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A Comprehensive Literature Review of Secondary Complications of Spinal Cord Injury

Noel A. Ysasi, Ph.D., CRC, University of Kentucky
Shelby Kerwin, B.A., University of Kentucky
Irmo Marini, Ph.D., CRC, CLCP, University of Texas-Rio Grande Valley
Bradley McDaniels, M.S., CRC, University of Kentucky
Danielle Leigh Antol, M.S., University of Texas-Rio Grande Valley

Abstract

Spinal cord injury (SCI) and secondary complications (SCs) that occur as a direct result of the injury can be a contributing factor for increased hospitalization and need for specialized healthcare. For instance, level of injury, time since injury, gender, age, and personal health care have shown to increase and/or decrease the incidence rate of specific SCs. The authors conducted a comprehensive literature review for 12 SCs to examine the relative prevalence of each for people with SCI. The data utilized was to determine the probability (>50%) versus the possibility (<50%) of various complications so as to afford those involved in life care planning to make evidence-based decisions regarding inclusion in their plans. The results indicate many SCs do not meet the probability threshold for contributing to the life-long challenges and commensurate financial obligations faced by those with a SCI.

Keywords: Spinal cord injury, secondary complications, incidence rate

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In the early 1970s, the model SCI care system program was federally funded; as part of the program, all funded model systems were required to contribute data on patients they treated to a national database. This database is now known as the National Spinal Cord Injury Statistical Center (NSCISC) Database (DeVivo & Chen, 2011). NSCISC aims for the collection, management, and analysis of the world's largest and longest spinal cord injury research database. Published reports by the National SCI Statistical Center (2013) indicate the overall annual rate of hospitalized individuals with spinal cord injury is approximately 40 cases per every one-million or approximately 12,000 new cases each year in the United States. The prevalence of individuals who were alive in the United States in 2013 and who have SCI has been estimated to be approximately 238,000 to 332,000 persons (National SCI Statistical Center, 2013). As of 2013, the database has accumulated the medical histories for over 151,000 persons with SCI in the U.S. since 1973. Epidemiological data shows that SCI primarily affects young adults with nearly half of all injuries occurring between the ages of 16 and 30. Among individuals in the combined United States data set, the mean age at injury increased from 28.7 years during the 1970s to 37.1 years between 2005 and 2008 (DeVivo & Chen, 2011). Since 2010, the average age has continued to steadily increase and is now 42.6 years (National SCI Statistical Center, 2013).

When examining the etiology of SCI injuries, motor vehicles accidents account for 36.5% of reported SCI cases in the U.S., followed by falls (28.5%), acts of violence (9.2%), and sports-related injuries (9.2%). In addition, when observing ethnicity, particular ethnic groups sustain a SCI at a higher rate in comparison to other groups and have been reported in the model system, noting 67% are Caucasian, 24.4% are African American, 7.9% are Hispanic, 2.1% are Asian, and 0.8% are Native American (National SCI Statistical Center, 2013). Furthermore, the NSCIS (2013) reports the most frequent neurological category at the time of discharge of persons with SCI reported to the model SCI system is incomplete tetraplegia (40.6%), followed by incomplete paraplegia (18.7%), complete paraplegia (18.0%), and complete tetraplegia (11.6%). To understand SCI, it is important to first comprehend the functional limitations and basic anatomy of the spinal cord.

Secondary Complications

Spinal cord injury produces a wide variety of changes in the individual's body structure that can lead to a number of complications, which impacts health, social activity, employment, and quality of life (Van Den Berg, Castellote, Pedro-Cuesta, & Mahillo-Hernandez, 2010). Secondary complications are potential long-term medical problems that can result after a SCI and play an important role in the continuum of care. Pope and Tarlov (1991) state a "secondary condition is any additional physical or mental health condition that is casually related to a primary disabling condition and that can be either a pathology, an impairment, a functional limitation, or an additional disability" (p. 214). According to the World Health Organization (WHO, 2013), persons with SCI often encounter various secondary medical complications that include, but are not limited to: respiratory complications, autonomic dysreflexia, deep vein thrombosis, urinary tract infections, spasticity, osteoporosis, pressure ulcers, upper extremity/repetitive motion overuse, and chronic pain. Acute care, rehabilitation services, and vigilant continuing health care are imperative for prevention and management of secondary complications.

