Chapter 3
Spinal Deformity and Related Conditions

The term spinal deformity includes several conditions in which the spine is abnormally curved or aligned. One of the more frequent spinal deformities is scoliosis, or a side-to-side abnormal curvature of the spine. Spinal deformity and scoliosis can be found at birth due to genetic causes, develop during childhood, or develop late in life due to degenerative disc and joint disease.

Common signs of scoliosis are a prominent shoulder, shoulder blade, or chest wall asymmetry. Another sign is uneven hips with one hip seemingly higher than the other. (Figure 3.0.1) It is important not to confuse scoliosis with poor posture and to realize that scoliosis will usually not disappear with age. Other deformities include kyphosis, an exaggerated rounding of the back that may occur by itself or in conjunction with osteoporosis, and spondylolisthesis, a slippage of one vertebra onto its neighboring vertebra. A variety of other spinal deformity conditions will be discussed in this chapter including spondylolysis and Scheuermann kyphosis.

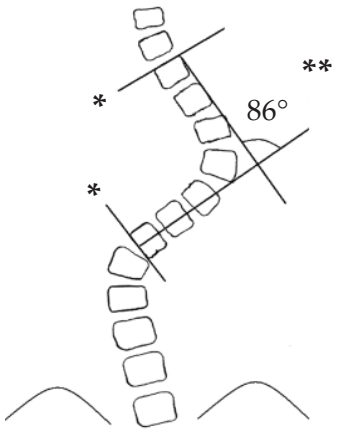
In spite of the severity of these conditions and the impact they have on the lives of children and adults, the prevalence of spinal deformities in children under the age of 18 is difficult to determine due to relatively low numbers and the degree to which the condition manifests initially in pain or disability. Estimated prevalence of spinal deformity conditions has been cited in numerous studies. (Table 3.1)

Section 3.1: Scoliosis and Spinal Deformity in Children

There are several different types of scoliosis. The most common type of scoliosis is idiopathic, meaning the cause of the curve is unknown. Approximately 80% to 85% of scoliosis cases are idiopathic.[1] Idiopathic scoliosis can initially occur as early as the first three years of life (infantile idiopathic scoliosis), from 4 to 10 years of age (juvenile idiopathic scoliosis), or from 10 years of age to skeletal maturity (adolescent idiopathic scoliosis). Adolescent idiopathic scoliosis is the most common type.

Figure 3.0.1: Scoliosis

Figure 3.1.1: Cobb Angle



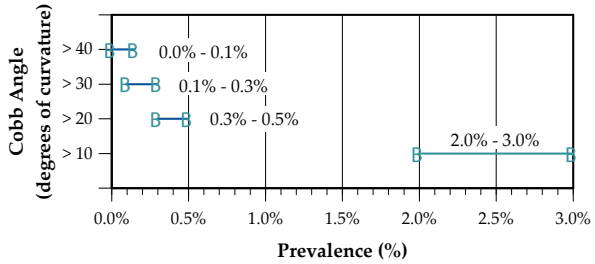
*Both lines are drawn along the end of the vertebrae that are most tilted from the horizontal.
** The Cobb angle is the angle formed by the intersection of these two lines.

Scoliosis, if severe enough (>25°), is usually treated with bracing if the child is growing or with surgery if the curvature is more severe (>45°-50°). The standard radiographic/x-ray measurement technique for all forms of scoliosis is the Cobb angle measurement technique (Figure 3.1.1), measured from the end-plates of the maximally tilted end vertebral bodies in a standing radiograph.[2] Whether the curve is >25° or >40°-45°, the treatment is preventive in nature, helping to avoid progression of the curve and more significant future problems if left untreated. While this preventive aspect is hugely valuable and intuitively important, its benefit is difficult to measure from a public health standpoint, especially for rare conditions of childhood, such as juvenile and adolescent pediatric scoliosis.

Section 3.1.1: Adolescent Idiopathic Scoliosis

According to the Scoliosis Research Society (SRS), idiopathic scoliosis is diagnosed when a patient has asymmetry on forward bending combined with a curve of at least 10°.[3] By this definition, the prevalence of adolescent idiopathic scoliosis in children from 10 to 16 years of age is 2%-3%. (Table 3.2 and Graph 3.1.1) Though the male-to-female ratio for smaller curves is about equal, larger curves seem to be more common in females. Similar results were found in a study conducted in 1985, where 29,195 children were screened for idiopathic scoliosis.[4]

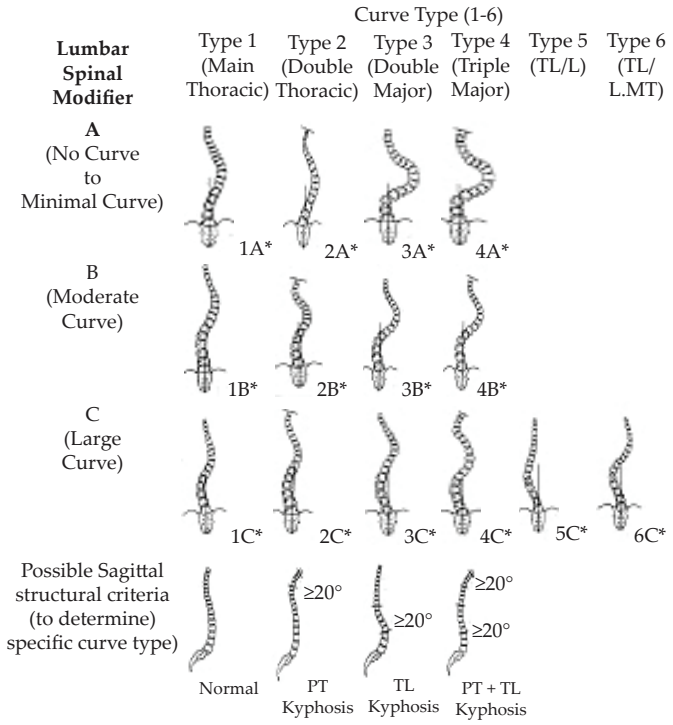
Graph 3.1.1: Prevalence of Adolescent Idiopathic Scoliosis



Source: Weinstein SL: Adolescent idiopathic scoliosis: Prevalence and natural history. *Instr Course Lect* 1988;38:115–126.

