large an area is involved. A stroke is a sudden event accompanied by one or more of the following signs:

- Numbness or weakness, especially on one side of the body
- Loss of consciousness or altered consciousness
- Decreased vision in one or both eyes
- Language difficulties, either in speaking or understanding
- Difficulty walking; loss of balance or coordination
- Confusion or loss of memory
- Swallowing difficulties
- Paralysis of any body area, including face
- Sudden, severe headache with no known cause
- Neck pain
- Nausea and vomiting

Time is critical in the treatment of stroke; it is therefore important that individuals recognize its symptoms. A large population-based telephone survey conducted in Cincinnati in 1995, however, found large gaps in the public's knowledge about stroke (10). When asked to list the most common stroke warning signs, only 57% correctly listed at least one sign; of these 28% correctly listed two or more signs, and only 8% listed three or more signs. Sixty percent (60%) of respondents younger than 75 correctly listed at least one sign, compared with only 47% of older respondents.

STROKE TESTS

When a patient presents at the emergency room with a suspected stroke, there are several tests available to the doctor to determine the type, location, and severity of the event. Testing depends on the doctor's assessment of the patient and is done on a case-by-case basis. Available tests include:

- Head CT or head MRI – Used to determine if a stroke has occurred and, if so, what type, i.e., ischemic or hemorrhagic. Can define the location and extent of the stroke and determine if there have been previous strokes.

- Angiography – Radiographic imaging with dye injected directly into an artery. Can show narrowing of the vessel and detect the location and size of aneurysms and vascular malformations.

- Doppler ultrasound/carotid duplex imaging – Use of high-frequency sound waves to detect blockages in the carotid arteries.

- ECG (electrocardiogram) or echocardiogram – may be used to diagnose underlying heart disease or if a cardiac embolus is suspected.

STROKE TREATMENT

Ischemic Stroke

A person coming to the hospital with stroke symptoms will normally be given a CT scan to determine is he or she has had an ischemic or hemorrhagic stroke. If an ischemic stroke is detected, the standard treatment is the intravenous (IV) administration of a clot-busting (thrombolytic) medication such as t-PA (tissue plasminogen activator). T-PA, however, must be administered within three hours of a stroke onset, necessitating that the patient go to the hospital at the first signs of a stroke event. Data from the National Institute of Neurological Disorders and Stroke (NINDS) indicate that patients treated with t-PA within the three-hour window were at least 33% more likely than untreated patients to recover with little or no disability (11). The NINDS study showed that the average length of stay was shorter (10.9 days) for t-PA treated patients than for nontreated patients (12.4 days); t-PA treated patients were also more likely than others to return home following discharge rather than to a rehabilitation center or nursing home (12). It is estimated, however, that only about 2% of stroke sufferers, however, get to the hospital in time for t-PA therapy and qualify as candidates for t-PA (13).

The most serious risk associated with IV t-PA is bleeding. An estimated 25% of patients will experience some bleeding (14), mostly minor (such as gum or nose bleeding). The NINDS study found that 6.4% of patients suffered bleeding in the brain (15). Other published studies have found both lower percentages and higher percentages of bleeding in the brain, for example, 3.3% in the FDA-mandated Standard Treatment with Alteplase [t-PA] to Reverse Stroke (STARS) Study and 15.7% in a 1997-98 study of two major Cleveland hospitals (15). Because of the risk of bleeding, not all patients can receive t-PA; some of the contraindications include history of intracranial bleeding, major surgery within the past 14 days, serious head trauma, dental extractions within seven days, and pregnancy. Other thrombolytic agents are currently under investigation that might have fewer contraindications than t-PA.

Intra-arterial (IA) administration of t-PA involves the delivery of the drug directly into the clot or the region surrounding the clot through the insertion of a catheter into the affected artery. Intra-arterial therapy has been shown in clinical trials to be more effective in treating intracranial blockages than IV treatment and lengthens the window for treatment to six hours (16); however, because of the specialized resources (i.e., equipment and physician expertise in stroke and neurointervention techniques) necessary to perform the procedure, it is limited in its availability. Until the procedure receives FDA approval, it is primarily confined to clinical trials and large stroke centers.

Research into mechanical clot retrieval is also ongoing; one such device, the MERCI retriever (mechanical embolus removal in cerebral ischemia) is undergoing testing for FDA approval (17). The device is inserted into a leg artery in a catheter tube and threaded up to the brain and the clot. Inside the tube is a wire that coils into a corkscrew shape when pushed out. The wire grips the clot; at the same time a tiny balloon is inflated to stop blood flow and avoid a second stroke should pieces break off the clot. The clot is then sucked into the tube and removed. Scientists see several benefits to mechanical clot retrieval, including avoiding the risk of drug-induced bleeding, extending the window of treatment to eight hours, and a faster treatment time.

Another area of treatment currently under investigation is the use of neuroprotective drugs. The initial damage during an ischemic stroke takes place in what is called the "ischemic core," where blood flow is 20% or less and cells face irreversible damage within minutes. Surrounding the core is an area of brain tissue called the "ischemic penumbra," where blood flow is between 20 to 50% of normal. These cells are endangered but not yet irreversibly damaged. Some neuroprotective drugs are designed to limit damage to cells in the penumbra, others to prevent potential damage associated with the return of blood flow after the thrombus has been dissolved following IV or IA clot-busting treatment. These drugs are currently in clinical trials to determine their safety and efficacy.

Current research on other stroke therapies ranges from the development of a stroke vaccine for at-risk individuals to minimize the extent of damage should a stroke occur (18) to a neural implant trial under way at the University of Pittsburgh's Medical College, where scientists are investigating the possibility of injecting laboratory-grown nerve cells into the stroke patient's brain in the hope the cells would multiply, allowing patients to regain lost functions (19). Additional projects include the NIH's Institute for Neurological Disease and Stroke "Neuroprotheses Project" examining the use of electronics as "neural bridges" (20).

Hemorrhagic Stroke

If a CT or MRI scan has detected bleeding in or around the brain itself, i.e., a hemorrhagic stroke, immediate treatment is also imperative. Both cerebral and subarachnoid hemorrhages can be more deadly than ischemic strokes. The causes of a hemorrhagic stroke include hypertension, a ruptured or leaking aneurysm, a leaking vascular malformation, or anticoagulation medication.

For patients with anticoagulation-induced bleeding, those medications are immediately stopped, and protamine, vitamin K, or fresh frozen plasma may be given to reduce bleeding. Ruptured aneurysms or arteriovenous malformations are generally treated surgically by the use of detachable microcoils or by microsurgical clipping. Microsurgical clipping is the more well-established and longer-used technique. It involves performing a craniotomy, locating the aneurysm and clipping the base to stop blood from entering the aneurysm. Microcoils use an endovascular technique, during which a catheter is threaded into the affected artery using a cerebral angiogram to guide its path. The catheter contains tiny platinum coils that are released into the aneurysm, inducing clotting to prevent further bleeding. The technique used depends upon the assessment of the patient's medical team.

STROKE EFFECTS

The effects of a stroke vary widely depending on the type of stroke, the part of the brain affected, and the severity or extent of the stroke. Stroke injury can affect vision, motor activity, sensory levels, speech, chewing and swallowing food, thinking, and emotions. **Paralysis** or weakness on one side of the body may occur. **Aphasia** is the impairment of language ability, i.e, to talk, comprehend, read, or write, and most commonly occurs when injury is on the left side of the brain. **Dysarthria** is a condition in which the muscles used in speech are affected, causing slurring or slowed speech**. Dysphagia**, or difficulty in swallowing, occurs in about 45% of victims of acute stroke (21). **Memory loss** can affect both short- and long-term memories, making even simple daily activities confusing and frustrating to carry out. **Emotional lability** refers to the sudden and extreme mood swings that can follow a stroke. **Depression** is common among stroke victims; in fact, depression was found by Ramasubbu et al. to be the only treatable condition independently associated with limitations in physical functioning (22). It has also been shown to increase the risk of death from stroke (22), underlying the need to effectively treat depression soon after stroke to optimize rehabilitation potential. A Danish study of 1,197 stroke patients published in *Neurology Reviews* in 2003 reported that one-third of those patients developed **dementia** within three months of their stroke (23). Researchers found that older age, hypertension, and recurrent stroke to be the most significant risk factors for predicting dementia after stroke.

There are several scales that are used to quantify the degree of disability caused by a stroke, including the Modified Rankin Scale, the Barthel Activities of Daily Living Scale, the NIH Stroke Scale, and the Hunt and Hess Classification of Subarachnoid Hemorrhage, to name only a few. These scales are used to evaluate the patient following an acute stroke. The measurement of neurological dysfunction permitted by these assessment tools is useful in predicting stroke outcome, that is, the degree of recovery that can be expected, and determine interventions and treatment.

Stroke recovery is seldom complete; researchers estimate that approximately 40% of patients who are able to return home need some help in everyday living (24). Most survivors of a first ischemic stroke who receive rehabilitation services return home (84%) but few are able to return to work (25, 26). Kelly-Hayes et al. used Framingham Heart Study data to assess disability in ischemic stroke survivors at six months following their strokes (27). Results showed that 43% of all elderly (aged 65 and older) survivors had moderate to severe neurological deficits, with women more disabled than men. When the researchers controlled for age and stroke subtype, however, they found that it was older age that accounted for the severity of the disability, and women are more likely to be older when they suffer a stroke. The Framingham data showed that, at six months post-stroke, 50% of survivors had some one-sided paralysis, 26% were dependent in activities of daily living, 30% were unable to walk unassisted, 35% were depressed, 19% had aphasia, and 26% were in a nursing home.

STROKE REHABILITATION

The majority of gains in a stroke sufferer's ability to function that occur within the first 30 days following the stroke are due to spontaneous recovery (28). Additional gains are often achieved, however, through rehabilitation. Successful rehabilitation depends on several factors including the extent of injury to the brain, the survivor's attitude, the skill of the rehabilitation team, and the support of family and friends.

The goal of rehabilitation is to allow the stroke survivor to be as independent as possible, overcoming or mitigating disability due to stroke damage. **Physical therapy** is usually an important component of rehabilitation. Relearning daily activities such as eating, dressing, and bathing, is often accomplished through **occupational therapy**. **Speech therapy** can help patients with aphasia to overcome problems understanding or forming speech.

STROKE RISK FACTORS

Strokes tend to occur with equal frequency among both men and women; data from the 2002 Behavioral Risk Factor Surveillance System (BRFSS)[1] indicated that 3.1% of West Virginia adults, or an estimated 43,419 individuals, had been told by a doctor that they had suffered a stroke, 3.1% of women and 3.2% of men. Women, however, are more likely than men to die from stroke. In 2001, women accounted for 61% of total stroke deaths in the United States. In West Virginia, a total of 1,262 people died of stroke in 2001, 780 or 62% of whom were women. Among women only, stroke was the third leading cause of death in the state.

> In 2001, 1,262 West Virginians died of stroke; 62% were women. Among women, stroke was the third leading cause of death in the state.

The risk of stroke increases with age; in fact, age is the single most important risk factor for stroke. BRFSS data showed a range of reported stroke from 2.7% of respondents aged 45-54 to 5.1% of those aged 55-64 to a high of 9.1% among those aged 65 and older. In the United States in 2001, three-quarters (74.5%) of all stroke deaths occurred among people age 75 and older, while 88% occurred among those aged 65 and older. In West Virginia, 90% of all stroke deaths were among residents aged 65 and over.

Statistics show that the risk of stroke more than doubles in each successive decade after 55 years of age (30). Women are less likely than men to suffer a stroke before the age of 65, at which time the gap closes. While strokes are less common among younger people, they still occur. According to some sources, about 28% of all stroke victims are under the age of 65 (31); younger victims are more likely to survive a stroke, although they are often left disabled. In West Virginia, 11.9% of men and 18.2% of women who reported a stroke had their first stroke before the age of 55 (29). Strokes also occur, although rarely, among children. Pediatric strokes happen more frequently among boys than girls and twice as often among African-American children as among white children (32). Boys are also more likely to die from a stroke than are girls.

> In West Virginia, 12% of men and 18% of women who have had a stroke had their first stroke before the age of 55.

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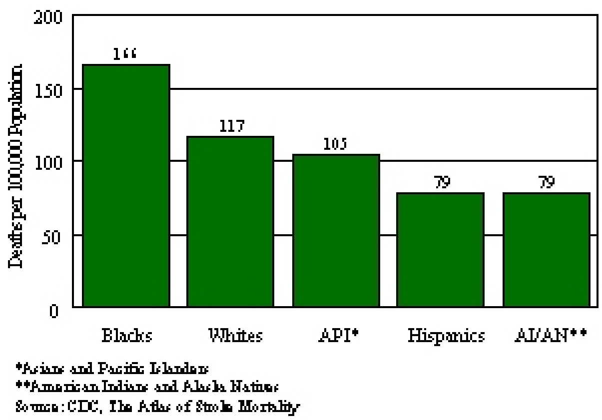
[1]The BRFSS is a monthly telephone survey established by the Centers for Disease Prevention and Control (CDC) that allows states to monitor health behaviors among their adult populations (18+). The BRFSS was begun in 1984 with 15 participating states, expanding to 54 states and territories in 2001. The prevalence of stroke occurrence was measured in West Virginia in 2000 and 2002. The West Virginia Bureau for Public Health publishes annual reports on the BRFSS survey results, which were used extensively in the preparation of this document (29).

The male-to-female mortality ratio differs by age and type of stroke. Mortality rates for both ischemic and hemorrhagic stroke are lower for women than for men under the age of 65 but higher for ischemic stroke among women aged 65 and older (33). Death rates for intracerebral hemorrhagic stroke are similar for men and women, but women have a higher risk of death from subarachnoid hemorrhage, a differential that increases with age. The survival ratio also differs by sex; because of their longer life expectancy, women make up more than half of the stroke survivors in the United States.

Stroke is a particularly serious problem among African-Americans, who have dramatically higher death rates from stroke than other racial and ethnic groups. In fact, of the three leading causes of death in the United States – heart disease, cancer, and stroke – the disparity is greatest for stroke (34). According to CDC's *Atlas of Stroke Mortality*, whose researchers examined 1991-1998 data for persons aged 35 and older, African-Americans had the highest rates of mortality, followed by whites, Asians and Pacific Islanders, Hispanics, and American Indians and Alaska Natives (35) (Figure 2). A study published in the January 2003 *Neurology* reported that elderly blacks (aged 65+) were 6% more likely to die within three years after a stroke than were elderly whites (36). Premature stroke deaths are also more likely among African-Americans. Research published in the *Morbidity and Mortality Weekly* in 2000 found that the relative risk of stroke among African-Americans compared with non-Hispanic whites is *four times higher at ages 35-54, three times higher at ages 55-64, and nearly twice as high at ages 65-74* (37).