An extensive range of SCs affecting the SCI population has been reported. Up until the mid-1970s, renal failure and other related urinary tract complications were reported to be the main cause of death in individuals with SCI (Freed, Bakst, & Barrie, 1966). Nonetheless, medical, pharmaceutical, and technological advances have brought changes in mortality rates for the SCI population. Epidemiological studies assessing the incidence and prevalence of SCs affecting persons with SCI continue to be explored.

Frankel et al. (1998) examined long-term survival in a population sample of 3,179 SCI survivors over a 50-year longitudinal study. The demographic characteristics included 81.4% males and 18.6% females with age at injury noted as 57% for the 0-30 age group, 22.2% for the 31-45 age group, 14.1% for the 46-60 age group, and 6.7% for the 61 and above age group. The study utilized the Frankel classification scale to determine the level of injury; A, B, and C include participants with minimal or no muscle control below their injury, and Frankel D and E denotes participants that have useful motor function below their injury. The injury level was noted as follows: 4.2% tetraplegia (C1-4 ABC), 25.0% tetraplegia (C5-8 ABC), 44.1% paraplegia (ABC), and 26.7% as (All D). The study revealed the leading cause of death for the entire 50-year period of the study was correlated to diseases of the respiratory system (pneumonia/influenza/other respiratory) at 23%, urinary deaths ranked second at 19%, followed by cardiovascular events (ischemic/non-ischemic heart disease) at 18%. Moreover, data demonstrated individuals with tetraplegia and paraplegia are 4.67 and 2.07 times more probable to die from pneumonia, influenza, and other respiratory diseases, respectively, than individuals classified as Frankel D injured at the same age. Additionally, males are 75% more likely to die of urinary tract diseases than females, and individuals with tetraplegia and paraplegia are 4.35 and 2.20 times more likely to die from these causes, respectively, than individuals classified as Frankel D (Frankel et al., 1998).

A similar study conducted by McKinley, Jackson, Cardeans and DeVivo (1999) reviewed data from the NSCISC and analyzed the incidence of long-term SCs among individuals with SCI. Annual evaluations were completed at 1, 2, 5, 10, 15 and 20 years post-injury with a sample size documented as: year 1, (n = 6,776); year 2, (n = 5,744); year 5, (n = 4,100); year 10, (n = 2,399); year 15, (n = 1,285); and year 20, (n = 500). Results revealed the development of pressure ulcers (PUs) as the most recurrent medical complication documented at 15.2% in the first annual follow-up year post injury and increased gradually during the subsequent evaluations: Year 1 (15.2%), Year 2 (17.8%), Year 5 (19.9%), Year 10 (23.3%), Year 15 (24.7%), and Year 20 (29.4%). Individuals with complete paraplegia had the highest total prevalence of Stages III and IV PUs at 9.1%, compared to tetraplegia-complete (6.6%), tetraplegia-incomplete (3.2%) and paraplegia-incomplete (2.4%). Autonomic dysreflexia was consistently the second most common SC reported: Year 1 (10.9%), Year 2 (10.6%), Year 5 (10.4%), Year 10 (10.6%), Year 15 (13.7%), and Year 20 (17.6%). Furthermore, the study revealed that complete tetraplegia was associated with increased risk of pneumonia/atelectasis and observed more frequently among individuals 60 years of age and older. Data reported for sample size include: Year 1 (3.5%), Year 2 (3.9%), Year 5 (3.0%), Year 10 (2.3%), Year 15 (2.5%), and Year 20 (1.87%). Additionally, an increased trend of abnormal renal testing was found for individuals with tetraplegia (complete or incomplete) at 1, 10, and 15 year evaluations with similar findings regarding age as a factor among persons 60 years of age and older.