Several studies have investigated the natural history and natural course of curve progression in adolescent idiopathic scoliosis. All report the strongest predictive factors in the development of idiopathic scoliosis are age, magnitude of curve, and gender.[5-9] Girls are more likely to have adolescent idiopathic scoliosis than boys, and some

Figure 3.1.2: Lenke Classification



Source: Lenke LG, Betz RR, Harms J, et al: Adolescent idiopathic scoliosis: A new classification to determine extent of spinal arthrodesis. *J Bone Joint Surg Am* 2001;83(8):1169-81.

studies report the onset is earlier in girls than boys. A factor highly correlated with curve progression is age at diagnosis; patients diagnosed at a younger age have a greater risk of curve progression. It should be noted, however, that those diagnosed at a younger age seem to have a more favorable response to milder forms of treatment, supporting school screening to detect and lead to earlier diagnosis for those children with a smaller degree of curvature.

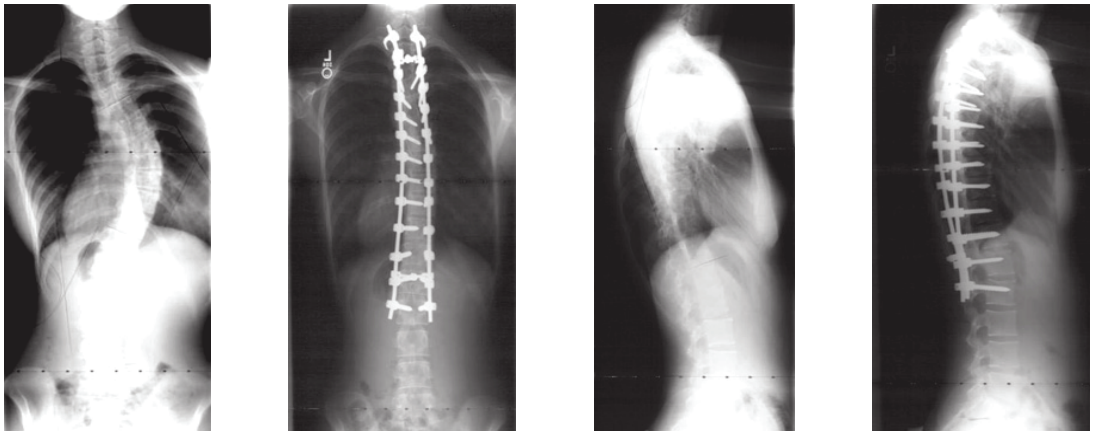
A two-dimensional classification system, the Lenke classification system, was developed to assess the type of a curve for adolescent idiopathic scoliosis. (Figure 3.1.2)

The three components included in this system include curve type, lumbar spine modifier, and sagittal thoracic modifier.[10] A study conducted in 2001 evaluated the prevalence of six curve types in 606 adolescent patients diagnosed with idiopathic scoliosis. Approximately one-half (51%) of the patients were found to have a Type 1, or main thoracic, curve.

Treatment decisions for individuals with adolescent idiopathic scoliosis are made based on location, shape, pattern, and cause of the curve. The treatment choice is also a function of the patient's future growth potential. Treatment choices include observation, bracing, and surgery. Observation is usually reserved for patients who have curves ≤25°. Bracing, which is used to stop curve progression (rather than for lasting correction of the curve), is usually used for patients who have curves ≥25° and who are still growing. Surgery is generally used for patients with curves ≥45°. (Figure 3.1.3)

While technical outcomes of surgery are well known and show obvious benefits for those with significant deformity, long-term health-related outcomes have yet to be precisely documented. The paucity of high-quality, long-term studies of sufficient size hampers our understanding of the mortality and morbidity rates for patients with congenital and idiopathic scoliosis, both with and without treatment. Fifty years of follow-up studies of children and adolescents with untreated scoliosis have shown conflicting results, with some studies indicating a higher risk of mortality and respiratory compromise.[11,12] Another study shows compromise only in patients with early reduced lung function and a large curvature.[13] Yet another study has shown no differences in untreated childhood scoliosis and a control group.[14] Several articles from the 1960s and one recent article report that low back pain does not occur more frequently in untreated scoliosis patients than in the general population,[14-16] unless the curvature is greater than 40°.[17,18] It has also been shown that persons treated with surgery, rather than bracing, for adolescent idiopathic scoliosis have less pain at 10 to 20 year follow-up, although function remains similar.[19,20] The cosmetic/self-image aspect of scoliosis is obvious and important, and often a major factor affecting the lives of individuals with this condition.

Figure 3.1.3: Idiopathic Scoliosis



Section 3.1.2: Juvenile Idiopathic Scoliosis

In 12% to 21% of idiopathic scoliosis cases, the diagnosis is made between 4 and 10 years of age. When diagnosed at this age the condition is called juvenile idiopathic scoliosis.[21] Between the ages of 4 and 6, the female-to-male ratio of juvenile idiopathic scoliosis is 1:1; however, the ratio of female to male cases rises to between 2:1 and 4:1 in children between the ages of 4 and 10, and to 8:1 in children who are 10 years of age.[21] Both right and left curves are found with equal frequency for patients younger than 6 years, but rise to a 3:1 ratio of right versus left thoracic curves after the age of 6.[22]

Observation is the main treatment for patients with a small curve less than 20° to 25°. Follow-up visits are recommended every 4, 6, 9, or 12 months depending on the patient's age, the degree of the curve, and the characteristics of the clinical deformity.[21]

Curves between 25° and 50° are usually treated with bracing in this age group. Bracing can be done either on a part-time or full-time basis, depending on the size of the curve as well as the age of the child.[21] A study completed in 1982 evaluating the success of bracing reported an excellent prognosis when part-time bracing was utilized for patients with a curve of ≤35° and rib-vertebra angle difference (RVAD)[i] of ≤20°; however, curves ≥45° and RVAD of ≥20° had a less favorable prognosis for successful treatment with bracing.[21]

Overall, the curve patterns in patients with juvenile idiopathic scoliosis are similar to those with adolescent idiopathic scoliosis. Approximately 70% of patients with juvenile idiopathic scoliosis exhibit curve progression and require some form of treatment. In a study conducted in 1981, 55 of 98 patients (56%) with juvenile idiopathic scoliosis required spinal surgery.[21] The most common and traditional surgery is posterior instrumentation and fusion.[21]

Section 3.1.3: Infantile Idiopathic Scoliosis

Infantile scoliosis currently accounts for less than 1% of all cases of idiopathic scoliosis in the United States. Boys are affected by infantile idiopathic scoliosis at a higher rate than girls (3:2 ratio).[23] Infantile scoliosis curves tend to be left-sided (75%-90%). Past studies have indicated this rare type of scoliosis occurs more frequently in Europe than in North America.[24]