Figure 2. Stroke Mortality Rates (Ages 35+) by Racial and Ethnic Grc
United States, 1991-1998



Numerous studies have shown an inverse relationship between stroke mortality and socioeconomic status, especially among African-Americans (38, 39). A 1998 study examined the frequent assumption that these differences are in fact due to the increased likelihood of unhealthy behaviors among lower SES groups. Lantz et al., using a nationally representative sample of 3,617 adults in the Americans' Changing Lives survey, investigated the degree to which cigarette smoking, alcohol use, sedentary lifestyle, and obesity (all risk factors for stroke) affected the association between all-cause mortality and low-income status. Their findings showed that these behaviors explained no more than 12 to 13% of the effect of income on mortality (40), indicating the need for further examination of the impact of lower socioeconomic status on stroke morbidity and mortality.

There is much evidence to support the hypothesis that the chance of stroke is greater among persons who have a **family history** of stroke, suggesting a genetic predisposition. A Danish study of twins with long-term follow-up found an increased risk of stroke among monozygotic pairs of twins (41). Researchers with the Family Heart Study (supported by the National Heart, Lung, and Blood Institute) assessed the personal and familial histories of stroke in 3,168 individuals. Their findings showed a significant association of increased risk of stroke with parental history, especially on the father's side (42). Stroke among younger persons (aged 65 or less) was found to significantly correlate with familial history by British scientists, both for large vessel disease (odds ratio [OR]=2.93, 95% CI:1.68 to 5.13) and small-vessel disease (OR=3.15, 95% CI:1.81 to 5.50) (43); however, no correlation with cardioembolic stroke was found.

Researchers worldwide are studying the genetic basis for stroke, in agreement that it is likely to be multigenic and influenced by environmental factors. In 2003, Icelandic researchers with the company deCode Genetics identified a specific gene (PDE4D) associated with ischemic stroke, finding that those who have the stroke-susceptibility gene have a three to five times greater chance of having an ischemic stoke (44). The preliminary results of a population-based study conducted by researchers in the United States suggest a significant association between the presence of an apolipoprotein E4 or E2 allele and the risk of hemorrhagic stroke (45). A genetic abnormality that affects the body's processing of cholesterol has recently been found to increase the risk of stroke among adults younger than 45. The abnormality in the PON1 gene was found in a study at the Whitaker Cardiovascular Institute at the Boston University School of Medicine; overall in the study population, the presence of the genetic abnormality was the second most potent risk factor for stroke, following hypertension (46).

OTHER STROKE RISK FACTORS

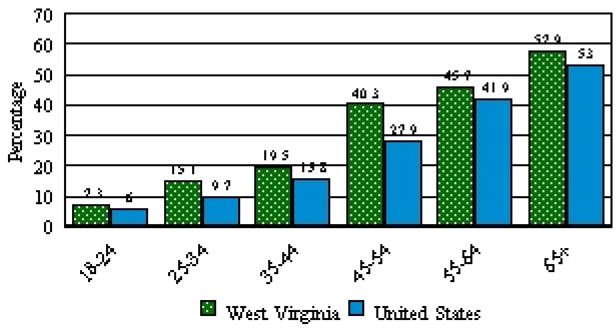
While an individual's sex, age, racial/ethnic group, family history, and socioeconomic status are viewed as nonmodifiable risks for stroke, there are numerous other risk factors that are amenable to change. There are also risk factors, such as heart disease and certain blood disorders, for which the potential risk can be decreased through careful monitoring and changes in one's lifestyle. The most widely recognized of these risk factors for stroke are discussed below. Where possible, state and national prevalence data from the BRFSS have been included.

Hypertension, or high blood pressure, is the **leading** cause of both ischemic and hemorrhagic strokes. Normal blood pressure is defined as a persistent reading below the levels of 120 mm Hg for systolic pressure (the amount of force exerted when the heart beats) and 80 mm Hg for diastolic pressure (the force exerted when the heart is at rest). High normal blood pressure, or prehypertension, includes readings of 120-139 mm Hg for systolic and 80-89 mm Hg for diastolic pressure. Hypertension refers to consistent readings of equal to or higher than 140 mm Hg for systolic pressure and/or 90 mm Hg for diastolic pressure. A recent study published in *Diabetes This Week* indicated that "nondipping" blood pressure, i.e., blood pressure that decreases less than 10% when a person is asleep, is an additional risk factor (47).

> In 2001, West Virginians reported higher rates of hypertension than their national counterparts regardless of sex, age, or income. Nearly one-third of adults in the state have been told they have high blood pressure.

The American Heart Association estimates that as many as 50 million Americans age 6 and older have high blood pressure (48). Overall, one in four adults suffers from hypertension, but this statistic increases to one in three among African-Americans. Of persons with high blood pressure, nearly one-third (32%) are not aware they have it; the Heart Association also estimates that only 27% of people with high blood pressure are receiving adequate treatment (diet or drugs). A higher percentage of men than women have hypertension, up to the age of 55; following age 55, more women have high blood pressure. Even though hypertension risk increases with age, it can also occur in children; it is estimated that 1% to 2% of school-aged children have high blood pressure (49).

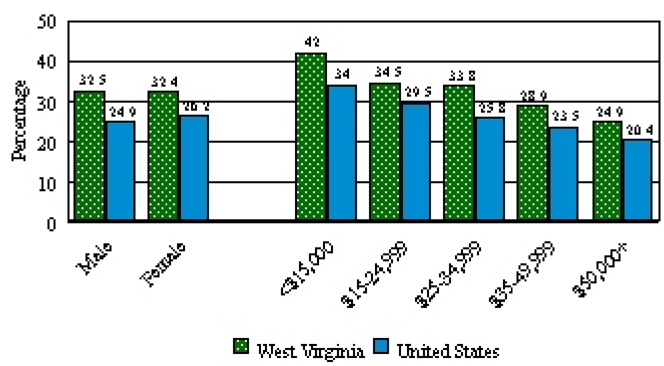
Figure 3. Prevalence of Hypertension Awareness by Age
BRFSS, West Virginia and United States, 2001



For nine out of ten persons with hypertension, the cause is unknown (50). Known risk factors for primary or essential hypertension include a family history of high blood pressure, aging, being African-American, obesity, excessive alcohol consumption, and high sodium intake (in those individuals with a susceptibility). Other possible risk factors include physical inactivity, low potassium, calcium, and magnesium intake, sleep apnea, and insulin resistance. Among men, long-term exposure to lead may contribute to hypertension (51); in women, high blood pressure is two to three times more likely among those taking oral contraceptives, especially if they are older or obese (52). Secondary hypertension is caused by such conditions as pregnancy or narrowing of the kidney arteries or by certain medications.

The Behavioral Risk Factor Surveillance System measures adult hypertension prevalence biennially by asking survey respondents the question "Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?" Nationally, 25.6% (national median) of respondents answered yes to this question in 2001; however, 32.5% of West Virginia adults reported having been told they have high blood pressure (hypertension awareness), a statistically significant difference, and the continuation of an upward trend since 1992. In 2001, West Virginians reported higher rates of hypertension than their national counterparts regardless of sex, age, or income level, as noted in Figures 3 and 4. Five years of BRFSS data were combined in order to produce an adequate sample size to analyze responses among West Virginia's African-American population. The 1998-2002 prevalence of hypertension among African-American adults was 44.1%, compared with 30.8% for whites over the same time period.

Figure 4. Prevalence of Hypertension Awareness by Sex and Income
BRFSS, West Virginia and United States, 2001



Certain **cardiac disorders** increase the risk of having a stroke; in fact, heart disease is the second most important risk factor for stroke (53). According to data from the National Stroke Association (NSA), approximately 15% of all stroke sufferers have a heart condition called atrial fibrillation (AF) (54). AF occurs when the two upper chambers of the heart, the atria, beat rapidly and irregularly, allowing blood to pool in the heart. This can lead to the formation of blood clots that can then travel to the brain, causing a cerebral embolism. The risk of AF increases with age and hypertension. The NSA estimates that AF is associated with 7% of all strokes among people aged 50 to 59; by ages 80 to 89 this percentage has increased to 36% (54). Other heart disorders that contribute to stroke risk include heart valve disease, dilated cardiomyopathy, and myxoma (a benign heart tumor that can embolize, with fragments entering the circulatory system).

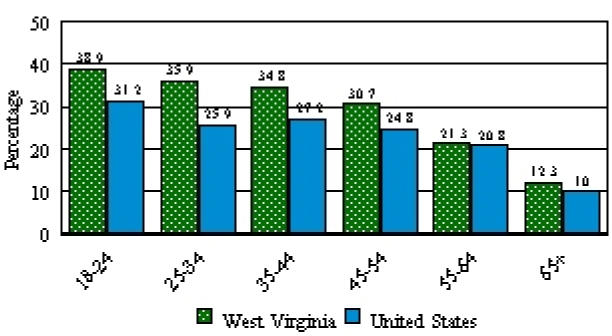
An individual who has had one or more **TIAs** has nearly 10 times the risk of a stroke as someone who has not had a TIA (55). The chance of a subsequent full ischemic stroke is greatest within the first month following a TIA. It is estimated that 50% of strokes occurring following a TIA will occur within the first year; after that, the risk diminishes.

In 2002, West Virginia adults smoked at rate of 28.4%; however, recent data show that youth smoking in the state declined by 20% between 1999 and 2002.

Cigarette smoking doubles an individual's chance of having a stroke (56). The carbon monoxide and nicotine in tobacco smoke damage blood vessel walls, which leads to an increased likelihood of clot formation. A meta-analysis of 32 studies showed that smoking independently contributes to the risk of stroke (57); the greatest risk was of subarachnoid hemorrhage, followed by ischemic stroke and cerebral hemorrhage. A 2003 study of the incidence of SAH among young adults aged 18-49 found that two-thirds of those who had suffered a SAH were current cigarette smokers (58). According to one of the researchers, "If you're a smoker in this age group, you are about 3.7 times more likely to have this type of stroke than if you're not a smoker" (59).

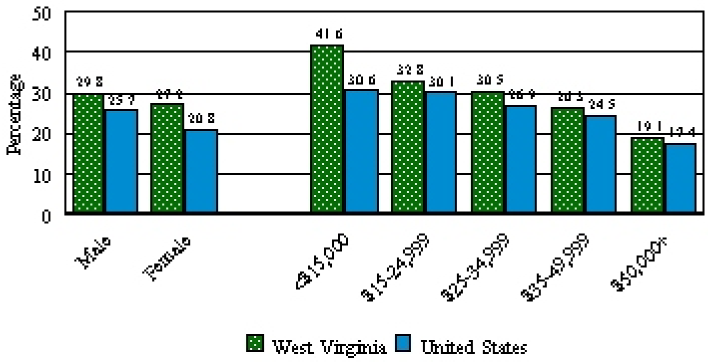
A prospective study on cessation of smoking and the risk of stroke in middle-aged men over a 13-year period showed that, after adjustment for other risk factors, current smokers had nearly four times the risk of stroke compared with never smokers (60). Ex-smokers had a lower risk than current smokers but a higher risk than never smokers. Switching to a pipe or cigars conferred no benefit. Cessation was most beneficial to hypertensive men.

Figure 5. Prevalence of Current Cigarette Smoking by Age
BRFSS, West Virginia and United States, 2002



Secondhand, or passive, smoke has also been found to increase stroke risk. An Australian study published in the *American Journal of Public Health* reported that the risk of ischemic stroke

Figure 6. Prevalence of Current Cigarette Smoking by Sex and Income
BRFSS, West Virginia and United States, 2002



was doubled for persons whose spouses smoked when compared with those whose spouses did not smoke, even after adjusting for the subject's own smoking, high blood pressure, heart disease, diabetes, and educational level (61).

BRFSS data for 2002 show West Virginia adults smoke at a significantly higher rate than the national average (28.4% vs. 23.0%). Both males and females in the state are significantly more likely to be smokers than their counterparts nationally; in addition, higher rates of smoking were reported by state respondents in every age and income category (see Figures 5 and 6). The 1998-2002 rate of smoking among African-Americans was 31.8%; the five-year white rate was 27.1%.

The 2002 West Virginia Youth Tobacco Survey, published in 2003, reported that high school students showed a significant decrease in current smoking from 1999, when the rate was 42.2%, to 2002, when the rate was 33.7% (62). These declines may be reflected in the BRFSS prevalences among adults in coming years.

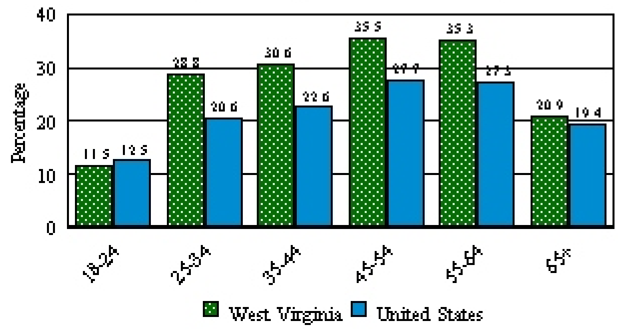
In 2002, only 28.5% of men and 43.8% of women in West Virginia were of a healthy weight, i.e., not overweight or obese.

The relationship between **obesity** and stroke has only recently become more clearly defined. While it has been recognized that excess weight increases the risk of stroke, this increased risk was often attributed to the link between obesity and hypertension, diabetes, and high cholesterol levels. Several new studies, however, have documented that obesity, abdominal obesity in particular, is an independent risk factor for stroke. The Northern Manhattan Stroke Study, funded by NINDS, found abdominal obesity to be an independent risk factor for ischemic stroke among all racial and ethnic groups, with a greater effect noted among younger (aged <65) study subjects, especially African-Americans and Hispanics (63).