Meyers et al. (2000) conducted a study to examine the most frequently occurring SCs among a sample of 117 individuals with predominately cervical level SCI (87%). The participants included 69% males and 31% females, a mean age 38.5 years (SD =10.8), and a race distribution of 83% white and 17% nonwhite. The study revealed a mean of 6.5 (SD = 3.0) of the 17 SCs investigated. The most prevalent SCs included muscle spasms (87%), UTIs (73%), skin breakdown (66%), fatigue (64%), chronic pain (49%), bowel problems (47%), autonomic dysreflexia (46%), anxiety (43%), depression (42%), respiratory infections (21%), migraines (16%), contractures (13%), asthma (10%), and seizures (3%). It is imperative for the life care planner to have awareness of the prevalence, frequency, severity, symptoms/implications, and costs associated with treatment of all secondary complications in the SCI population.

Pressure Ulcer

Pressure ulcers (PU), also known as ischemic ulcers, bed sores or skin sores, have been defined by the National Pressure Ulcer Advisory Panel ([NPUAP], 2014) as a "localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear and/or friction" (para. 4). Moreover, the wound develops within the upper layers of the skin as a result of continued pressure; this enlarges into a radial formation within the profound tissue layers (Black et al., 2007). Similarly, the International Statistical Classification of Disease and Related Health Problems (ICD-10) notes a PU refers to the diagnosis of pressure ulcer (L89) which is inclusive to the category of the skin and subcutaneous tissue (WHO, 2010).

The most widely recognized classification system for pressure ulcers is composed of a four-stage scale; the severity of Stages I through IV is based according to the depth of ulceration (Bansal, Scott, Stewart, & Cockerell, 2005). In 2007, the NPUAP redefined the description of a PU and the stages/categories of ulceration, including the four original stages and introducing two additional categories on deep tissue injury (DTI) and unstageable pressure ulcers. The NPUAP defined six stages/categories as follows: (1) Category/Stage I – Non-blanchable erythema: beginning stage of developing ulcer with some redness; (2) Category/Stage II – Partial thickness: the skin has decreased in thickness with developing open ulcer with redness and may be ruptured or filled with serum; (3) Category/Stage III – Full thickness skin loss: occurring with loss of full thickness of skin while exposing fat tissue and recognized as a deep wound; (4) Category/Stage IV – Full thickness tissue loss: arising with full thickness of tissue loss exposing bone, muscle, and/or tendons that is visible to the naked eye; (5) Deep Tissue Injury (DTI) involving blood-filled blisters from pressure and/or previous laceration; and Unstageable/Unclassified appearing as an ulcer with full-thickness tissue loss and discoloration of the skin concealed by slough (NPUAP, 2015).

The most common sites for pressure ulcers after two years of injury include the feet 2%, malleolus 4%, heel 5%, sacrum 18%, trochanters 26% and the ischium 31% (Yarkony & Heinemann, 1995). The incidence rate of PU varies greatly with the health care setting and it has been reported to range from 0.4% to 38% in hospitals, 2.2% to 23.9% in skilled nursing facilities, and from 0% to 17% in home health agencies (Cuddigan, Ayello, & Sussman, 2001; Lyder & Ayello, 2008).

Pressure ulcers represent the most frequent medical complication among individuals with SCI occurring in approximately (34%) of individuals during the acute rehabilitation phase; with prevalence rates in subsequent years post-injury ranging from 14-46% (NSCISC, 2006). The high prevalence rate is due to the loss of sensation, poor motor control limiting repositioning and the loss of muscle and subcutaneous tissue making the bony prominences more vulnerable. Factors including age, gender, level of SCI lesion, and time since injury have been examined to identify whether these risk factors are related to pressure ulcer development.