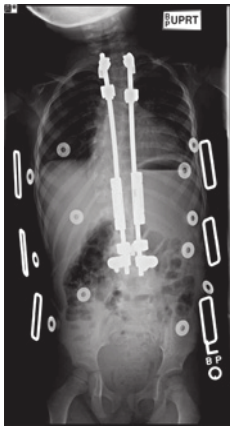
Treatment for patients with infantile idiopathic scoliosis is determined by anticipated or actual curve progression.[23] In addition to measuring the Cobb angle, the RVAD is used as a common predictor of curve progression.[25] Patients with a Cobb angle of ≤25° and a RVAD of ≤20° are at a low risk for progression and should be re-evaluated every 4 to 6 months.[23]

Nonoperative treatment, such as bracing or casting, will be initiated if a curve progression of ≥ 10° occurs. Surgical treatment should be considered when nonoperative measures, including both bracing and casting, are not successful.[23] Surgical treatment is utilized when a curve is ≥ 45° and progressive in an immature child.[23] Overall, surgical methods are continually evolving with the goal of obtaining and maintaining curve correction while simultaneously preserving or encouraging spinal and trunk growth.

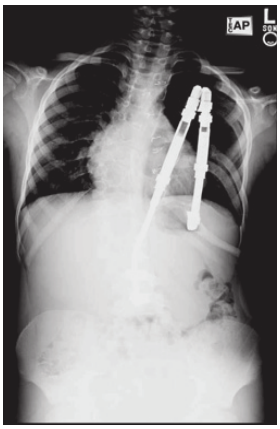
Surgical options currently utilized include various types of spinal fusion or hemiepiphysiodesis, a minimally invasive implant procedure to slow progression of curve growth. Additional techniques include growing-rod instrumentation (rods that expand and support the deformed spine) and vertical expandable (telescoping) prosthetic

[i] **RVAD - Rib Vertebral Angle Degree**: The angle formed on each side between the apical thoracic vertebra and its corresponding rib. The rib-vertebra angle difference is the difference between the rib-vertebral angle on the convexity of the curve subtracted from that on the concavity and may be either a positive or negative value. In a normal spine the rib-vertebra angle difference at any vertebra is zero. Resolving curves are nearly always thoracic and when first seen the rib-vertebral angle difference is less than 20° in 80% of patients. The usual pattern is for the rib-vertebral angle difference to decrease as the curve resolves. (DS Bradford, 1987) Available at: http://www.infantilescoliosis.org/terms_and_definitions.htm. Accessed August 15, 2010.

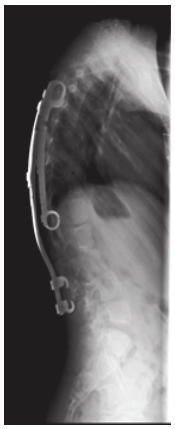
Figure 3.1.4: Infantile Idiopathic Scoliosis



Growing Rod



VEPTR: Back view



VEPTR: Side view

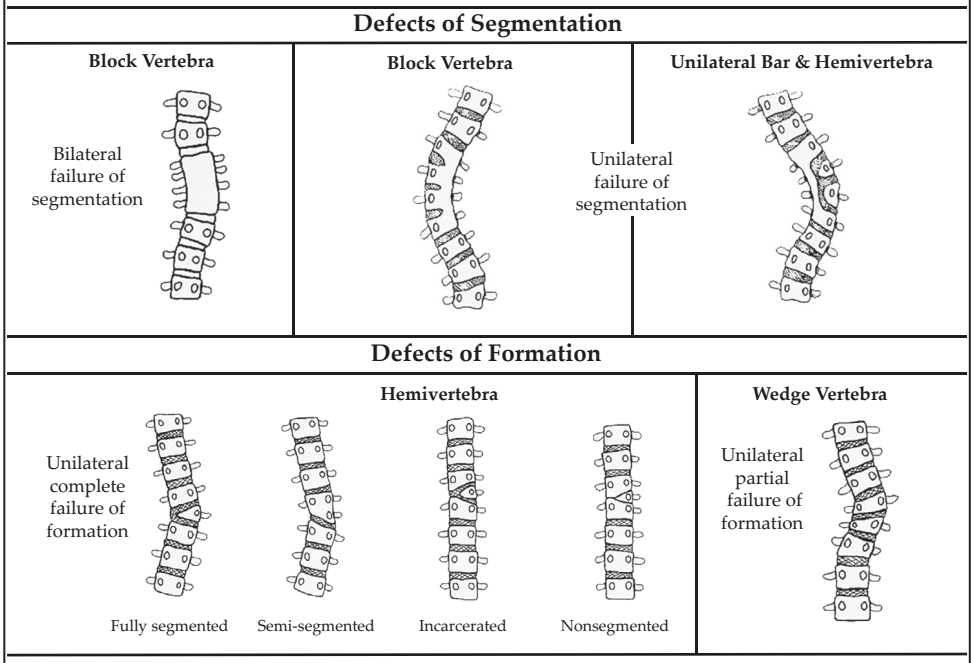
Section 3.1.4: Congenital Scoliosis

Congenital scoliosis is believed to affect approximately 1 child for every 1000 live births.[26] The cause is unknown in most cases, but in some cases it is associated with various syndromes. (Figure 3.1.5) Diagnosis is occasionally made during prenatal ultrasound. In cases of congenital scoliosis, additional congenital conditions, such as chest wall malformation or kidney or heart abnormalities, are often present.

Treatment options for congenital scoliosis are bracing and/or surgery, and are similar to those discussed for idiopathic scoliosis. Bracing is not as effective for congenital scoliosis as it is for idiopathic scoliosis.

Major abnormal spinal deformity presenting during infancy or early childhood poses a clinical problem because of the anticipated long growth period (at least 10 years); variable presentation and treatment methods; and the length of time that must pass before meaningful outcome results can be assessed in the small number of patients for definitive studies. Curves that result from congenital scoliosis are often not treated as easily as idiopathic curves because the deformity is in the bones rather than the soft tissue, causing the curve to be rigid.[27]

Figure 3.1.5: Congenital Anomalies



Source: McMaster MJ: Congenital scoliosis, in: Weinstein SL (ed): *The Pediatric Spine: Principles and Practice*, ed 2. Philadelphia, PA: Lippincott Williams & Wilkins; 2001; p 163.

titanium rib (VEPTR) instrumentation.[ii] (Figure 3.1.4) The goal of using surgical methods is to halt the progression of the curve and gain correction of the deformity, allowing maximum growth of the spine, lungs, and thoracic cage.[23]

[ii] **Titanium Rib or VEPTR** (Vertical Expandable Prosthetic Titanium Rib): An expandable titanium metal rod placed in a vertical position alongside the spine and attached to the ribs and pelvis or the spine. The VEPTR expands and supports a deformed chest wall cavity giving the lungs room to operate and grow. Used to treat many chest wall deforming and/or spine defect diagnoses which result in Thoracic Insufficiency Syndrome. Available at: http://www.infantilescoliosis.org/terms_and_definitions.htm. Accessed August 15, 2010.