Research published in the *Archives of Internal Medicine* analyzed data from the Physicians' Health Study, confirming an independent relationship between obesity and stroke risk in men (64). Men having a body mass index (BMI) of 30 or greater were twice as likely to suffer a stroke as men with a BMI of less than 23. In fact, gaining only six or seven pounds can increase stroke risk by 6%. A similar study by Harvard researchers looked at women in the Nurses' Health Study. Their findings showed that obesity significantly raised the risk of ischemic stroke among women (65).

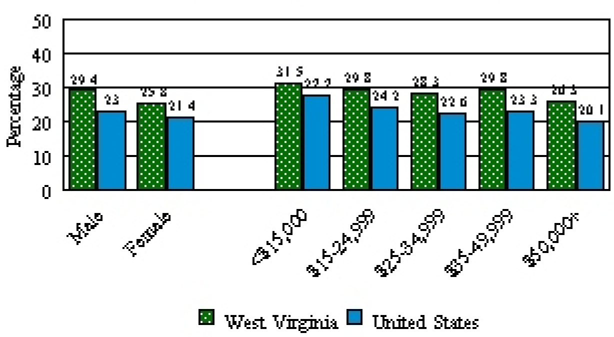
Scientists at the University of Michigan Medical School published research findings in *Journal of the American Medical Association* (*JAMA*) in 2002 that suggested that the link between obesity and stroke might be explained by high levels of the hormone **leptin** (66). Leptin is released by fat cells and normally acts to signal the brain to suppress appetite when a person is full. In grossly overweight people, however, this process breaks down and obese persons become resistant to leptin's signal. Researchers suggest that there is an interaction between high levels of leptin and the leptin receptor on platelets, resulting in an increased tendency for blood clotting and thus an increased risk for stroke. In subsequent studies, both ischemic and hemorrhagic stroke have been associated with high leptin levels (67, 68).

Figure 7. Prevalence of Obesity by Age
BRFSS, West Virginia and United States, 2002



In 2002, West Virginia ranked highest among the 54 participants of the BRFSS with an obesity (BMI=30+) prevalence of 27.6% (significantly higher than the U.S. rate of 22.2%). Nearly three out of every ten adult males (29.4%) in the state were obese in that year; 25.8% of adult females were obese. West Virginians were more likely than their national counterparts to be obese in every income category and in all but the youngest age group (Figures 7 and 8). Another 42.1% of men and 30.4% of women were overweight (BMI=25.0-29.9) in that year. In other words, only 28.5% of men and 43.8% of women were of a healthy weight in 2002. Among the state's African-American population, the 1998-2002 prevalence of obesity was 40.5%, compared with a five-year rate of 23.7% among whites.

Figure 8. Prevalence of Obesity by Sex and Income
BRFSS, West Virginia and United States, 2002



The prevalence of obesity in West Virginia has, with few exceptions, shown a consistent upward trend since 1987. Given the relationship between obesity and stroke, this would indicate that a corresponding increase in stroke incidence and mortality is a potential problem.

High levels of both **cholesterol and triglycerides** have been shown to have independent effects on the risk of stroke. A study published in *Archives of Internal Medicine* in 2002 reported that age-adjusted rates of ischemic stroke and TIA were found to increase with increasing total cholesterol and low-density cholesterol and decreasing high-density cholesterol levels (69). A 2001 study demonstrated conclusively, for the first time, that having a high triglyceride level is a strong independent predictor of an individual's risk for stroke or TIA (70). After adjusting for other risk factors, the researchers found a nearly 30% higher risk among persons with high triglycerides.

In 2001, West Virginia ranked first among BRFSS participants in the rate of adults who had been told they had high cholesterol.

When there is an excess of cholesterol in the blood, especially low-density lipoprotein cholesterol, it becomes deposited in artery walls. These fatty deposits, or plaques, are called atheromas and occur in large and medium-sized arteries, including the carotid and vertebral arteries. The narrowing of these arteries can result in blood clots or reduced blood flow to the brain and increase the risk of ischemic stroke or TIA.

The BRFSS monitors the prevalence of adults who have been told by a doctor or other health professional that their blood cholesterol is high. In 2001, West Virginia ranked 1st among the 54 participants in respondents that reported having high cholesterol levels. The state prevalence of cholesterol awareness of 37.7% was significantly higher than the national rate of 30.2%. Both men and women had significantly higher rates than men and women in the nation as a whole. As Figures 9 and 10 show, state respondents were more likely to have been told their cholesterol was high than other respondents in every age group but one and in every income category. Aggregating 1998-2002 data, the African-American rate of high cholesterol was 26.0%, the white rate 37.2%.

Figure 9. Prevalence of Cholesterol Awareness by Age
BRFSS, West Virginia and United States, 2001

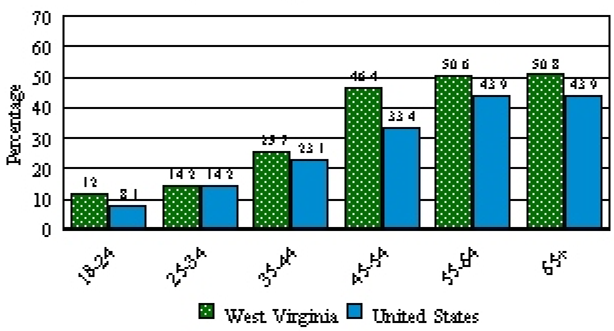
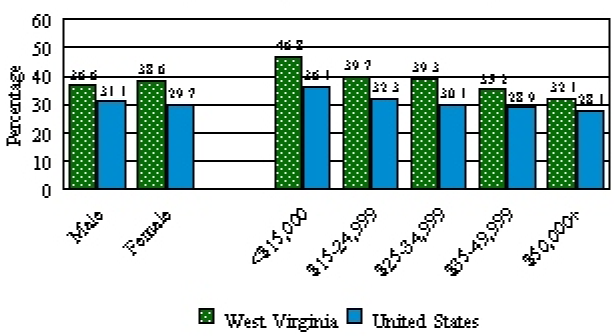


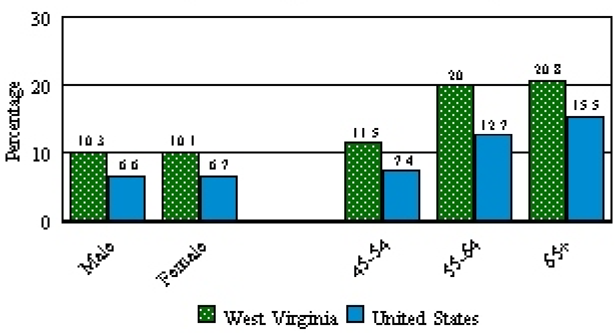
Figure 10. Prevalence of Cholesterol Awareness by Sex and Inco:
BRFSS, West Virginia and United States, 2001



Diabetes has long been recognized as an independent risk factor for vascular disease; because circulatory problems and blood clotting are major factors in diabetes, the risk for ischemic stroke and TIA is increased two- to threefold (71, 72). Increased glucose in the blood causes damage to artery walls; when combined with high levels of cholesterol, this even more significantly increases the risk of developing atherosclerosis. Diabetes combined with hypertension also raises the odds of having a stroke, again from the increased damage to vessel walls. In particular, the risk of brain lesions called "silent strokes" is increased, according to an article published in 2003 in *Stroke* (73). Japanese researchers found that silent strokes, which occur when the smaller blood vessels in the brain become blocked, were significantly more likely to occur if patients, particularly males, had diabetes and had suffered hypertension for 10 years or more. Silent strokes are markers for future, more serious strokes. A Danish study of diabetic and nondiabetic acute stroke patients found that the patients with diabetes were on average 3.2 years younger at the time of their stroke, were more likely to be hypertensive, recovered more slowly, and had higher mortality rates than nondiabetic stroke sufferers (74).

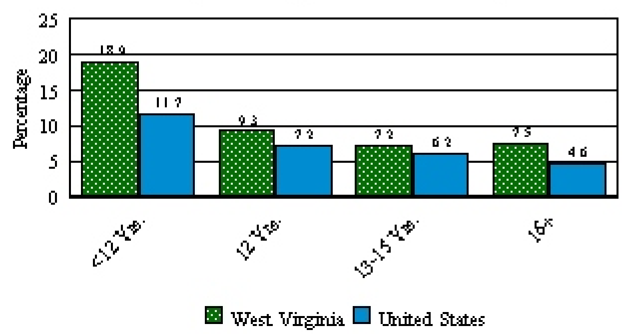
> West Virginians are more likely to have diabetes than people in the rest of the country regardless of sex, age, or educational level.

Figure 11. Prevalence of Diabetes by Sex and Age
BRFSS, West Virginia and United States, 2002



In 2002, West Virginia ranked 2nd to Puerto Rico in diabetes prevalence among the 54 BRFSS participants. The state's rate of 10.2% was significantly higher than the national median of 6.7%. As shown in Figure 11, both sexes reported significantly higher rates than men and women nationwide, as did each age group from 45 and older; sample sizes were too small among younger respondents for valid comparisons. Sample sizes were also too small in certain income categories for comparison, but large enough by educational level to show that West Virginians were more likely than others to report having diabetes in each level (Figure 12). African-Americans in West Virginia reported a prevalence of diabetes of 10.5% from 1998-2002, compared with 7.0% for the white population.

Figure 12. Prevalence of Diabetes by Education
BRFSS, West Virginia and United States, 2002



Physical activity has an impact on the risk of stroke in numerous ways. It has an independent effect and it can help reduce or eliminate several other risk factors associated with stroke:

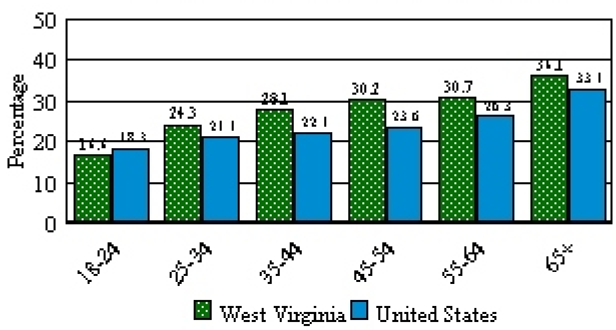
- high blood pressure
- cigarette smoking (smokers who exercise on a regular basis are more likely to stop smoking)
- diabetes (exercise may reduce insulin requirements)
- obesity/overweight
- high triglycerides
- high cholesterol

A meta-analysis published in *Stroke* in 2003 reviewed 23 studies examining physical activity and stroke (75). Lee et al. found that both moderately and highly active people had lower risks of stroke than low-activity people; moderately active people were 20% less likely to suffer a stroke than low-activity people, and high-activity people were 27% less likely to have a stroke. Both ischemic and

Since 1994, the prevalence of adults reporting physical inactivity in West Virginia has decreased by 37%, following a national trend toward adding more leisure-time exercise to our lives.

hemorrhagic strokes were less frequent in moderately and highly active individuals. Researchers in the Northern Manhattan Stroke Study also found benefits to physical activity in lowering stroke risk (76). In that study, leisure-time activity was found to be significantly protective for stroke, even after adjusting for hypertension, diabetes, smoking, alcohol use, obesity, heart disease, and peripheral vascular disease. Both moderate and heavy physical activity were associated with a decrease in stroke occurrence in a dose-response relationship among both men and women, in younger and older age groups, and among whites, African-Americans, and Hispanics.

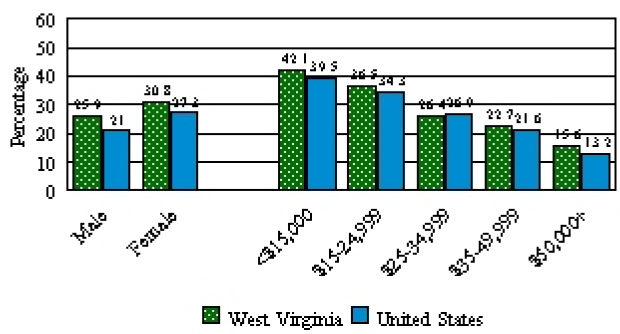
Figure 13. Prevalence of Physical Inactivity by Age BRFSS, West Virginia and United States, 2002



The BRFSS survey asks the question "During the past month, did you participate in any physical activities?" In 2002, West Virginia ranked 10th among the 54 BRFSS participants in the rate of respondents who answered no to this question. The state's prevalence of 28.4% was significantly higher than the national median of 24.4% but shows a marked decrease from a high of 45.3% reported in 1994 and continues a promising trend among state residents.

In 2002, West Virginians were more likely to report physical inactivity in every age group except young adults aged 18-24 (Figure 13). Both statewide and nationally, women were more likely than men to report being inactive (Figure 14). The state also showed higher rates in every income category but one ($25,000-$34,999). Physical inactivity was reported by 39.6% of African-Americans and 38.8% of whites from 1998-2002.

Figure 14. Prevalence of Physical Inactivity by Sex and Incor BRFSS, West Virginia and United States, 2002



Studies on **alcohol use** and stroke have produced mixed results. A meta-analysis performed by Reynolds et al. and published in *JAMA* in 2003 reviewed 35 studies on the effects of alcohol consumption on stroke (77). Their results indicated that heavy alcohol consumption (>60 g per day) increased the relative risk of total stroke, ischemic stroke, and hemorrhagic stroke, while light or moderate consumption (<24 g per day) decreased the risk of total and ischemic stroke when compared with abstainers.

Binge drinking increases blood pressure, thereby increasing the risk of stroke. In 2002, 11.4% of adult West Virginians reported binge drinking.

Researchers using data from the Stroke Prevention in Young Women study found that moderate alcohol consumption (defined for this study as two or fewer drinks per day) was associated with a decreased risk of ischemic stroke among women aged 15-44 (78). These results persisted even after controlling for age, race, education, and smoking status. Data from the Northern Manhattan Stroke Study showed a protective effect of moderate alcohol consumption (defined as not exceeding one drink per day for women and two per day for men), which persisted after adjusting for other stroke factors and was found among men and women, all age groups, and whites, blacks, and Hispanics (79). The same study showed an association between heavy alcohol use (seven or more drinks per day) and increased risk of ischemic stroke; another study by Kissela et al. confirmed the association between heavy alcohol consumption and subarachnoid hemorrhage (80). A more recent study, however, conducted by researchers at Johns Hopkins University found no evidence that low to moderate alcohol use lowered stroke risk (81).