McKinley et al. (1999) reviewed data on 20,804 participants from the NSCISC on annual evaluations performed at 1, 2, 5, 10, 15, and 20 years post-injury. The overall sample size for each year was recorded at: year 1, (*n* = 6,776); year 2, (*n* = 5,744); year 5, (*n* = 4,100); year 10, (*n* = 2,399); year 15, (*n* = 1,285); and year 20, (*n* = 500). Participants were stratified in three age groups (1-30 years; 40-59 years, and 60+ years) with neurological classifications of (tetraplegia-complete; tetraplegia-incomplete; paraplegia-complete; and paraplegia-incomplete). Results revealed the development of PU as the most recurrent medical complication (*n* = 739; 15.2%) within the first annual follow-up year post-injury and increased gradually during the subsequent evaluations at year 2, (*n* = 614; 17.8%); year 5, (*n* = 416; 19.9%); year 10, (*n* = 250; 23.3%); year 15, (*n* = 112; 24.7%); and year 20, (*n* = 30; 29.4%). Moreover, among participants who developed pressure ulcers, those with tetraplegia-complete averaged 1.64 PU per person, paraplegia-complete 1.62 PU, tetraplegia-incomplete 1.4 PU, and paraplegia-incomplete 1.27 PU per person. In addition, participants with paraplegia-complete had the highest percentage of Stages III and IV pressure ulcers at (9.1%), in comparison to tetraplegia-complete (6.6%), tetraplegia-incomplete (3.2%), and paraplegia-incomplete (2.4%). McKinley et al. (1999) noted age was not a factor for pressure ulcer development. In relation to gender, the percentage of males presenting with more than one pressure ulcer was statistically different in comparison to females at annual year 1 (males, 15.8%; females, 12.6%) and year 2 (males, 18.5%; females, 14.2%).

Chen, DeVivo, and Jackson (2005) conducted a similar longitudinal regression study examining the time trends in prevalence of pressure ulcers in post injury years (1, 2, 5, 10, and 15) among 3,361 community residents with SCI registered with the National Spinal Cord Injury Database. Participants included (*n* = 2,788 males; *n* = 575 females) with a mean age at injury of 31.3 years and disclosing their ethnicity as follows: Caucasian (*n* = 1,886; 56%); African American (*n* = 1,012; 30%); Hispanic (*n* = 413; 12%); and other (*n* = 50; 2%). The level of injury was noted as tetraplegia (*n* = 1,603; 48%) and paraplegia (*n* = 1,752; 52%) with neurological classification of ASIA A (*n* = 1,800; 54%), ASIA B (*n* = 438; 13%), ASIA C (*n* = 502; 15%), and ASIA D (*n* = 607; 18%). Findings revealed the prevalence of PU remained steady during the first 10 years after injury: year 1 (11.5%); year 2 (13.2%); year 5 (13.1%); year 10 (14.3%); however, it increased significantly after 15 years post injury at (21.0%). Furthermore, the most frequently occurring PU was Stage II and accounted for 859 visits (53%), followed by Stage III in 426 visits (27%), and Stage IV in 310 visits (20%). Additional findings indicated odds ratios (OR) greater than 1.0 resulted an increased risk of PU; correspondingly, PU were most common among males (OR 1.3), African Americans (OR 1.7), participants with less than a high school education (OR 1.3), and in persons with complete SCI (1.0).

A retrospective review of 144 medical records from the UK Spinal Injuries Unit (SIU) was completed by Ash (2002) to evaluate the occurrence of pressure ulcer development in the period between injury, admission, and discharge. The sample characteristic included males (*n* = 115) and females (*n* = 29) with an average age of 40 years old. The average length of time from injury to admission to SIU was 14 days while the average length of stay between injury and discharge was 152 days. The level of injury among the participants was noted as tetraplegia/neck injury, (*n* = 78; 54%) and paraplegia/back injury, (*n* = 66; 46%); with neurological classification of ASIA A, (*n* = 49; 34%) and ASIA B-E, (*n* = 95; 66%). Findings demonstrated (32%; *n* = 32) of all patients already had a PU on admission, (38%; *n* = 54) suffered an ulcer during their hospital stay, and only (2%; *n* =

3) had an ulcer on discharge. The overall incidence rate for all grades (Grade 1-3) of PUs between injury and discharge was noted at (56%; *n* = 80). A total of 153 PUs were recorded among all the participants, with the most common sites being sacral (*n* = 70; 46%), heel (*n* = 30; 20%), occipital (*n* = 12; 8%), penis (*n* = 9; 6%), and hip (*n* = 9; 6%).