Section 3.1.5: Neuromuscular Scoliosis

Scoliosis also occurs in conjunction with several congenital conditions that occur in infancy or childhood. These include muscular dystrophy, cerebral palsy, spina bifida, and spinal muscular atrophy. Scoliosis associated with these conditions is referred to as neuromuscular scoliosis. Both the likelihood and the severity of the scoliosis generally increases with the severity of the underlying condition. For example, a child with severe cerebral palsy who is unable to walk is more likely to have severe scoliosis than a child with mild cerebral palsy who can walk. These conditions are also discussed in Chapter 7, Congenital and Infantile Developmental Conditions of the Musculoskeletal System.

Cerebral palsy (CP) is defined as a nonprogressive disturbance in the developing brain of the fetus or infant. Musculoskeletal problems are frequently seen as a result of the motor disorder. The more common musculoskeletal problem is scoliosis. Besides bracing, which is usually an ineffective form of treatment for more severe muscular scoliosis, surgical procedures are frequently indicated in pediatric patients with CP. In 2005, more than 100,000 children under the age of 18 were disabled with CP, and its prevalence has increased by 18% in the past two decades.[28] In 1997, 37,000 pediatric patients were discharged from hospitals with a diagnosis of CP. Among these patients, spinal fusion with instrumentation was among the top five most commonly performed surgical procedures, and was performed on 765 patients that year in the United States. Treatment for CP with spinal fusion accounted for more than 4,000 hospital days and charges of nearly $40 million.[28]

The prevalence of spina bifida (a failure of the spine—usually, the lower spine—to close and form normally during fetal development) has decreased dramatically since the 1970s with the introduction of folic acid into the diet of pregnant women. Since 1990, the annual incidence of spina bifida has been reported at 3.2 cases per 10,000 live births, with no variation in ethnic groups observed.[29]

There are several different types of muscular dystrophy (i.e., abnormal function of muscle), but all are genetic in cause and due to a lack of protein that helps muscle cells function. The most common type is Duchenne muscular dystrophy, and it primarily affects males who inherit a defective gene through their mother.[30] Duchenne muscular dystrophy occurs in approximately 1 in 3500 live male births.[30] Many patients with Duchenne muscular dystrophy develop scoliosis by the age of 12.[31] Because muscular dystrophy is usually progressive, patients are typically treated surgically, usually with spinal fusion.[32] Potential advantages of surgery include comfort and sitting tolerance, cosmetic improvement, elimination of the need for orthopaedic braces, ease of nursing care for parents, and pain relief.

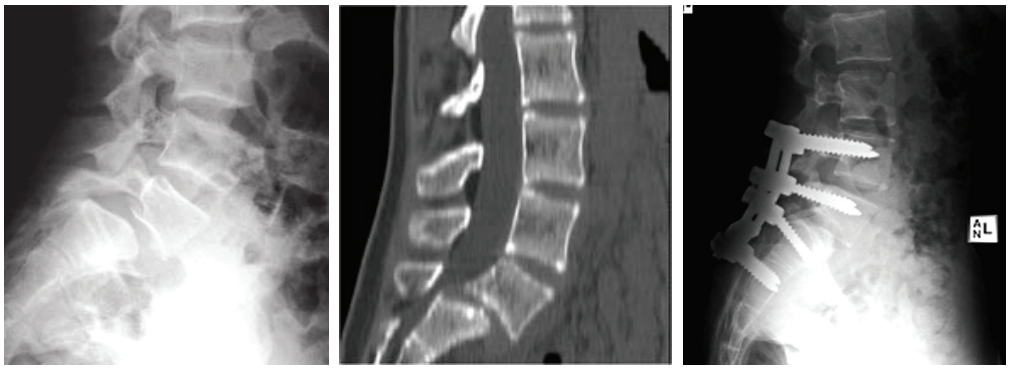
Spinal muscular atrophy (SMA) affects eight children out of every 100,000 live births. The prevalence of scoliosis for patients with SMA is directly related to the severity of the disease and the specific type of SMA that the patient has.[33] SMA equally affects both females and males.[34] There is no specific treatment for SMA, but bracing can slow the inevitable progression of a scoliotic curve and postpone surgical treatment in some cases. Surgical treatment is generally spinal fusion or a segmental spinal instrumentation, and is performed when the curve progresses to greater than 50° to 60°. The goal of surgical treatment is to improve balance and sitting capability of the patient.[33]

Section 3.2: Other Childhood Spinal Conditions

Additional spinal conditions seen in children include spondylolysis, a stress fracture of the lower end of the spine; spondylolisthesis, a condition where one of the spinal vertebrae (usually in the lower/lumbar spine) slips forward on the one below it; Scheuermann kyphosis, an often painful condition manifested in exaggerated roundness of the upper part of the spine; and others. Occasionally, children have herniated

discs that require surgical intervention. Children also can have different types of spinal infections and tumors. While most of these conditions are rare, they can cause significant disability if not recognized early and treated appropriately. Again, the preventive nature of treatment is intuitively obvious, but difficult to measure for these rare conditions.

Figure 3.2.1: Spondylolysis and Spondylolisthesis



Preoperative radiograph CT Scan Postoperative radiograph

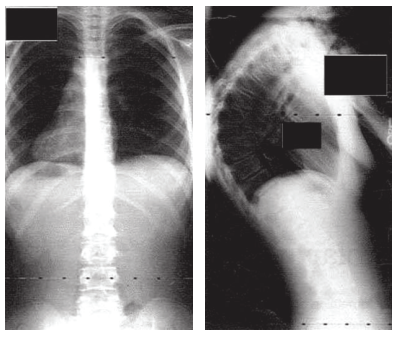
Section 3.2.1: Spondylolysis and Spondylolisthesis