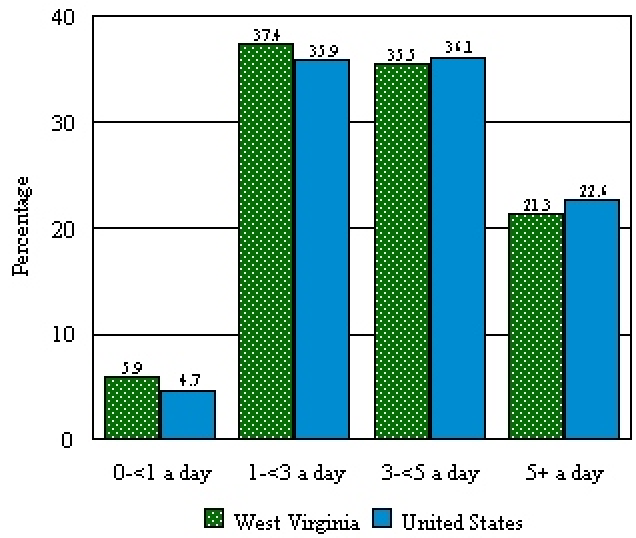
Binge drinking, i.e., having five or more drinks on one occasion, is known to raise blood pressure, increasing stroke risk (82). The BRFSS monitors the prevalence of binge drinking on a biennial basis, most recently in 2002. In that year, West Virginia was 49th among 54 participants in percentage of adults who reported having had five or more drinks on one occasion at least once during the month prior to their interview. Eleven percent (11.4%) of state respondents reported binge drinking, compared with the national median of 16.1%.

Only about one-fifth of West Virginia adults eat the recommended five or more servings of fruits and vegetables each day.

Diets high in **fruit and vegetable consumption** have been found to be associated with a lower risk of stroke. Data from the all-female Nurses' Health Study and the all-male Health Professionals' Follow-up Study were analyzed to evaluate the relationship between fruit and vegetable intake and ischemic stroke (83). Results pointed to a inverse relationship between the consumption of fruits and vegetables, especially cruciferous and green leafy vegetables and citrus fruits. The Hiroshima/Nagasaki Life Span Study examined fruit and vegetable intake and its association with both ischemic and hemorrhagic stroke (84). Daily consumption of green and yellow vegetables and fruits was found to be associated with a lower risk of ischemic stroke and intracerebral hemorrhage in both men and women.

The BRFSS monitors the average daily consumption of fruits and vegetables among West Virginia's adult population. In 2002, only about one in five (21.3%) West Virginians reported eating the recommended five or more servings of fruits and vegetables each day, compared with 22.6% of adults nationwide (Figure 15). State women were more likely to meet the recommendation (26.4%) than were men (15.7%).

Figure 15. Average Fruit and Vegetable Consumption per Day
BRFSS, West Virginia and United States, 2002



The consumption of **fish** and **omega-3 polyunsaturated fatty acids** has also been linked to a significantly reduced risk of ischemic stroke among both men and women (85, 86), as has a higher intake of **whole-grain foods** (87, 88).

There are several **blood disorders** that can increase the risk of stroke. Both an excess and a deficiency of red blood cells can lead to stroke. Polycythemia refers to a moderate or marked increase in the number of red blood cells in circulation. This thickens the blood, increasing the possibility of a blood clot forming. Anemia is an abnormally low number of red blood cells. Red blood cells carry hemoglobin, which provide oxygen to the body. When this mechanism is compromised, it can result in a lack of oxygen to the brain, causing stroke.

Sickle cell anemia is a genetic disorder in which the red blood cells are hard and shaped like little sickles instead being soft and round like normal cells. Because of this, sickle cells move through the blood vessels with greater difficulty and are more likely to clog the smaller vessels. When this happens, there can be a lack of oxygen to the brain. While sickle cell anemia is found among many nationalities and ethnic groups, it is most common among African-Americans; it is estimated that approximately 9% of African-Americans carry the sickle-cell trait (89). A recent study published in *Radiology* found that African-American children with siblings with sickle cell anemia are more likely to have “twisted” arteries in the brain, which are commonly seen in elderly hypertensive persons but rarely in children. The researchers hypothesize that this finding might help to explain why young to middle-aged African-American men are three to four times more likely to suffer a stroke than white American men of the same age (90).

Sleep apnea, a disorder that causes its sufferers to stop breathing briefly but repeatedly during their sleep, has been linked to a higher risk of hypertension and stroke. The American Stroke Association recently published findings showing that sleeping more than eight hours a night, snoring, and daytime drowsiness were associated with an increased risk for stroke (91). The disrupted sleep of a person with sleep apnea can result in all of these risks.

Numerous studies have found an independent association between high levels of **homocysteine** (tHcy), an amino acid found in the blood, and an increased risk of stroke (92). Data from the Framingham Heart Study showed nonfasting total homocysteine levels to be a risk factor for incident stroke in elderly persons (93). Finnish researchers examined the relationship between tHcy levels and cerebral infarction among Finnish male smokers; after adjusting for traditional stroke risk factors, they found an increase in the risk of stroke per quartile increase in tHcy (94). A Danish study found elevated total tHcy to be an independent explanatory variable of recurrent stroke within 15 months after an initial stroke (95).

Researchers have always questioned why some individuals without conventional stroke risk factors such as high blood pressure, smoking, high cholesterol levels, etc., still suffer from cerebrovascular disease. **Inflammation** could be one answer. Inflammation is the body's response to an injury and is designed to kill germs and repair tissue damage. The plaque produced by cholesterol contains many of the inflammatory elements used by the body to fight infection and is drawn to injured and infected arteries. While designed to be helpful in the short term, this process is damaging when long-term inflammation continually draws plaque to artery walls. The buildup of plaque within arteries results in atherosclerosis, which sets the stage for ischemic stroke.

C-reactive protein (CRP) is a protein found in the blood whose level indicates the presence of inflammation in the body; researchers have found that high levels of CRP are present for many years (six to eight) preceding a first cardiovascular or cerebrovascular event. The American Heart Association estimates that persons with high levels of CRP have a doubled risk of stroke compared with those with lower levels of the protein (96). Physical activity, statins, and aspirin have all been shown to reduce CRP levels (97). Other studies have found additional markers in the blood (e.g., interleukin-6) that can predict cerebrovascular disease risk (98).

International attention is now being given to the possible role of **infection** in predicting stroke risk. Low-grade infections can be caused by either bacteria (e.g., chlamydia pneumoniae) or viruses (e.g., herpes simplex) (99). A German study of carotid plaque found in patients undergoing carotid endarterectomy supported the "infectious burden" hypothesis, i.e., there is an association between the number of infections a person has experienced and the risk for developing atherosclerosis (97). The German researchers were especially interested in the relationship between oral infection and atherosclerotic plaques, which was supported by their findings. Preliminary findings from the Oral Infections and Vascular Disease Epidemiology Study (INVEST) published in 2003 in *Stroke* suggest a link between tooth loss caused by **gum disease** and cerebrovascular disease (100). INVEST researchers found that the prevalence of carotid plaque increased with the number of missing teeth in study participants.

Recent research has linked the risk for stroke with **migraine**, especially migraine with aura, among young women. Findings presented at a 1999 symposium of the American Association for the Study of Headache showed that women who suffered from migraine were two to three times more likely to have a stroke than women without migraine; migraine with aura increased the risk to six times that of women without migraine (101). Smoking and/or taking oral contraceptives further increased the risk.

Stroke among young people is increasing due to the use of **illicit drugs**, in particular cocaine and amphetamines (102). Both of these drugs raise blood pressure and can cause an irregular heart beat, both risk factors for stroke. In addition, cocaine constricts blood vessels at the same time blood pressure is increasing; this constriction can result in reduced or blocked blood flow to the brain (103). Cocaine use also promotes inflammation and clotting changes, which lead to cerebrovascular disease (104). While both ischemic and hemorrhagic strokes can occur due to illicit drug use, hemorrhagic strokes are much more common in stroke patients with recent drug use (105).

Several studies have examined the association between **stress and anger** and stroke. Everson et al. analyzed data from a population-based study of Finnish men, the Kuopio Ischemic Heart Disease Study, to evaluate the role of anger expression and hostility in cerebrovascular disease (106). Men who reported the highest level of expressed anger had twice the risk of stroke compared with men reporting the lowest level of expressed anger. These results were limited to men with a history of ischemic heart disease; however, the findings persisted even after adjustments for age, resting blood pressure, BMI, high cholesterol levels, smoking, alcohol consumption, fibrinogen, socioeconomic status, antihypertensive medication, and diabetes. Self-reported stress intensity and the risk of stroke were analyzed in the Copenhagen City Heart Study (107). Researchers found that persons who reported high stress intensity had nearly twice the risk of fatal stroke compared with persons with no stress (relative risk [RR] 1.89; 95% C.I. 1.11 to 3.21), but no significant differences were found among subjects who had nonfatal strokes.

PREVENTION OF STROKE

Primary prevention refers to those activities designed to prevent the onset of a disease or condition. The most effective way to prevent stroke is, of course, to avoid the risk factors that are associated with the disease. While age, sex, race, and family history are nonmodifiable risk factors, a person has control over many lifestyle choices that are linked with stroke and discussed above. These include never starting, or quitting, cigarette smoking, maintaining a healthy weight, eating more fruits and vegetables, consuming alcohol moderately, if at all, and being physically active. All these behaviors can contribute to avoiding hypertension, the most common cause of stroke, as well as the development of diabetes, another serious stroke risk factor, and atherosclerosis.

Secondary prevention measures are aimed at identifying and treating those persons who have stroke risk factors, but may be currently asymptomatic, to prevent the occurrence of a cerebrovascular event. Lifestyle changes that lower risk and the identification and treatment of underlying disease such as atrial fibrillation are the main focus of secondary prevention interventions. Keeping hypertension under control involves quitting smoking and reducing exposure to environmental tobacco smoke, losing weight through a healthy diet, reducing one's dietary sodium intake and increasing one's potassium, calcium, and magnesium intake through supplements, becoming more physically active, and complying with a prescribed medication regimen that usually includes a beta-blocker or ACE inhibitor and a diuretic.

Controlling both blood pressure and glycemic levels is of utmost importance in persons with diabetes. Results from the U.K. Prospective Diabetes Study showed "substantial benefits" from even moderate reductions in arterial pressure among diabetic subjects and found "tight" blood pressure control, i.e., <150/85 mmHg, more beneficial than even strict glycemic control in preventing macrovascular complications (108).

Lowering total and low-density cholesterol and triglyceride levels and increasing high-density cholesterol lowers one's risk of stroke. Compliance with hyperlipidemia therapy in the form of lipid-lowering agents (statins) among persons with high cholesterol levels is a form of secondary prevention, as is anticoagulant (e.g., warfarin) or antiplatelet (e.g., aspirin, ticlopidine) therapy among patients with atrial fibrillation. Aspirin may also be prescribed to asymptomatic patients for its anti-inflammatory effects.

Patients who have experienced a TIA are at greater risk for a major stroke and are treated with anticoagulants or aspirin unless such use is contraindicated. Further evaluation and testing are performed to assess the presence and severity of carotid disease, or atherosclerosis. In the absence of a TIA occurrence, the first indication of asymptomatic cerebrovascular disease is often a carotid bruit, or swishing sound, detected by the physician in the carotid arteries that can also indicate carotid disease. Testing, e.g., carotid duplex or Doppler ultrasound, both of which use high-frequency sound waves to image blockage(s), is used to determine the severity of the obstruction. If the stenosis, or blockage, is greater than 60%, carotid endarterectomy is an option. Carotid endarterectomy is a surgical procedure during which the plaque causing the obstruction is removed from the artery. While there is consensus in the medical community on the value of endarterectomy in patients with high-grade stenosis and TIA, it is lacking on the usefulness of the procedure in asymptomatic patients. The current American Heart Association guidelines for performing endarterectomy recommend the surgery in younger, healthier patients with associated risk factors who have 60% or greater stenosis if the estimated surgical risk is <3% and life expectancy is at least five years (109). For patients for whom the surgical risk is 3% to 5%, the guidelines indicate surgery if the stenosis is 75% or greater.

Women and African-Americans are less likely than white males to receive carotid endarterectomy (110, 111). Possible explanations for these differences include the fact that women are more likely than men to have intracranial atherosclerosis, requiring alternate methods of prevention. African-Americans are also less likely to have severe atherosclerosis in the carotid arteries; in addition, racial bias, affordability, and racial variation in patient decision to have the procedure may influence the statistics. Further investigation is warranted to explain gender and racial differences.

Tertiary prevention goes beyond secondary prevention measures to address the care of persons who have already suffered a first stroke. Tertiary measures are aimed at the prevention of a second or third stroke and the minimalization of disability through patient rehabilitation, in order to reestablish partial or complete independence and improve quality of life.

Research shows that patients who suffer a recurrent stroke have poorer outcomes than those who suffer a first stroke (112). A study by the Stroke Prevention Patient Outcomes Research Team (PORT) found that 57% of patients with a first stroke survived 24 months after their stroke, compared with 48% of those who had a recurrent stroke. While costs were similar for hospital stays and in the first one to three months following a stroke, total costs were higher for patients with a recurrent stroke for months four to twenty-four.

THE ECONOMIC COSTS OF STROKE

Data from the American Heart Association estimate the 2004 economic costs of stroke at $53.6 billion (1) Nearly two-thirds (62%) of this, or $33.0 billion, was comprised of direct health care expenditures:

- 26.5 billion – hospital/nursing home
- 2.7 billion – physicians/other health professionals
- 1.1 billion – drugs
- 2.7 billion – home health/other medical durables

Thirty-eight percent (38%) of the total, or $20.6 billion, represented indirect costs:

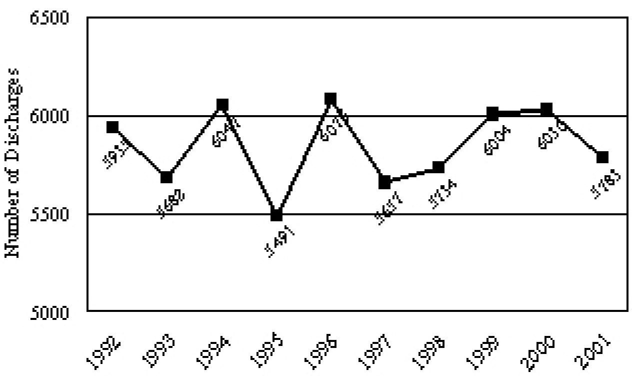
- 6.1 billion – lost productivity due to morbidity
- 14.5 billion – lost productivity due to mortality

Stroke was the 8th most expensive medical condition in the United States in 1997, according to a study by the Division of Social and Economic Research of the Agency for Healthcare Research and Quality (113). Medicare was by far the primary source of payment for direct costs associated with stroke, covering an estimated 66%, the highest percentage among the top 15 most expensive conditions. Stroke had the highest mean per person expenditure ($14,172), as well as the highest percentage of total expenditures used for home health care (13%).