Ash (2002) states people with complete lesions (ASIA A) are 37% more likely to develop PU in comparison to those with incomplete lesions (ASIA B-E). The author noted level of lesion (tetraplegia vs. paraplegia) was not significant to PU incidence. Other findings indicated 60% of males were more likely to develop a pressure ulcer than females (38%; *n* = 11) while the average age of participants developing PUs was 40 years of age, although the author indicates the difference was not statistically significant when comparing data to individuals who had not developed a PU. Ash (2002) recommends a holistic approach that manages pressure ulcer risk and shifts the responsibility of pressure ulcer prevention from healthcare providers to patients (Ash, 2002).

Gender and age have been considered a risk factor in pressure ulcer development among individuals with SCI. However, there are a few studies that specifically address this issue. Eslami et al. (2012) completed a cross-sectional study investigating the prevalence of PUs based on the patient's age and time passed since injury in a population sample of 7,489 persons with SCI. The sample was composed of 4,993 males and 2,493 females with the median age group between 21 and 30 years. At the time of injury, 7,095 (76.8%) participants were more than 10 years old and 394 (5.3%) were older than 50 years. A total of 5,897 participants were injured for more than one year and 815 for less than one year. The levels of SCI included cervical (16.5%), thoracic (22.7%), and lumbar (57.9%). Based on the level of injury, paraplegia accounted for (66.8%) of the participants and tetraplegia (9.6%). Overall, findings indicated PUs were found among 34.6% of the sample, among 38% of patients age ≥ 11 years, patients less than one year and more than one year since time of injury were at an incidence rate of 45% and 35%, respectively.

Additionally, the prevalence of PUs in participants with less than one year since acquiring a SCI was noted at 45% in comparison to participants who acquired a SCI more than one year since at 35%.

To further explore age, gender, and level of injury, Garber, Rintala, Hart, and Fuhrer (2000) conducted a longitudinal two-panel study of Phase 1 (first year) and Phase 2 (3 years later) among 118 men with SCI. The mean age at Phase 1 was noted at 40.49 years and Phase 2 at 43.53 years. The level of injury included: tetraplegia ABC, (*n* = 49; 41.5%); paraplegia ABC, (*n* = 52; 44.1%); and tetraplegia or paraplegia D, (*n* = 17; 14.4%). Overall, findings indicated of the 118 participants, (*n* = 38; 32.2%) reported having at least one PU in the year prior to Phase 1 and (*n* = 37; 31.4%) in the year prior to Phase 2. Other predictors of PU occurrence were younger age at onset of SCI, greater level of impairment, and longer duration of SCI, although no prevalence results were indicated in the study.

Similarly, Saladin and Krause (2009) identified the racial/ethnic difference in pressure ulcer prevalence after SCI among 475 participants with a race distribution of Caucasian (*n* = 127), Hispanic (*n* = 122), African-American (*n* = 121), and American-Indian (*n* = 105). The sample was comprised of (*n* = 190) females and (*n* = 185) males with an average of 12.8 years since injury. The level of injury included: C1-C4/non-ambulatory, (11.6%); C5-C8/non-ambulatory, (29.1%); non-cervical/non-ambulatory, (39.7%); and ambulatory, (19.6%). Findings indicated 15% of the participants reported a current PU while 32% reported a PU within the last 12 months. Furthermore, of the PU accounted within the last 12 months, 16% reported an occurrence of only one PU, 8% developed two PUs, and 3.4% reported three or more. While examining the incidence rate in relation to race and ethnicity, American-Indians had the highest percentage of pressure ulcers at 49.5 %, followed by African-American 35.8%, Caucasian 24.6%, and Hispanic 23.1%. See Table 1 for a summary of PU study findings.