Spondylolysis is disintegration or dissolution of a vertebra. It is usually accompanied by spondylolisthesis, a forward displacement of a lumbar vertebra on the one below it, especially the fifth lumbar vertebra on the sacrum, producing pain by compression of nerve roots. (Figure 3.2.1) Although spondylolysis is virtually nonexistent in newborns, by the age of 6 the incidence has reached approximately 6% for the general pediatric population. Both spondylolysis and spondylolisthesis are found at higher levels in certain populations. Examination of Eskimo skeletons indicates the incidence of spondylolysis is 13% in pediatric patients. A study conducted in 1953 found an overall incidence of 4.2% in the general pediatric population, with incidence of 6.4% in white males, 2.8% in black males, 2.3% in white females, and 1.1% in black females. Most reports have found a higher incidence of spondylolysis in males than in females (2:1 ratio, respectively), although females have a higher risk of progression.[35]

Many children with spondylolysis do not experience back pain and, therefore, may not require treatment. If the child remains asymptomatic, he or she is examined every 3 to 6 months; if the child begins to experience pain, a bone scan and proper radiographs are often used to reassess the situation and confirm the diagnosis. Conservative management, such as bracing, may help. Spondylolysis that progresses or remains painful in spite of conservative measures, and which interferes with daily activities, is treated with a localized spinal fusion. A similar observation/treatment pattern is used for children with spondylolisthesis. Surgery is recommended if the slip of one vertebra over another is greater than 50%. Overall, the goal of surgery for either condition is to stabilize the spondylolytic segment, prevent further slippage, relieve pain and/or nerve root irritation, and prevent neurological deficit. When indicated, surgery can help correct hamstring tautness, poor posture, and abnormality of gait.[34]

Figure 3.2.2: Scheuermann Kyphosis

Note the increased curvature of the upper back associated with wedging and end plate irregularity of individual vertebrae at the apex.



Section 3.2.2: Scheuermann Kyphosis

Scheuermann kyphosis affects 0.4% to 8% of healthy children. Kyphosis is an exaggerated outward curvature of the thoracic region of the spinal column resulting in a rounded upper back. (Figure 3.2.2) There is no definitive answer to whether it affects males or females at higher rates, with prevalence leaning to both sexes found in studies.[36] Patients who are skeletally mature with acceptable kyphosis (curvature) and no observable symptoms do not require treatment. If the individual is still growing and the kyphosis is severe, treatment is required, and bracing or casting is usually used, with surgery rarely indicated and only for skeletally mature patients with chronic back pain and a curve of more than 60°.[34]

Section 3.3: Adult Spinal Deformity and Degenerative Scoliosis

Deformity of the adult spine includes patients with curvature of the spine (scoliosis) of varying magnitudes caused or impacted by degenerative disc and joint disease. Adult scoliosis may be the result of persistent or progressive deformity since adolescence or a new, de novo, onset of deformity as a result of degeneration or "aging" of the spine. Degenerative scoliosis accounts for the majority of scoliosis cases in older populations aged 65 years and older, as reflected in the low proportion of older patients with a diagnosis of primary idiopathic scoliosis.

The prevalence of adult spinal deformity and scoliosis is not well established, with estimates ranging from 2.5% to 25% of the population.[16,37-41] A recent study reported mild to severe adult scoliosis prevalence as high as 68% in a healthy (no known scoliosis or spine surgery) population aged 60 and over.[42] Many cases of degenerative scoliosis are undiagnosed, but elderly patients often seek care because of back and leg pain that may be caused by scoliosis and associated spinal stenosis.

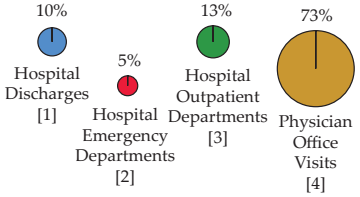
Degenerative scoliosis is one of the most challenging spine conditions to treat due to the variability of the condition. It is generally thought to originate with the degeneration of the intervertebral discs, which leads to misalignment of the vertebral column. Degenerative scoliosis, particularly in the very elderly, is often associated with other conditions, such as osteoporosis. Treatment outcomes for both nonsurgical and surgical procedures are not well documented; hence, recognition and earlier intervention are important to ward off the more complex problems of adult scoliosis. The role played by undiagnosed, mild idiopathic adolescent scoliosis on the development of degenerative scoliosis in later life is unknown.

Section 3.4: Health Care Resource Use for Spinal Deformity in 2006/2007

While the incidence of spinal deformity among patients seeking care in any given year can be estimated, the relatively low proportion of the population seeking care for spinal deformity conditions precludes statistically reliable numbers. In addition, many persons do not seek care, or seek care for severe or disabling back or leg pain that is often caused by spinal deformity. Hence, the overall prevalence of spinal deformity in the total population is projected to be much higher than current data implies. Furthermore, degenerative scoliosis is rarely a primary, or 1st, diagnosis and may not be included as a diagnosis at all.

Idiopathic and degenerative scoliosis are both found in a higher proportion of females than

Graph 3.4.1: Distribution of Health Care Visits for Spinal Deformity and Related Conditions Diagnoses, United States 2006/2007

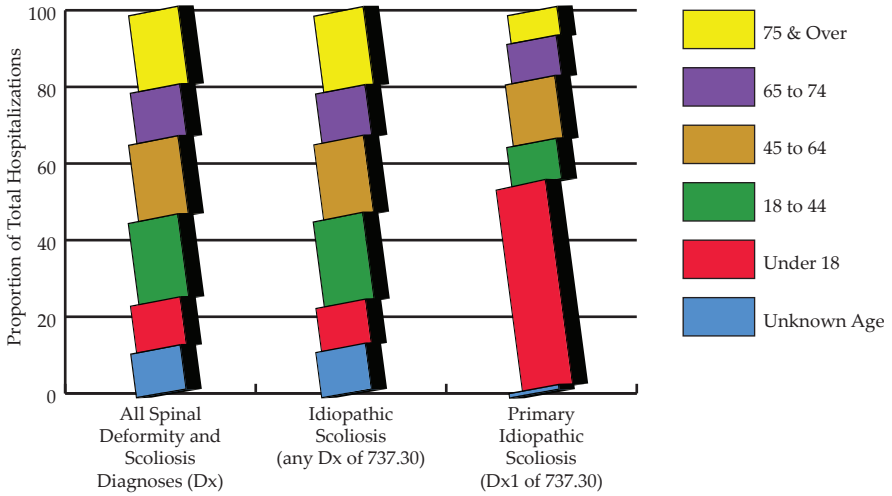


[1] Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007
[2]Source: National Center for Health Statistics, National Hospital Ambulatory Medical Care Survey, Hospital Emergency, 2006
[3] Source: National Center for Health Statistics, National Hospital Ambulatory Medical Care Survey, Outpatient, 2006
[4] Source: National Center for Health Statistics, National Ambulatory Medical Care Survey, 2006

males.[3] As the ratio of the curve increases, indicating more severe scoliosis, the female to male ratio is reported as high as 10:1 among persons with a curve of greater than 30°.[13,43]