Taylor et al. estimated the lifetime costs of incident stroke by stroke subtype in a study published in *Stroke* in 1996 (114). The aggregate lifetime cost of all estimated 392,344 strokes occurring in 1990 was estimated to be $40.6 billion; $29.0 billion (71%) for ischemic stroke, $6.0 billion (15%) for intracerebral hemorrhage, and $5.6 billion (14%) for subarachnoid hemorrhage. The study's authors attributed 45% of costs to acute-care costs incurred in the first two years following a first stroke; long-term ambulatory care accounted for 35% and nursing home costs for approximately 18%.

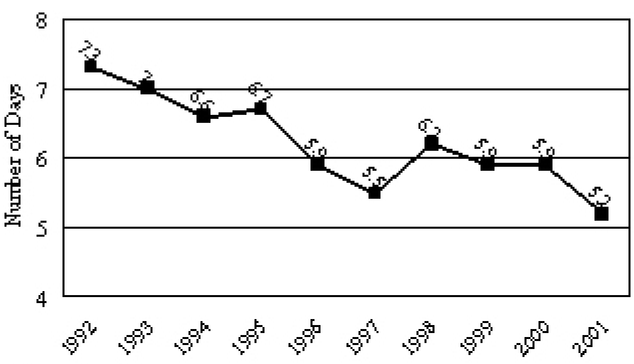
A retrospective study by Hass et al. of nursing home residents in Rochester, Minnesota, compared residents with a confirmed stroke, either major or minor, with those who had not had a stroke. Nursing home residents who had suffered a major stroke were younger and more disabled, requiring more services. While the mean number of nursing home days did not differ between residents with a stroke and those without, the per diem Medicaid reimbursement was 11% higher for those residents with major stroke (115). Residents who suffered a minor stroke showed similar characteristics and costs as residents who had not had a stroke.

Figure 16. Total Hospital Discharges for Stroke*
WV Residents Discharged from WV Hospitals, 1992-2001



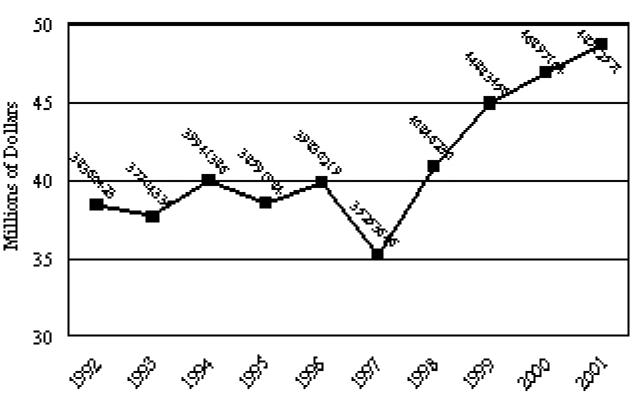
*Diagnosis Related Groups (DRGs) 14 and 15. See Appendix A for definitions.
Source: WV Health Care Authority

Figure 17. ALOS* of In-Patient Hospitalizations for Stroke**
WV Residents Discharged from WV Hospitals, 1992-2001



*Average Length of Stay
** DRGs 14 and 15
Source: WV Health Care Authority

Figure 18. Total Charges for In-Patient Hospitalizations for Strok
WV Residents Discharged from WV Hospitals, 1992-2001



*DRGs 14 and 15
Source: WV Health Care Authority

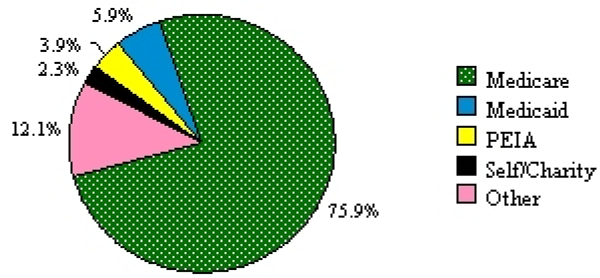
Data obtained from the West Virginia Health Care Authority show that in 2001 there were 5,783 hospitalizations of West Virginia residents in West Virginia hospitals due to stroke. Women accounted for 62% of these; 57% were among persons aged 45-64 and 19% among those aged 85+.

There was little variation in the numbers of stroke hospitalizations in the state from 1992-2001 (Figure 16). Over this same time period, however, the average length of stay (ALOS) for a patient with a stroke diagnosis decreased by 29%, from 7.3 days in 1992 to 5.2 days in 2001 (Figure 17). Charges, on the other hand, have risen steadily since 1997, from $35 million in 1997 to $49 million in 2001 (Figure 18).

A breakdown by payer of 2001 hospital charges ($48,712,571) for stroke is shown in Figure 19. The bulk of the charges (76%) were billed to Medicare, 6% were billed to Medicaid, and 4% to the Public Employees Insurance Agency (PEIA). The remaining charges were billed to other private and government insurance plans or covered by the patient or charity.

A comparison of 2001 rates of stroke hospitalization in the state and the nation is shown in Table 1. The state's overall rate of 32.1 hospitalizations per 10,000 population was higher than the national rate of 27.1. Both men and women were hospitalized for stroke at higher rates in West Virginia than in the nation as a whole. State rates were higher among elderly residents aged 85+.

Figure 19. Total Charges for In-Patient Hospitalizations for Stroke*
Distribution by Payer
WV Residents Discharged from WV Hospitals, 2001

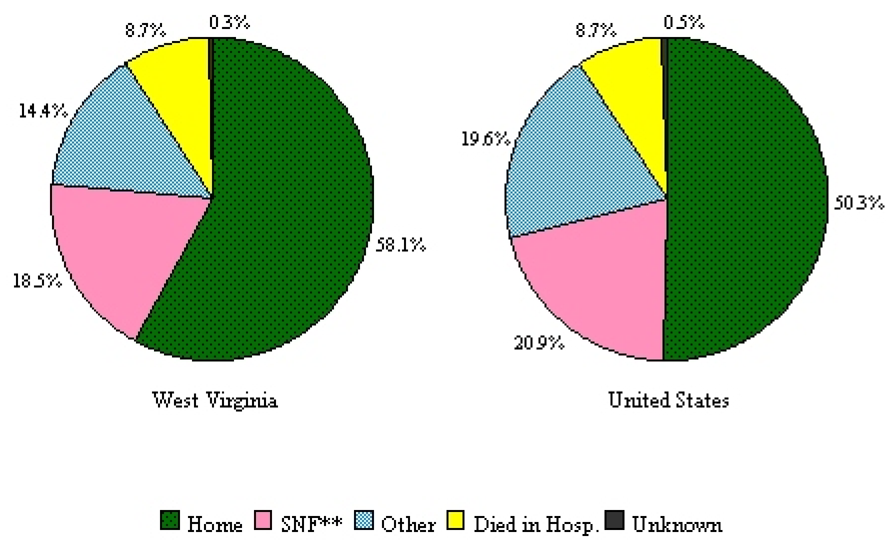


*DRGs 14 and 15
Source: WV Health Care Authority

Table 1. Hospitalization Rates* for Stroke West Virginia and United States, 2001		
Characteristic	West Virginia	United States
Total	32.1	27.1
Male	25.2	23.8
Female	38.4	30.3
18-44	2.6	2.7
45-64	25.7	25.9
65-84	135.5	137.9
85+	350.2	345.7
*Rates per 10,000 population		

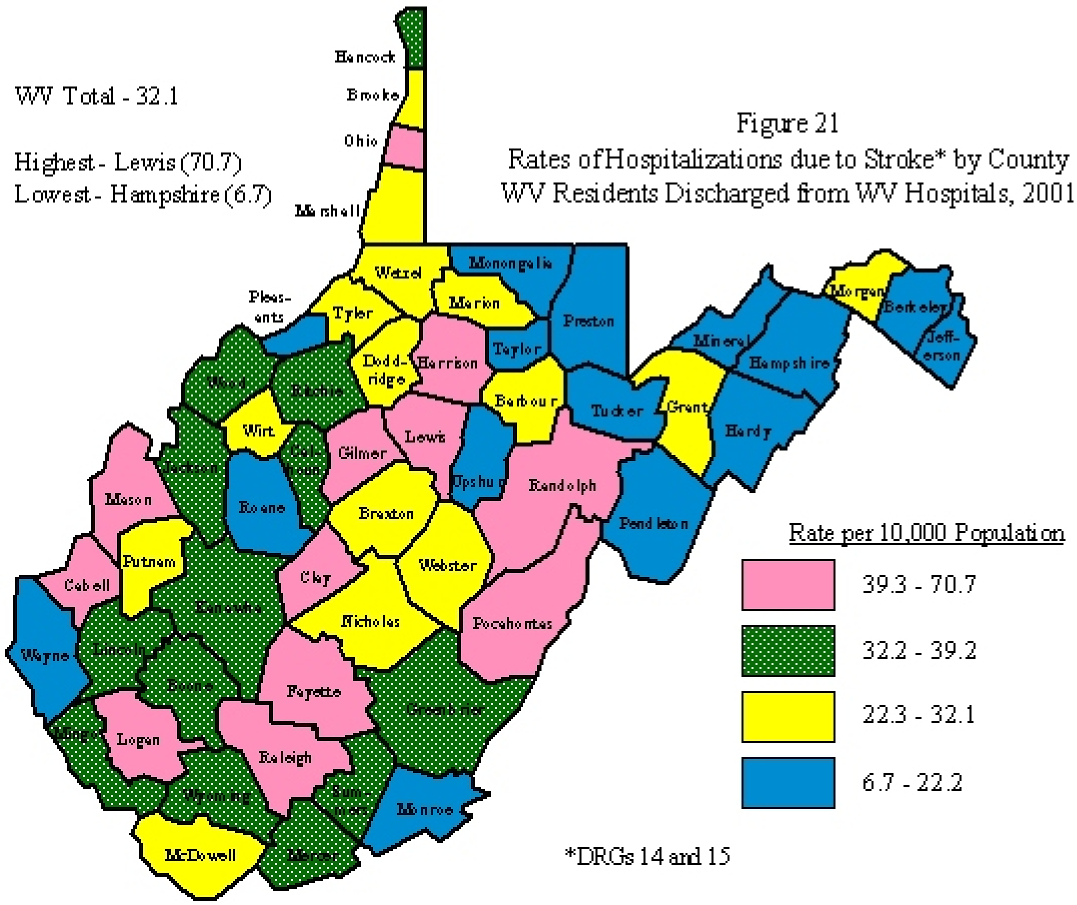
While the same percentage (8.7%) of patients admitted with a diagnosis of stroke die in the hospital both state- and nationwide, a larger percentage of patients who survive and are discharged from hospitals in West Virginia go home, as opposed to a skilled nursing or other facility (116). Nearly six out of ten patients (58.1%) with a stroke diagnosis are discharged to their homes in West Virginia, compared with half of such patients (50.3%) nationally. Figure 20 below illustrates these differences.

Figure 20. Percentage of Hospital Discharges among Stroke* Patients by Outcome
West Virginia and United States, 2000



*DRGs 14 and 15
**Skilled nursing facility
Source: WV Health Care Authority

County rates of stroke hospitalization in 2001 ranged from a low of 6.7 hospitalizations per 10,000 population in Hampshire County residents to a high of 70.7 in Lewis County, as illustrated in Figure 21. The lowest rates were reported in the Eastern Panhandle of the state. Individual county rates are found in Appendix B.



In 2000, West Virginia's overall age-adjusted[2] rate of stroke mortality was 61.4 deaths per 100,000 population, slightly higher than the U.S. rate of 60.8. Figure 22 illustrates the geographical distribution of stroke mortality across the country in that year (117). (The southeastern region called the "Stroke Belt" because of traditionally high rates of stroke mortality is clearly identified.) Individual state rates for 2000 are found in Appendix C.

Figure 22
Cerebrovascular Disease Mortality by State
United States, 2000

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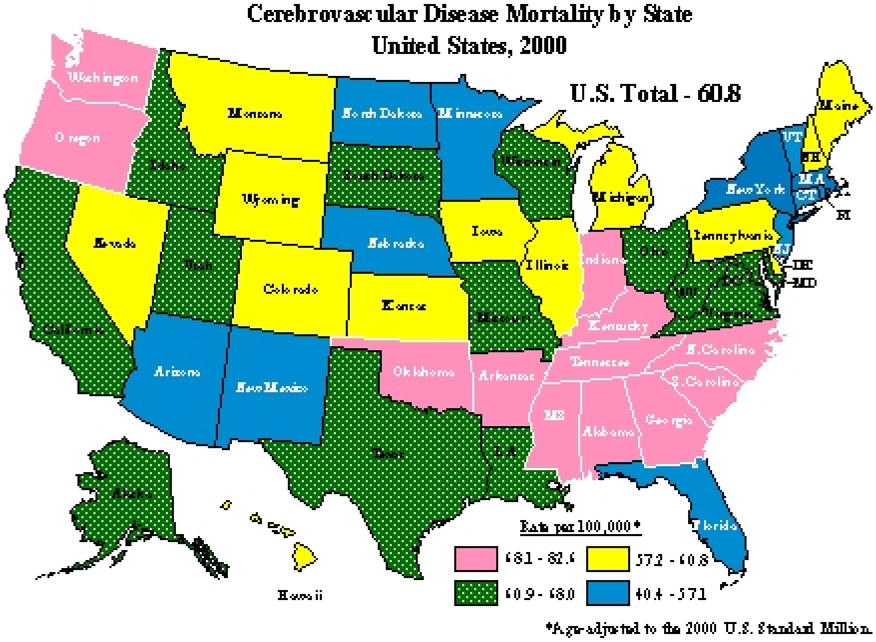

Table 2 compares age-adjusted stroke mortality rates by selected demographic characteristics for West Virginia and the United States for 2001. State rates were slightly higher than national rates in all demographic categories except one. African-Americans living in West Virginia had a rate of stroke death in 2001 that was about 7% lower than African-Americans in the country as a whole.