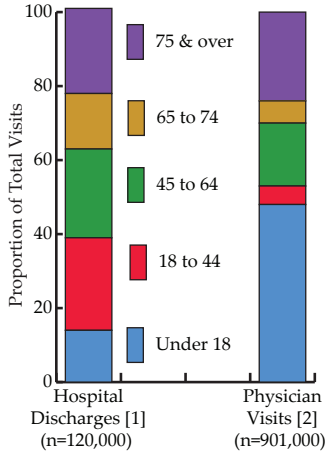
In 2007, an estimated 1.24 million patients utilized health care resources for care of problems associated with a spinal deformity. (Table 3.3) The majority (73%) of these care episodes were with a physician (Graph 3.4.1), and involved nonsurgical and pre-surgical management of this complex patient population. In addition, more than 200,000 persons visited hospital outpatient or emergency centers for care, and approximately 120,000 persons were hospitalized with a diagnosis of spinal deformity. Although it was not the only diagnosis, virtually all hospitalized patients had a diagnosis of scoliosis. Other diagnoses were kyphosis, a curvature of the thoracic region of the spinal column resulting in a rounded upper back, or excessive lordosis (swayback), an increased amount of curvature of the lumbar or cervical regions of the spinal column.

Graph 3.4.3: Relationship of Spinal Deformity and Primary Idiopathic Scoliosis Diagnoses by Age, United States 2007



Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007

Graph 3.4.2: Hospitalization and Physician Visits for Spinal Deformity and Related Conditions Diagnosis by Age, United States 2006/2007



[1] Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007
[2] Source: National Center for Health Statistics, National Ambulatory Medical Care Survey, 2006

NOTE: Data by age groups does not meet standards of reliability.

The overwhelming majority of spinal deformity and scoliosis patients in 2007 were female (69%), and close to one-half (44%) were under the age of 18. While hospitalizations for spinal deformity are represented nearly equally by all age groups in 2007, physician visits are primarily the young (under age 18) and the old (aged 75 and over). (Graph 3.4.2)

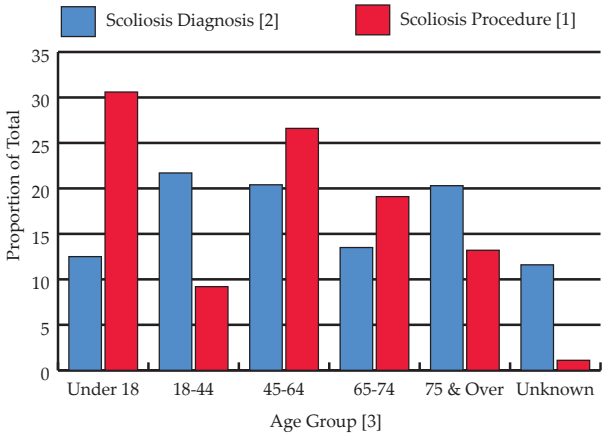
In 2007, 89% (107,200) of patients released from a hospital with a scoliosis diagnosis had a diagnosis of idiopathic scoliosis (ICD-9-CM code of 737.30). Eight percent (8%, or 8,300) of these 107,200 patients had a primary, or 1st, diagnosis of idiopathic scoliosis; 92% had an idiopathic scoliosis diagnosis that was in addition to their primary diagnosis.

Of these 107,200 patients with idiopathic scoliosis diagnoses, 12% were under the age of 18 years, while 20% were aged 75 and over. (Table 3.4 and Graph 3.4.3) However, a primary (1st) diagnosis of idiopathic scoliosis was far more common in young persons, with 54% under the age of 18, supporting the assumption that degenerative scoliosis or spinal deformity is frequently not the primary (1st) diagnosis of elderly patients.

More than one-half of the young patient group (55%) were between the ages of 14 and 17 years. Another 37% were between the ages of 11 and 13, with the remainder aged 10 years or younger.

Three of four patient visits to a physician's office in 2007 with a primary (1st) diagnosis of idiopathic scoliosis (72%) were for patients under the age of 18 years. More than 90% of these visits were for children aged 11 and older. (Table 3.5)

Graph 3.4.4: Relationship of Scoliosis Diagnosis and Spine Surgical Procedures by Age, United States 2007



[1] Scoliosis procedures include ICD-9-CM procedure codes 81.04, 81.05, 81.06, 81.08, 81.62, 61.63, 81.64, 84.51.
[2] Scoliosis conditions include ICD-9-CM diagnostic codes 737.30, 737.31, 737.32, 737.33, 737.34, 737.39.
[3] Data by age group does not meet criteria for reliability.

Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007

Although only 12% of scoliosis-diagnosed patients in 2007 were children under the age of 18, the young patients accounted for 31% of spine surgical procedures for scoliosis. Overall, one in six persons (17%) hospitalized with a scoliosis diagnosis underwent a surgical procedure for scoliosis, but 2 in 5 persons under the age of 18 underwent scoliosis surgical procedures. (Table 3.6 and Graph 3.4.4)

Section 3.4.1: Estimated 2007 Cost for Treatment of Scoliosis and Spinal Deformity

A conservative estimate of the hospitalization cost for adult scoliosis in 2007 was $520.9 million. This estimate, which generally does not include professional fees, is based on the average cost per hospital stay for four age groups of patients aged 18 and over with a primary (1st) diagnosis of idiopathic scoliosis. Child and adolescent primary idiopathic scoliosis hospitalization fees added an additional $511.2 million, for a total estimated hospitalization cost to treat primary idiopathic scoliosis in 2007 of $1.04 billion. (Table 3.4)

Additional hospital costs of nearly $3.2 billion were incurred by patients with a diagnosis of idiopathic scoliosis in addition to their primary (1st) diagnosis. It is unknown what proportion of these costs resulted directly from treatment given as a result of scoliosis; however, it can be assumed some proportion of these additional costs would not have occurred in the absence of the scoliosis condition.

In addition to health care costs associated with surgery for spinal deformity and scoliosis, significant nonsurgical resources are utilized by adults with scoliosis, increasing the burden of this condition on the health care system. A study of nonsurgical resource use, including exercise, bracing, medications, steroid injections, and formal pain management, by adults with a spinal curvature of ≥30° showed 90% of patients utilized nonsurgical resources, with those patients with a high level of symptoms using more resources than those with a low level of symptoms.[44]

Overall, the cost related to spinal deformity is significant, with more than one million patient visits each year for treatment of pain due to this condition. A majority of spinal deformity cases each year are the result of degenerative scoliosis. With the aging of the U.S. population, increased awareness, identification, and treatment of spinal deformity in its earliest stages is necessary to reduce the current and future burden of this condition.