Lower rates among West Virginia's African-American population were also found by the authors of the *CDC's Atlas of Stroke Mortality*, who aggregated data from 1991through 1998 in order to analyze racial, ethnic, and geographic disparities in stroke deaths in the United States and within each state (35). Figure 23 depicts their findings for West Virginia and the United States as a whole. While little difference is seen in the rates among whites, the rates among African-Americans in the state were lower than comparable U.S. rates among both sexes. Stroke mortality among African-Americans in West Virginia, however, is still much higher than that among the white population.

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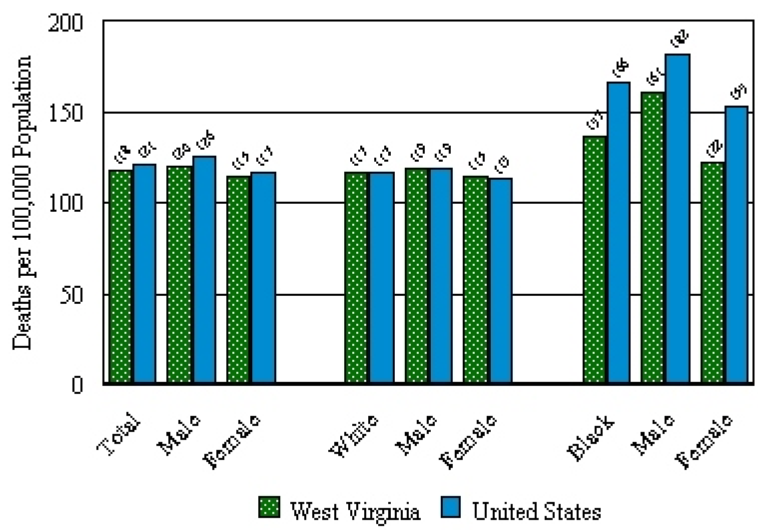
[2]Age-adjusted to the 2000 U.S. standard million.

Table 2. Cerebrovascular Disease Mortality Rates by Selected Demographic Characteristics West Virginia and United States, 2001					
Characteristic	West Virginia			United States	
	# of Deaths	Crude Rate	Age-adjusted Rate*	Crude Rate	Age-adjusted Rate*
Total	1,262	69.8	59.8	57.4	57.9
Male	482	54.8	60.6	45.2	59.0
Female	780	83.9	57.6	69.2	56.4
White	1,217	70.8	59.9	63.9	56.0
Black	44	76.9	74.4	54.4	79.9
45-64	103	22.6	--	23.9	--
65+	1,136	410.3	--	409.8	--

*Rates are age-adjusted to the U.S. 2000 standard million.

Figure 23. Stroke Death Rates by Race and Sex
West Virginia and United States, 1991-1998



Premature death, or death before the age of 65, is a significant problem among African-American residents of West Virginia. Data were aggregated for five years, 1997-2001; during that time, *nearly one in four (23%) stroke deaths among African-Americans occurred before the age of 65.* Among white residents, in contrast, 10% of stroke deaths were premature. Calculating the rate of YPLL (i.e., Years of Potential Life Lost before Age 65, or the difference between age 65 and the age at death for all deaths from stroke) by race for 1997-2001 yielded a rate of 297.1 YPLL per 100,000 population among African-Americans compared with 97.4 among the state's white population.

CDC used 1999 data to examine the distribution of stroke-related deaths by place of death, defined as either pretransport, dead on arrival at a hospital, in the emergency department, or in the hospital (118). When compared to the nation as a whole, similar percentages of West Virginia deaths occurred either during transport, i.e., DOA, or in the emergency department. Differences were noted, however, in the percentages of stroke deaths that occurred pretransport or in the hospital; a smaller percentage of deaths in the state were pretransport (39.2% vs. 47.6%) while a larger percentage occurred in the hospital (56.7% vs. 48.0%).

In 2001, stroke death rates showed a wide range by county (Figure 24). Summers County reported the lowest rate at 15.1 deaths per 100,000 population, while Calhoun County had the highest rate at 106.2. Individual county rates are found in Appendix D (caution must be used in interpreting rates based upon small numbers of events).

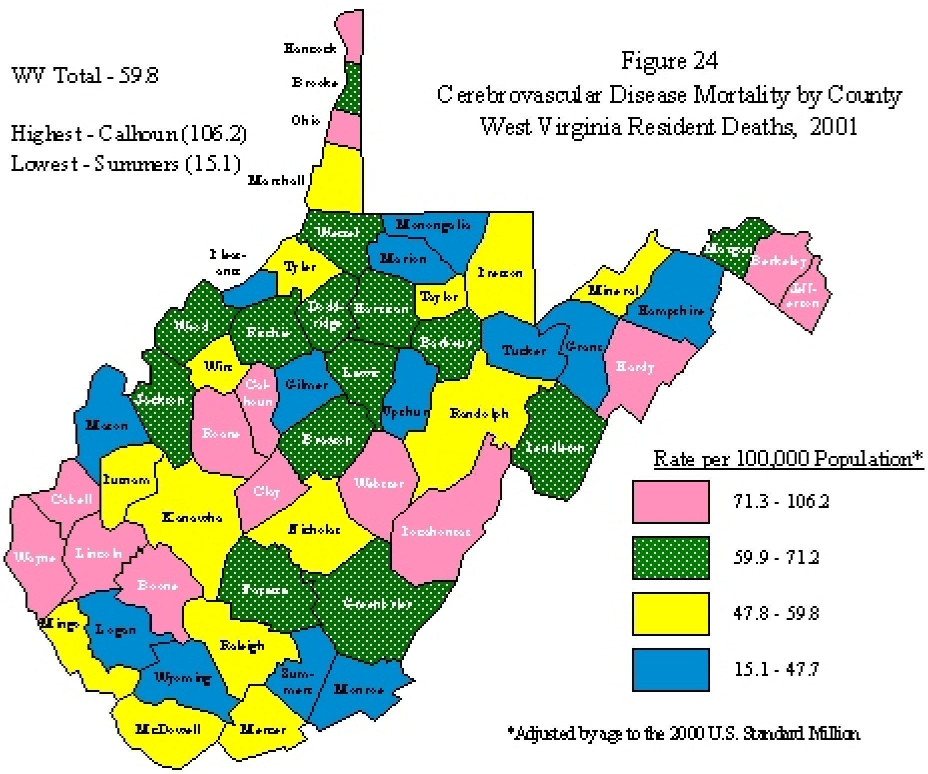


Figure 24
Cerebrovascular Disease Mortality by County
West Virginia Resident Deaths, 2001

*Adjusted by age to the 2000 U.S. Standard Million

STROKE CENTERS

A study of Medicare patients led by researchers at Duke University Medical Center found that stroke victims were more likely to survive if care was provided primarily by a neurologist rather than a nonspecialist (119). One-fourth (25%) of older (65+) patients treated for stroke by nonspecialists died within 90 days compared with 16% of those treated by neurologists; the researchers also found patients cared for by neurologists had less disability than other stroke patients.

The importance of specialized health care providers and the urgency of the limited time frames within which to treat stroke led the Brain Attack Coalition (chaired by the National Institute of Neurological Disorders and Stroke at NIH) to publish recommendations in 2000 for the establishment of hospital stroke centers to reduce stroke-related disability and death (120). There are two major goals behind these recommendations: (1) the improvement in the level of care received by stroke victims and (2) the standardization of the acute care provided to patients.

Two types of stroke centers were recommended by the Brain Attack Coalition, primary stroke centers to provide acute care and comprehensive stroke centers to care for those patients in need of extensive care. Based on the guidelines in place for emergency treatment provided in trauma centers, the recommendations for primary stroke centers include:

- an acute stroke team, to include a physician with experience in diagnosing and treating cerebrovascular disease and a minimum of one other health care provider. The team should be available 24 hours a day, seven days a week.
- written protocols to reduce time and complications of treatment
- improved coordination of EMS and hospitals
- an emergency department staff trained in the diagnosis and treatment of stroke
- access to an established stroke unit for specialized care
- provision of neurological services within two hours
- brain imaging capabilities and laboratory services
- a stroke registry or database to track and measure patient outcomes
- continuing medical education to the centers' professional staff

WEST VIRGINIA STROKE RESOURCES

Neurologists and Neurosurgeons

As of 2001, West Virginia had 55 licensed neurologists and 29 neurosurgeons providing patient care in the state. Figure 25 shows these practice locales by county. The majority of doctors with a specialty in neurology or neurosurgery are currently located in the southern and northern regions of the state, with limited access in the middle, more rural counties.

Stroke Registries

The West Virginia University (WVU) Stroke Center/West Virginia University Hospital (WVUH) Stroke Registry was begun in 2000. It is a hospital-based registry that collects data on all WVUH discharges with DRG 14 and 15 designations (and, as of October 1, 2002, DRG 524)[3]. Data are reviewed annually by the multidisciplinary members of the WVU Stroke Center; the database is used for quality assurance, tracking patient outcomes, and research.

In 2000, the Charleston Area Medical Center (CAMC) participated in a one-year pilot study of the ETHOS Stroke Registry, a national web-based acute stroke treatment registry. The following year, CAMC initiated its own hospital-based stroke registry. Data are collected on a monthly basis for all discharges with DRG 14, 15, and 524 designations and utilized during monthly Stroke Team meetings to monitor patient outcomes and develop and benchmark clinical, financial, and performance improvement activities.

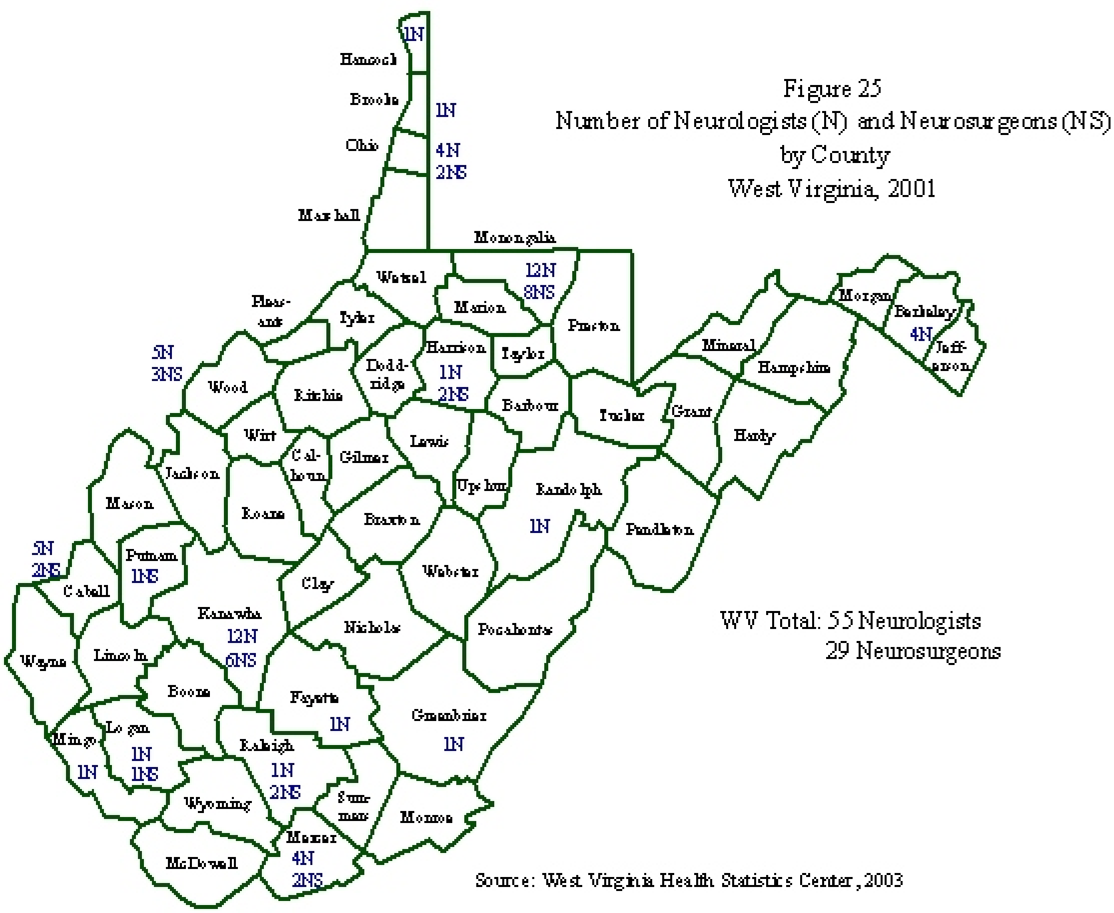


Figure 25
Number of Neurologists (N) and Neurosurgeons (NS)
by County
West Virginia, 2001

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[3]In 2002, coding changes resulted in TIA diagnoses being moved from DRG 15 to DRG 524.

Appendix A
Definitions of Diagnosis Related Groups 14, 15, and 524

Pre–October 1, 2002

DRG 14 – ICD-9 codes 430, 431, 432, 434, 436
Specific cerebrovascular disorders except TIA

DRG 15 – ICD-9 codes 433, 435
TIA and precerebral occlusions

October 1, 2002–Present

DRG 14 – ICD-9 codes 430, 431, 432.0, 432.1, 432.9, 433.01, 433.11, 433.2, 433.31, 434.01, 434.11, 434.91
Intracranial hemorrhage and stroke with infarction

DRG 15 – ICD-9 codes 433.00, 433.10, 433.20, 433.30, 433.80, 433.90, 434.00, 434.10, 434.90, 436
Nonspecific cerebrovascular accident and precerebral occlusion without infarction

DRG 524 – ICD-9 codes 435.0, 435.1, 435.2, 435.3, 435.8, 435.9, 437.1
Transient ischemia attack

Appendix B Stroke Hospital Discharges (DRGs 14 and 15) West Virginia Residents by County, 2001				
County	**Number of Discharges**	**Population**	**Rate per 10,000 Population**	**Rank**
Barbour	45	15,507	29.0	31
Berkeley	121	81,262	14.9	53
Boone	91	25,554	35.6	19
Braxton	46	14,800	31.1	27
Brooke	74	25,179	29.4	30
Cabell	387	95,266	40.6	10
Calhoun	24	7,451	32.2	25
Clay	42	10,357	40.6	11
Doddridge	19	7,425	25.6	36
Fayette	228	47,129	48.4	4
Gilmer	38	6,986	54.4	2
Grant	31	11,368	27.3	32
Greenbrier	114	34,453	33.1	23
Hampshire	14	21,035	6.7	55
Hancock	123	32,082	38.3	14
Hardy	20	12,795	15.6	52
Harrison	280	67,856	41.3	9
Jackson	104	28,204	36.9	17
Jefferson	72	44,926	16.0	51
Kanawha	724	195,790	37.0	16
Lewis	118	16,690	70.7	1
Lincoln	78	22,256	35.0	20
Logan	167	37,004	45.1	6
McDowell	65	26,137	24.9	37
Marion	150	56,433	26.6	35
Marshall	112	34,898	32.1	26
Mason	112	26,004	43.1	8
Mercer	241	62,207	38.7	13
Mineral	45	27,087	16.6	50
Mingo	104	27,561	37.7	15
Monongalia	143	82,895	17.3	47
Monroe	26	14,613	17.8	45
Morgan	34	15,263	22.3	40
Nicholas	64	26,404	24.2	38
Ohio	203	43,126	44.0	7
Pendleton	14	7,911	17.7	46
Pleasants	13	7,579	17.2	49
Pocahontas	45	8,957	50.2	3
Preston	64	29,460	21.7	42
Putnam	126	52,230	24.1	39
Raleigh	376	78,899	47.7	5
Randolph	111	28,267	39.3	12
Ritchie	37	10,278	36.0	18
Roane	32	15,267	21.0	43
Summers	41	12,526	32.7	24
Taylor	14	16,059	8.7	54
Tucker	13	7,168	18.1	44
Tyler	25	9,399	26.6	34
Upshur	51	23,318	21.9	41
Wayne	73	42,382	17.2	48
Webster	30	9,697	30.9	28
Wetzel	47	17,363	27.1	33
Wirt	18	5,935	30.3	29
Wood	296	87,306	33.9	22
Wyoming	86	24,869	34.6	21
Unassigned	15			
WV Total	**5,786**	**1,801,873**	**32.1**	

Appendix C
Cerebrovascular Disease Mortality Rates* (I60-I69) by State
United States, 2000

State	Rate per 100,000 Population	Rank
Alabama	72.1	7
Alaska	66.0	15
Arizona	55.6	43
Arkansas	78.9	3
California	61.6	23
Colorado	58.3	36
Connecticut	51.2	45
Delaware	58.8	32
Florida	50.5	47
Georgia	76.5	5
Hawaii	60.3	29
Idaho	61.7	22
Illinois	60.6	27
Indiana	71.9	8
Iowa	58.8	32
Kansas	60.7	26
Kentucky	68.1	12
Louisiana	64.4	18
Maine	58.7	35
Maryland	63.2	19
Massachusetts	51.2	45
Michigan	60.5	28
Minnesota	56.2	40
Mississippi	75.7	6
Missouri	65.3	16
Montana	59.9	30
Nebraska	55.8	41
Nevada	58.0	37
New Hampshire	57.2	38
New Jersey	48.8	48
New Mexico	52.2	44
New York	40.4	50
North Carolina	78.8	4
North Dakota	55.7	42
Ohio	60.9	25
Oklahoma	69.8	10
Oregon	71.9	8
Pennsylvania	59.5	31
Rhode Island	45.0	49
South Carolina	82.6	1
South Dakota	61.9	21
Tennessee	80.4	2
Texas	66.9	14
Utah	65.2	17
Vermont	57.0	39
Virginia	67.9	13
Washington	68.8	11
West Virginia	61.4	24
Wisconsin	62.6	20
Wyoming	58.8	32
U.S. Rate	60.8	
Source: USDHHS, NCHS	*Age adjusted to the 2000 U.S. standard million.	

Appendix D Deaths Due to Cerebrovascular Disease (I60-I69) West Virginia Residents by County, 2001				
County	**Number**	**Crude Rate**	**Adjusted Rate***	**Rank**
Barbour	12	77.1	61.9	25
Berkeley	42	55.3	73.2	13
Boone	22	86.2	84.5	7
Braxton	12	81.6	62.4	23
Brooke	23	90.4	64.9	20
Cabell	96	99.2	79.8	8
Calhoun	10	131.9	106.2	1
Clay	8	77.4	75.2	10
Doddridge	5	67.5	63.6	21
Fayette	37	77.8	61.3	26
Gilmer	3	41.9	37.4	49
Grant	4	35.4	29	52
Greenbrier	33	95.8	68.8	18
Hampshire	8	39.6	38.3	48
Hancock	34	104.1	77.5	9
Hardy	14	110.5	98.7	3
Harrison	56	81.6	61.1	27
Jackson	19	67.9	62.3	24
Jefferson	25	59.3	75.2	10
Kanawha	151	75.5	59.7	29
Lewis	16	94.6	70.4	15
Lincoln	18	81.4	87.2	6
Logan	15	39.8	41.4	44
McDowell	18	65.9	53.9	33
Marion	35	61.8	43.1	43
Marshall	20	56.3	48.2	41
Mason	8	30.8	28.7	53
Mercer	43	68.3	52.8	34
Mineral	15	55.4	48.8	40
Mingo	13	46	51.3	37
Monongalia	28	34.2	39.8	47
Monroe	7	48	40.5	45
Morgan	12	80.3	70.3	16
Nicholas	14	52.7	47.8	42
Ohio	51	107.5	73.5	12
Pendleton	8	97.6	70.1	17
Pleasants	3	39.9	33.1	50
Pocahontas	9	98.6	71.3	14
Preston	17	58	50.4	38
Putnam	22	42.6	51.7	35
Raleigh	56	70.7	59.6	30
Randolph	20	70.8	56.4	32
Ritchie	8	77.3	63.3	22
Roane	16	103.6	92.8	4
Summers	3	23.1	15.1	55
Taylor	10	62.2	49.6	39
Tucker	3	41	27.6	54
Tyler	7	73	59.3	31
Upshur	12	51.3	40.3	46
Wayne	40	93.2	91.6	5
Webster	12	123.5	103.2	2
Wetzel	14	79.1	65.9	19
Wirt	3	51.1	51.5	36
Wood	64	72.7	60.1	28
Wyoming	8	31.1	31.6	51

*Adjusted by age to the 2000 U.S. standard million from the 2000 Census populations for each county.

REFERENCES

1. American Heart Association. *Heart Disease and Stroke – 2004 Update.* Dallas, Tex.: American Heart Association, 2003.

2. American Heart Association. Stroke statistics. Online. 27 August 2003. <http://www.americanheart.org/presenter.jhtml?identifier=4725>

3. Howard G, Howard VJ, Katholi C, Oli MK, and Huston S. Decline in US stroke mortality. *Stroke* 2001;32:2213.

4. Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion. Cardiovascular health. Online. 7 October 2003. <http://www.cdc.gov/cvh/maps/strokeatlas/02-introduction.htm>

5. Elkins JS and Johnston SC. Thirty-year projections for deaths from ischemic stroke in the United States. *Stroke* 2003;34:2109.

6. HeartCenterOnline for Patients. Transient ischemic attack. Online. 12 August 2003. <http://www.heartcenteronline.com/myheartdr/common/articles...>

7. Kelly-Hayes M, Wolf PA, Kase CS, Brand FN, McGuirk JM, and D'Agostino RB. Temporal patterns of stroke onset: the Framingham Study. *Stroke* 1995;26:1343-1347.

8. Jakovljevic D, Salomaa V, Sivenius J, Tamminen M, Sarti C, Salmi K, Kaarsalo E, Narva V, Immonen-Raiha P, Torppa J, and Tuomilehto J. Seasonal variation in the occurrence of stroke in a Finnish adult population: the FINMONICA Stroke Register. *Stroke* 1996;27:1774-1779.

9. Oberg AL, Ferguson JA, McIntyre, and Horner RD. Incidence of stroke and season of the year: evidence of an association. *Am J Epidemiol* 2000;152:558-564.

10. Pancioli AM, Broderick J, Kothari R, Brott T, Tuchfarber A, Miller R, Khoury J, and Jauch E. Public perception of stroke warning signs and knowledge of potential risk factors. *JAMA* 1998;279:1288-1292.

11. National Stroke Association. Classes of acute treatment. Online. 26 August 2003. <http://209.107.44.93/NationalStroke/SymptomsAndTreatments>

12. National Institute of Neurological Disorders and Stroke. New stroke treatment likely to decrease health care costs and increase quality of life. Online press release. 22 April 1998. <http://www.ninds.nih.gov/news_and_events/pressrelease.htm>

13. Stroke-TIA.org Health Professionals. Update on acute stroke therapy. Online. 21 January 2004. <http://www.stroke-tia.org/stroke-tia/transcripts/1102.asp>

14. MEDLINEplus Health Information. Medical Encyclopedia. Thrombolytic therapy (tissue plasminogen activator - tPA). Online. 21 January 2004. <http://www.nlm.nih.gov/medlineplus/ency/article/007089.htm>

15. Yale-New Haven Hospital: HealthLINK: Women's Health. Clot-dissolving treatment for stroke investigated. Online. 8 May 2000. <http://www.ynhh.org/healthlink/womens>

16. The stroke management challenge: Is tPA the standard of care - and should it be? *Medical Crossfire* 2002;4(3).

17. Experimental device shows promise in fighting strokes. *Charleston Gazette*. 21 October 2003.

18. Hinkle JL and Bowman L. Neuroprotection for ischemic stroke. *J Neurosci Nurs* 2003;35(2).

19. University of Pittsburgh Office of News & Information. Pitt campaign chronicle: Leading the way. Online. 21 January 2004. <http://www.discover.pitt.edu/media/pcc020701>

20. Stein K. Bridge over troubled neurons. *Circuit City*. Online. 21 January 2004. <http://www.eventhorizon.com/samples/live_science/circuit>

21. NIMAST. Departments of Nutrition and Dietetics and Speech and Language Therapy. Difficulty swallowing. Online. 7 October 2003. <http://www.stroke.cwc.net>

22. Ramasubbu R. Psychobiology of stroke: a neglected area. Letter. *CMAJ* 1999;160:780.

23. Wilner A. Who is at risk for post-stroke dementia? *Neurology Reviews.Com*: Clinical trends and news in neurology. Online. <http://www.neurologyreviews.com/feb03/poststroke.html>

24. Estrogen therapy ineffective in preventing stroke, study finds. *Yale Bulletin & Calendar*. Online. 2 November 2001. <http://www.yale.edu/opa/v30.n9/story10.html>

25. Fast Facts: stroke. DrDonnica.com. Online. 8 September 2003. <http://www.drdonnica.com/display.asp?article=4385>

26. After stroke: the facts of stroke. Online. 11 February 2004. <http://www.lightparty/Health/STROKE.html>

27. Kelly-Hayes M, Beiser A, Kase CS, Scaramucci A, D'Agostino RB, and Wolf PA. The influence of gender and age on disability following ischemic stroke: the Framingham Study. *J Stroke Cere Dis* 2003;12(3).

28. American Heart Association. Stroke rehabilitation. *Heart and Stroke Encyclopedia*. Online. 27 August 2003. <http://www.americanheart.org/presenter.jhtml?identifier=4713>

29. Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion. Behavioral Risk Factor Surveillance System. Prevalence data. Online. <http://apps.nccd.cdc.gov/brfss...>

30. Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion. *The Burden of Chronic Diseases and Their Risk Factors*. Section II: The burden of heart disease, stroke, cancer, and diabetes, United States. Online. 11 February 2002. <http://www.cdc.gov/nccdphp/burdenbook2002/02_stroke.htm>

31. Health and Age. Stroke. Online. 1 September 2003. <http://www.healthandage.com/Home>

32. Fullerton HJ, Wu YW, Zhao S, and Johnston SC. Risk of stroke in children: ethnic and gender disparities. *Neurology* 2003;61:189-194.

33. Ayala C, Croft JB, Greenlund KJ, Keenan NL, Donehoo RS, Malarcher AM, and Mensah GA. Sex differences in US mortality rates for stroke and stroke subtypes by race/ethnicity and age, 1995-1998. *Stroke* 2002;33:1197.

34. Gorelick PB. Presidential Symposium Address: Cerebrovascular disease in African Americans. *Stroke* 1998;29:2656-2664.

35. Casper ML, Barnett E, Williams GI Jr., Halverson JA, Braham VE, Greenlund KJ. *Atlas of Stroke Mortality: Racial, Ethnic, and Geographic Disparities in the United States*. Atlanta, GA: Department of Health and Human Services, Centers for Disease Control and Prevention; January 2003.

36. Bian J, Oddone MD, and Samsa GP. Racial differences in survival post cerebral infarction among the elderly. *Neurology* 2003;60:285-290.

37. Centers for Disease Control and Prevention. Age-specific excess deaths associated with stroke among racial/ethnic minority populations – United States, 1997. *MMWR* 2000;49:94-97.

38. Modan B and Wagener DK. Some epidemiological aspects of stroke: mortality/morbidity trends, age, sex, race, socioeconomic status. *Stroke* 1992;23:1230-1236.

39. Casper ML, Wing S, and Strogatz D. Variation in the magnitude of black-white differences in stroke mortality by community occupational structure. *J Epidemiol Community Health* 1991;45:302-306.

40. Lantz PM, House JS, Lepkowski JM, Williams DR, Mero RP, and Chen J. Socioeconomic factors, health behaviors, and mortality. *JAMA* 1998;279:1703-1708.

41. Bak S, Gaist D, Sindrup SH, Skytthe A, and Christensen K. Genetic liability in stroke: a long-term follow-up study of Danish twins. *Stroke* 2002;33:769.

42. Liao D, Myers R, Hunt S, Shahar E, Paton C, Burke G, Province M, and Heiss G. Familial history of stroke and stroke risk: the Family Heart Study. *Stroke* 1997;28:1908-1912.

43. Health 24. Stroke runs in the family. Online. 30 September 2003. <http://www.health24.co.za/news/Stroke/1-947,21968.asp>

44. Wade N. Gene behind stroke is uncovered, scientists say. *International Herald Tribune*. Online. 22 September 2003. <http://www.iht.com/articles/110734.html>

45. Woo D, Sauerbeck LR, Kissela BM, Khoury JC, Szaflarski JP, Gebel J, Shukla R, Pancioli AM, Jauch EC, Menon AG, Deka R, Carrozzella JA, Moomaw CJ, Fontaine RN, and Broderick JP. Genetic and environmental risk factors for intracerebral hemorrhage. *Stroke* 2002;33:1190.