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Section 3.5: Spinal Deformity and Related Conditions Data Tables

Table 3.1: Estimated and Normalized Prevalence of Spinal Deformity and Related Conditions

	Cited Prevalence Rate (midpoint of range cited)			Normalized Prevalence Rate (per 100 persons)	Prevalence Rate (per 100,000 persons)
Congenital scoliosis [1]	1	in	1,000	0.100	100
Infantile idiopathic scoliosis [2]	0.04	in	100	0.040	40
Juvenile idiopathic scoliosis [3]	0.06	in	100	0.060	60
Adolescent idiopathic scoliosis [4]	2.5	in	100	2.500	2,500
Spina bifida [5]	4.6	in	10,000	0.046	46
Cerebral palsy [6]	0.001	in	100	0.001	1
Muscular Dystrophy [7]	1	in	3,500	0.029	29
Spondylolysis, age 6 [8]	6	in	100	6.000	6,000
Spinal muscular atrophy [9]	8	in	100,000	0.008	8
Scheuermann kyphosis [9,10]	4	in	100	4.000	4,000
Adult spinal deformity or scoliosis (age >18 yrs) [11,12,13]	11.3	in	100	11.300	11,300
Adult spinal deformity or scoliosis (age >60 yrs) [14]	68	in	100	68.000	68,000

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Table 3.2: Prevalence of Adolescent Idiopathic Scoliosis

Cobb Angle	Female-to-Male Ratio	Prevalence (%)
>10°	1.4-2.0 : 1	2.0%-3.0%
>20°	5.4 : 1	0.3%-0.5%
>30°	10 : 1	0.1%-0.3%
>40°	Not applicable	<0.1%

Source: Weinstein SL: Adolescent idiopathic scoliosis: Prevalence and natural history. *Instr Course Lect* 1988;38:115–126.

Table 3.3: Health Care Resource Usage with Spinal Deformity and Related Conditions Diagnosis by Gender and Age, United States 2006/2007

	Total Occurrences (in 000s)[2]								
		Gender		Age (in years)					Average Age at Diagnosis
	Total	Male	Female	<18	18-44	45-64	65-74	75 & Over	
Spinal Deformity & Related Conditions [1]									
Hospital Discharges [3]	120	30	90	15	26	25	16	24	58.8
Hospital Emergency Departments [4]*	59	30	29	*	22	*	12	23	55.4
Hospital Outpatient Departments [5]	156	55	101	106	8	*	*	40	31.8
Physician Office Visits [6]*	901	272	628	428	44	157	56	217	39.0
All Spinal Deformity & Related Conditions Diagnoses	1,236	387	848	549	100	182	84	304	

Spinal Deformity & Related Conditions	% by Resource	Proportion of Spinal Deformity & Related Conditions Treated at Resource by Demographic Group						
Hospital Discharges [3]	10%	25%	75%	14%	25%	24%	15%	23%
Hospital Emergency Departments [4]*	5%	51%	49%	*	*	*	*	*
Hospital Outpatient Departments [5]	13%	35%	65%	68%	5%	*	*	26%
Physician Office Visits [6]*	73%	30%	70%	48%	5%	17%	6%	24%
All Spinal Deformity & Related Conditions Diagnoses	100%	31%	69%	44%	8%	15%	7%	25%

* Estimate does not meet standards for reliability

[1] Spinal deformity & related conditions include ICD-9-CM codes 737.00 to 737.19, 737.20 to 737.22, 73729, 737.30 to 737.34, 737.39, 737.40 to 737.43, 737.80, 737.90

[2] Multiple occurrences per patient possible

[3] Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007

[4] Source: National Center for Health Statistics, National Hospital Ambulatory Medical Care Survey, Hospital Emergency, 2006

[5] Source: National Center for Health Statistics, National Hospital Ambulatory Medical Care Survey, Outpatient, 2006

[6] Source: National Center for Health Statistics, National Ambulatory Medical Care Survey, 2006

Table 3.4: Hospitalization and Mean Hospital Cost [1] for Scoliosis and Idiopathic Scoliosis by Gender and Age, United States 2007

	All Diagnoses	Proportion by Age and Gender Group	Proportion All Spinal Deformity Diagnoses of Total Group	Mean Charge	Mean Length of Stay (LOS)	Estimated Total Cost (in millions)	Proportion Estimated Cost by Age Group
Hospital Discharges with Scoliosis Diagnosis [2]							
				(n=117,766)	(n-119,953)		
TOTAL	119,957			$44,099	5.3	$5,289.98	
Male	29,550	24.6%					
Female	90,348	75.3%					
<18	14,982	12.5%		$72,203	5.8	$1,081.75	20.4%
18-44	26,024	21.7%		$30,804	4.8	$801.64	15.2%
45-64	24,428	20.4%		$53,039	5.4	$1,295.64	24.5%
65-74	16,208	13.5%		$53,076	5.1	$860.26	16.3%
75 & over	24,356	20.3%		$37,182	5.3	$905.60	17.1%
Unknown	13,959	11.6%					
18 & over	91,016	75.9%		$42,460	5.2	$3,864.54	73.1%
Hospital Discharges with Idiopathic Scoliosis Diagnosis [3]							
				(n=105,169)	(n=107,205)		
TOTAL	107,209		89.4%	$40,220	5.2	$4,311.95	
Male	25,729	24.0%	87.1%				
Female	81,426	76.0%	90.1%				
<18	12,284	11.5%	82.0%	$66,354	5.6	$815.09	18.9%
18-44	24,350	22.7%	93.6%	$28,990	4.8	$705.91	16.4%
45-64	21,583	20.1%	88.4%	$48,161	5.3	$1,039.46	24.1%
65-74	14,163	13.2%	87.4%	$47,930	5.1	$678.83	15.7%
75 & over	21,917	20.4%	90.0%	$34,815	5.3	$763.04	17.7%
Unknown	12,913	12.0%	92.5%				
18 & over	82,013	76.5%	90.1%	$38,875	5.1	$3,188.26	73.9%

[1] Generally, total charges do not include professional fees and non-covered charges. In the rare cases where professional fees cannot be removed, they are included in the database. Emergency department charges incurred prior to admission to the hospital may be included in total charges.

[2] Scoliosis conditions include ICD-9-CM codes 737.30, 737.31, 737.32, 737.33, 737.34, 737.39.

[3] Idiopathic scoliosis includes ICD-9-CM code 737.30.

Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007

Table 3.4: Hospitalization and Mean Hospital Cost [1] for Idiopathic Scoliosis by Gender and Age, United States 2007 (continued)

	All Idiopathic Scoliosis Diagnoses	Proportion by Age and Gender Group	Proportion All Idiopathic Scoliosis Diagnoses	Mean Charge	Mean Hospital Length of Stay	Estimated Total Cost (in millions)	Proportion Estimated Cost by Age Group
Hospital Discharges with Primary (Dx1) **Diagnosis of Idiopathic Scoliosis** [2]							
				(n=8,265)	(n=8,283)		
TOTAL	8,283		7.7%	$125,213	5.7	$1,037.1	
Male	2,133	25.8%	8.3%				
Female	6,128	74.0%	7.5%				
<18	4,452	53.7%	36.2%	$114,815	5.2	$511.2	49.3%
18-44	877	10.6%	3.6%	$130,776	6.2	$114.7	11.1%
45-64	1,361	16.4%	6.3%	$161,940	7.1	$220.4	21.3%
65-74	870	10.5%	6.1%	$141,024	5.6	$122.7	11.8%
75 & over	625	7.5%	2.6%	$100,634	5.6	$62.9	6.1%
Unknown	98	1.2%	0.7%				
18 & over	3,733	45.1%	4.1%	$139,544	6.3	$520.9	50.2%

Hospital Discharges with Pediatric Idiopathic Scoliosis Diagnosis (Age <18 Years)*

	<18 Years Idiopathic Scoliosis (All Diagnoses)	Proportion Idiopathic in All Spinal Deformity Diagnoses by Age Group	Primary Diagnosis (Dx1)	Proportion Primary in All Idiopathic Diagnoses by Age Group
TOTAL	12,284		4,452	36.2%
0-3	653	5.3%	*	0.0%
4-7	1035	8.4%	96	2.2%
8-10	1,138	9.3%	255	5.7%
11-13	3,411	27.8%	1,648	37.0%
14-17	6,047	49.2%	2,449	55.0%

* Estimate does not meet standards for reliability

[1] Generally, total charges do not include professional fees and non-covered charges. In the rare cases where professional fees cannot be removed, they are included in the database. Emergency department charges incurred prior to admission to the hospital may be included in total charges.

[2] Idiopathic scoliosis includes ICD-9-CM code 737.30.

Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007

Table 3.5: Physician Office Visits for Idiopathic Scoliosis* by Gender and Age, United States 2006

Physician Office Visits for Spinal Deformity [1]*

	All Diagnoses of Spinal Deformity	Proportion All Spinal Deformity by Age and Gender
TOTAL	900,833	
Male	272,405	30%
Female	628,428	70%
<18	427,718	47.5%
18-44	43,952	4.9%
45-64	156,777	17.4%
65-74	55,625	6.2%
75 & over	216,761	24.1%
18 & over	473,115	52.6%

Primary Diagnosis of Idiopathic Scoliosis (DX1 = 737.30) [2]*

	Primary Idiopathic Scoliosis	Proportion Primary Idiopathic Diagnosis by Age and Gender	Proportion Primary Idiopathic to All Idiopathic Diagnoses
TOTAL	408,426		74.3%
Male	65,571	16.1%	55.9%
Female	342,855	83.9%	79.2%
<18	292,877	71.7%	83.0%
18-44	32,135	7.9%	83.3%
45-64	*	0.0%	0.0%
65-74	*	0.0%	0.0%
75 & over	83,414	20.4%	98.3%
18 & over	115,549	28.3%	58.6%

Idiopathic Scoliosis [2]*

	Idiopathic Scoliosis Diagnosis	Proportion Idiopathic Diagnosis by Age and Gender	Proportion Idiopathic to All Spinal Deformity Diagnoses
TOTAL	549,965		61.1%
Male	117,315	21.3%	43.1%
Female	432,650	78.7%	68.8%
<18	352,718	64.1%	82.5%
18-44	38,567	7.0%	87.7%
45-64	59,276	10.8%	37.8%
65-74	14,568	2.6%	26.2%
75 & over	84,836	15.4%	39.1%
18 & over	197,247	35.8%	41.7%

Pediatric (<18 Years) Idiopathic Scoliosis Diagnosis [2]*

	Prevalence Idiopathic Scoliosis in Under 18 Population (All Diagnoses)	Proportion Idiopathic Diagnoses by Age	Primary (Dx1) Diagnosis	Proportion Primary Idiopathic Diagnoses by Age
TOTAL	352,718		292,877	83.0%
0-3	*	0.0%	*	0.0%
4-7	30,792	8.7%	30,792	10.5%
8-10	2,636	0.7%	*	0.0%
11-13	198,510	56.3%	167,627	57.2%
14-17	120,780	34.2%	94,458	32.3%
Total 0-17	352,718	100.0%	292,877	100.0%

* Estimates do not meet standards for reliability. Data is included because it constitutes the majority of patient visits for spinal deformity and scoliosis in 2006.

[1] Spinal deformity & related conditions include ICD-9-CM codes 737.00 to 737.19, 737.20 to 737.22, 73729, 737.30 to 737.34, 737.39, 737.40 to 737.43, 737.80, 737.90

[2] Idiopathic scoliosis includes ICD-9-CM code 737.30.

Source: National Center for Health Statistics, National Ambulatory Medical Care Survey, 2006

Table 3.6: **Spine Procedures [1] with Scoliosis Diagnosis [2] by Age, United States 2007**

	Age [3]						
	Under 18	18-44	45-64	65-74	75 & Over	Unknown	Total
Scoliosis Diagnosis (N)	14,982	26,024	24,428	16,208	24,356	13,959	119,957
Proportion of Total by Age Group	12.5%	21.7%	20.4%	13.5%	20.3%	11.6%	100.0%
Scoliosis Procedure (N)	6,118	1,844	5,319	3,817	2,637	227	19,961
Proportion of Total by Age Group	30.6%	9.2%	26.6%	19.1%	13.2%	1.1%	100.0%
Proportion of Age Group with Sciolosis Diagnosis and Scoliosis Procedure	40.8%	7.1%	21.8%	23.6%	10.8%	1.6%	16.6%

[1] Scoliosis procedures include ICD-9-CM procedure codes 81.04, 81.05, 81.06, 81.08, 81.62, 61.63, 81.64, 84.51.

[2] Scoliosis conditions include ICD-9-CM diagnostic codes 737.30, 737.31, 737.32, 737.33, 737.34, 737.39.

[3] Data by age group does not meet criteria for reliability.

Source: Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample, 2007