46. ScienceDaily. Genetic abnormality may increase stroke risk fourfold among young. Online. 7 June 2002. <http://www.sciencedaily.com/releases/2002/06/020607074229.htm>

47. Nighttime blood pressure and stroke risk. *Diabetes This Week*. Online. 31 December 2000. <http://www.diabetesnet.com/news/news123100.php>

48. American Heart Association. High blood pressure statistics. Online. 6 October 2003. <http://www.americanheart.org/presenter.jhtml;jsessionid...>

49. Pediatric Oncall. Hypertension (high blood pressure) in children. Online. 27 August 2003. <http://www.pediatriconcall.com/forpatients/CommonChild>

50. American Society of Hypertension. *Understanding Hypertension: Patient Information Guide*. New York: American Society of Hypertension, 2000.

51. WebMDHealth. High blood pressure (hypertension). Online. 5 December 2003. <http://my.webmd.com/content/healthwise/161/51164.htm>

52. American Heart Association. Women, heart disease and stroke statistics. *Heart & Stroke Encyclopedia*. Online. 27 August 2003. <http://www.americanheart.org/presenter.jhtml?identifier=4787>

53. Martin Memorial Health Systems. Cardiovascular diseases: risk factors for stroke. Online. 3 September 2003. <http://www.mmhs.com/clinical/adult/english/cardiac/strkrisk.htm>

54. National Stroke Association. Controllable stroke risk factors. Online. 26 August 2003. <http://209.107.44.93/NationalStroke/StrokePrevention>

55. Diabetic-lifestyle.com. Stroke – signals and risk factors. Online. June 1999. <http://www.diabetic-lifestyle.com/articles/jun99_whats_1.htm>

56. Chicago Institute of Neurosurgery and Neuroresearch. Stroke risk factors. Online. 16 February 2004. <http://www.cinn.org/ibsc/stroke/strokeriskfactors.html>

57. Shinton R and Beevers G. Meta-analysis of relation between cigarette smoking and stroke. *BMJ* 1989 Mar 25;298(6676):789-94.

58. Broderick JP, Viscoli CM, Brott T, Kernan WN, Brass LM, Feldmann E, Morganstern LB, Wilterdink JL, and Horwitz RI. Major risk factors for aneurysmal subarachnoid hemorrhage in the young are modifiable. *Stroke* 2003;34:1375.

59. GlobalTechnoScan.com. Bleeding strokes in young and middle-aged adults largely preventable. *Weekly Magazine*. Online. 28 May 2003. <http://www.globaltechnoscan.com/28thMay-June03/strokes.htm>

60. Wannamethee SG, Shaper AG, Whincup PH, and Walker M. Smoking cessation and the risk of stroke in middle-aged men. *JAMA* 1995;274(2):155.

61. You RX, Thrift AG, McNeil JJ, Davis SM, and Donnan GA. Ischemic stroke risk and passive exposure to spouses' cigarette smoking. Melbourne Stroke Risk Factor Study (MERFS) Group. *Am J Public Health* 1999;89(4):572-575.

62. West Virginia Department of Education and West Virginia Department of Health and Human Resources. *2002 West Virginia Youth Tobacco Survey*. Charleston, WV: West Virginia Department of Health and Human Resources, 2003.

63. Suk SH, Sacco RL, Boden-Albala B, Cheun JF, Pittman JG, Elkind MS, and Paik MC. Abdominal obesity and risk of ischemic stroke: the Northern Manhattan Stroke Study. *Stroke* 2003;34:1586.

64. Risk of stroke from obesity is now measurable. *Harvard University Gazette*. 12 December 2002.

65. Rexrode KM, Hennekens CH, Willett WC, Colditz GA, Stampfer MJ, Rich-Edwards JW, Speizer FE, and Manson JE. A prospective study of body mass index, weight change, and risk of stroke in women. *JAMA* 1997;277(19):1539.

66. University of Michigan Health System. Leptin linked to obesity and blood clots. UMHS news release. Online. 2 April 2002. <http://www.med.umich.edu/opm/newspage/2002>

67. Soderberg S, Stegmayr B, Ahlbeck-Glader C, Slunga-Birgander L, Ahren B, and Olsson T. High leptin levels are associated with stroke. *Cerebrovasc Dis* 2003;15(1-2):63-9.

68. Soderberg S, Ahren B, Stegmayr B, Johnson O, Wiklund PG, Weinehall L, Hallmans G, and Olsson T. Leptin is a risk marker for first-ever hemorrhagic stroke in a population-based cohort. *Stroke* 1999;30:328-337.

69. Koren-Morag N, Tanne D, Graff E, and Goldbourt U. Low- and high-density lipoprotein cholesterol and ischemic cerebrovascular disease: the bezafibrate infarction prevention registry. *Arch Intern Med* 2002;162(9):993-9.

70. LoweringCholesterol.net. Triglycerides a risk factor for stroke. *News in Science*. Online. 12 December 2001. <http://www.loweringcholesterol.net/story/triglycerides...>

71. American Federation for Aging Research. Stroke information center: what are the risk factors for stroke? Online. 12 February 2004. <http://www.infoaging.org/d-stroke-3-risk.html>

72. The Stroke Foundation of New Zealand. Preventing stroke: stroke risk factors. Online. 12 February 2004. <http://www.stroke.org.nz/prevention/risk_factors.html>

73. American Heart Association. Diabetes and hypertension combo invite silent stroke. Online. 19 September 2003. <http://www.americanheart.org/presenter.jhtml?identifier=3015383>

74. Jorgensen J, Nakayama H, Raaschou HO, and Olsen TS. Stroke in patients with diabetes: The Copenhagen Stroke Study. *Stroke* 1994;25(10):1977-84.

75. Colorado HealthSite. Physical activity and stroke risk. Online. 16 December 2003. <http://www.coloradohealthsite.org/CHNReports/stroke>

76. Sacco RL, Boden-Albala B, Lin IF, Kargman DE, Hauser WA, Shea S, and Paik MC. Leisure-time physical activity and ischemic stroke risk: the Northern Manhattan Stroke Study. *Stroke* 1998;29(2):380-7.

77. Reynolds K, Lewis LB, Nolen JDL, Kinney GL, Sathya B, and He J. Alcohol consumption and risk of stroke. *JAMA* 2003;289(5):579.

78. Doctor's Guide. Some alcohol use helps women curb stroke risk. Online. 4 January 2001. <http://www.docguide.com/news/content.nsf/news...>

79. American Cancer Society. Moderate alcohol consumption may prevent stroke. *ASC News Today*. Online. 9 February 1999. <http://www.cancer.org/docroot/NWS/content/NWS>

80. Kissela BM, Sauerbeck L, Woo D, Khoury J, Carrozzella J, Pancioli A, Jauch E, Moomaw CJ, Shukla R, Gebel J, Fontaine R, and Broderick J. Subarachnoid hemorrhage: a preventable disease with a heritable component. *Stroke* 2002;33:1321.

81. EurekAlert. Moderate alcohol use may be associated with brain shrinkage. Online. 4 December 2003. <http://www.eurekalert.org/pub_releases/2003-12...>

82. BBC News. Stroke warning to binge-drinkers. Online. 16 December 2003. <http://www.bbc.co.uk/1/hi/health/3321425.stm>

83. Joshipura KJ, Ascherio A, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, Hennekens CH, Spiegelman D, and Willett WC. Fruit and vegetable intake in relation to risk of ischemic stroke. *JAMA* 1999;282(13):1233-1239.

84. Sauvaget C, Nagano J, Allen N, and Kodama K. Vegetable and fruit intake and stroke mortality in the Hiroshima/Nagasaki Life Span Study. *Stroke* 2003;34:2355.

85. He K, Rimm EB, Merchant A, Rosner BA, Stampfer MJ, Willett WC, and Ascherio A. Fish consumption and the risk of stroke in men. *JAMA* 2002;288(24):3130.

86. Iso H, Rexrode KM, Stampfer ML, Manson JE, Colditz GA, Speizer FE, Hennekens CH, and Willett WC. Intake of fish and omega-3 fatty acids and risk of stroke in women. *JAMA* 2001;285(3):304.

87. Ascherio A, Rimm EB, Hernan MA, Giovannucci EL, Kawachi I, Stampfer ML, and Willett WC. Intake of potassium, magnesium, calcium, and fiber and risk of stroke among US men. *Circulation* 1998;98:1198-1204.

88. Liu S, Manson JE, and Stampfer ML. Whole grain consumption and risk of ischemic stroke in women: a prospective study. *JAMA* 2000;284:1534-40.

89. AME/MUSC. What is sickle cell anemia? *Fact Sheets*. Online. 18 December 2003. <http://health-e-ame.com/factsheets/sicklecell.php>

90. St. Jude Children's Research Hospital. Reducing stroke risk in African Americans. *Medical & Science News*. Online. 18 December 2003. <http://www.stjude.org/media...>

91. Cardinal F. Snoring, apnea and strokes. *What You Need to Know about Sleep Disorders*. Online. 26 August 2003. <http://sleepdisorders.about.com/library/weekly/aa021801a.htm>

92. Eikelboom JW, Lonn E, Genest J Jr., Hankey G, and Yusuf S. Homocyst(e)ine and cardiovascular disease: a critical review of the epidemiologic evidence. *Ann Intern Med* 1999;131(5):363-375.

93. Bostom AJ, Rosenberg IH, Silbershatz H, Jacques PF, Selhub J, D'Agostino RB, Wilson PWF, and Wolf PA. Nonfasting plasma total homocysteine levels and stroke incidence in elderly persons: the Framingham Study. *Ann Intern Med* 1999;131(5):352-355.

94. Fallon UB, Virtamo J, Young I, McMaster D, Ben-Shlomo Y, Wood N, Whitehead AS, and Smith GD. Homocysteine and cerebral infarction in Finnish male smokers. *Stroke* 2003;34:1359.

95. Boysen G, Brander T, Christensen H, Gideon R, and Truelsen T. Homocysteine and risk of recurrent stroke. *Stroke* 2003;34:1258.

96. American Heart Association. Inflammation, heart disease and stroke: the role of C-reactive protein. Online. 13 February 2004. <http://www.americanheart.org/presenter.jhtml...>

97. Edelson E. Inflammation molecules signal heart risk. *HealthDay*. Online. 20 October 2003. <http://www.altcorp.com/AffinityLaboratory/crpinflammation.htm>

98. Shah PK. Circulating markers of inflammation for vascular risk prediction. *Circulation* 2000;101:1758.

99. Lindsberg PJ and Grau AJ. Inflammation and infections as risk factors for ischemic stroke. *Stroke* 2003;34:2518.

100. American Stroke Association. Tooth loss may be early warning sign of cardiovascular disease. *Stroke Journal Report*. Online. 1 August 2003. <http://www.strokeassociation.org/presenter.jhtml....>

101. Doctor's Guide. Migraine a risk factor for stroke in women, oral contraception pill adds to risk. Online. 2 November 1999. <http://www.docguide.com/news/content.nsf/news...>

102. Miranda J and O'Neill D. Stroke associated with amphetamine use. *Irish Medical Journal* 2002;95(9).

103. AllRefer Health. Stroke secondary to cocaine. Online. 22 January 2004. <http://health.allrefer.com/health/stroke...>

104. McLean Hospital. Frequent cocaine use linked to heart attack and stroke. Press release. Online. 8 May 2002. <http://www.mcleanhospital.org/PublicAffairs/20020508...>

105. Medical College of Wisconsin. Cocaine use increases risk of hemorrhagic stroke. HealthLink. Online. 24 April 2000. <http://healthlink.mcw.edu/article/956624781.html>

106. Everson SA, Kaplan GA, Goldberg DE, Lakka TA, Sivenius J, and Salonen JT. Anger expression and incident stroke. *Stroke* 1999;30:523-528.

107. Truelsen T, Nielsen N, Boysen G, and Gronbaek M. Self-reported stress and risk of stroke: the Copenhagen City Heart Study. *Stroke* 2003;34:856.

108. UK Prospective Diabetes Study (UKPDS) Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes. *BMJ* 1998;317:703-13.

109. Caplan L. Asymptomatic carotid bruit. *Best Practice of Medicine*. Online. 14 November 2001. <http://merck.praxis.md/index.asp?page=bpm>

110. American Medical Women's Association. Position paper on cerebrovascular disease in women. Online. 24 April 2000. <http://www.amwa-doc.org/publications/Position_Papers...>

111. Horner RD, Oddone EZ, and Matchar DB. Theories explaining racial differences in the utilization of diagnostic and therapeutic procedures for cerebrovascular disease. *Milbank Q* 1995;73(3).

112. Samsa GP, Bian J, Lipscomb J, and Matchar DB. Epidemiology of recurrent cerebral infarction: a Medicare claims-based comparison of first and recurrent strokes on 2-year survival and cost. *Stroke* 1999;30:338-349.

113. Cohen JW and Krauss NA. Spending and service use among people with the fifteen most costly medical conditions, 1997. *Health Aff* 2003;22(2):129-138.

114. Taylor TN, Davis PH, Torner JC, Holmes J, Meyer JW, and Jacobsen MF. Lifetime cost of stroke in the United States. *Stroke* 1996;27:1459-1466.

115. Hass SL, Ransom JE, Brown RD, O'Fallon WM, Whisnant JP, and Leibson CL. The impact of stroke on the cost and level of care in nursing homes: a retrospective population-based study. *Mayo Clin Proc* 2001;76:493-500.

116. Centers for Disease Control and Prevention. Public health and aging: hospitalizations for stroke among adults aged 65+ years – United States, 2000. *MMWR* 2003;52(25):586-589.

117. Morgan KO and Morgan S, eds. *Health Care State Rankings 2003*. Lawrence, KS: Morgan Quitno Press, 2003.

118. Centers for Disease Control and Prevention. State-specific mortality from stroke and distribution of place of death – United States, 1999. *MMWR* 2002;51(20):429-433.

119. Duke University Medical Center. Stroke survival, disability influenced by who cares for patients, study finds. News release. Online. 29 October 1996. <http://dukemednews.duke.edu/news/article.php...>

120. National Institute of Neurological Disorders and Stroke. Recommendations for the establishment of primary stroke centers. Online. 26 January 2004. <http://www.ninds.nih.gov/health_and_medical/stroke...>

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