Table 1
Pressure ulcer (PU) incidence in spinal cord injured patients

Author	TSI	Age	Males	Fem.	Level of Injury	Incidence
Ash (2002)	14 days	*M* = 40	n=115 (80%)	n=29 (20%)	ASIA A, n=49 (34%) and ASIA B-E, n=95 (66%)	n=80 (56%)
Chen et al. (2005)		*M* = 31.3	n=2,788 (83%)	n=575 (17%)	Para, n=1752 (52%) Tetra, n=1603 (48%)	Yr. 1: n=329 (11.5%) Yr. 2: n=269 (13.2%) Yr. 5: n=168 (13.1%); Yr. 10: n=65 (14.3%) Yr. 15: n=17 (21.0%)
Eslami et al. (2012)	<1 Yr. >1 Yr.	10-50+ Med. age 21-30	n=4,996	n=2,493	Cerv. (16.5%); Thor. (22.7%) Lumb. (57.9%)	n=2,591 (34.6%)
Garber et al. (2000)	Phase 1: 11.95 *M*	*M* = 40.49	n=118	N/A	Para ABC (44.1%) Tetra ABC (41.5%) Tetra or Para D (14.4%)	n=38 (32.2%)
	Phase 2: 14.99 *M*	*M* = 43.53	n=118	N/A	Para ABC (44.1%) Tetra ABC (41.5%) Tetra or Para D (14.4%)	n=37 (31.4%)
McKinley et al. (1999)	Yr. 1	1-60+	Total n=6,776		Para Tetra	I (5.6%); C (22.3%) I (9.3%); C (25.2%)
	Yr. 2		Total n=5,744		Para Tetra	I (8.3%); C (24.5%) I (10.2%); C (26.4%)
	Yr. 5		Total n=4,100		Para Tetra	I (10.9%); C (25.5%) I (11.5%); C (27.2%)
	Yr. 10		Total n=2,339		Para Tetra	I (14.5%); C (28.2%) I (18.4%); C (25.1%)
	Yr. 15		Total n=1,285		Para Tetra	I (18.4%); C (26.7%) I (20.8%); C (27.6%)
	Yr. 20		Total n=500		Para Tetra	I (12.5%); C (29.8%) I (13.3%); C (40.6%)
Saladin and Krause (2009)	*M* = 12.8 yrs.	*M* = 29.3	AI n=105; AA n=121; C n=127; H n=122		C1-C4 (11.6%); C5-C8 (29.1%); Non-cervical (39.7%); Amb (19.6%)	AI n=52 (49.5%); AA n=43 (35.8%); C n=31 (24.6%); H n=28 (23.1%);

Note. TSI = Time Since Injury; I = Incomplete; C = Complete; AI=American-Indian, AA=African-American, C=Caucasian, H=Hispanic, Para = paraplegia, Tetra = tetraplegia, Amb. = Ambulatory, *M* = mean, Med. = median, Cerv. = cervical, Thor., = thoracic, Lumb. = Lumbar, X-Sect. = cross-sectional, Long. = longitudinal, Retro. = retrospective.

Respiratory Dysfunction

Respiratory dysfunction among persons with SCI encompasses a variety of complications that include but are not limited to: aspiration, atelectasis, bronchitis, lung abscess, pneumonia, ventilator failure, and infection of the respiratory system (Jackson & Groomes, 1994; Jha & Charlifue, 2011). The increased risk for this secondary complication (SC) includes higher level of injury (i.e., complete tetraplegia, incomplete tetraplegia, followed by paraplegia) and being of older age at the time of injury (Jha & Charlifue, 2011). Respiratory dysfunctions are one of the leading causes of hospitalization and mortality among those with either acute or chronic SCI (Burns, 2007; Hitzig et al., 2008). After conducting a thorough review of the literature, most if not all studies incorporated pneumonia, atelectasis, and aspiration as the primary causes for respiratory dysfunction.

In a five-year study by five Model Regional SCI Care Systems to identify the incidence of respiratory dysfunction, 14 specific complications were included to examine the effects in relation to level of injury (Jackson & Groomes, 1994). Of these 14, three were reported as having the highest incidence for complications (i.e., aspiration, atelectasis, and pneumonia). Demographic information of the 261 participants in the study included persons with a C1-C4 level injury (*n* = 56; 22%), C5-C8 level injury (*n* = 123; 47%), and T1-T12 level of injury (*n* = 81; 31%), with the mean age for all groups being 29.1 (Jackson & Groomes, 1994). A total number of 175 patients (67%) involving all levels of injury experienced 544 respiratory complications. The incidence for respiratory complications since time of injury involved the following conditions: atelectasis (36%) occurring 17.7 days' time since injury (TSI), followed by pneumonia (31%) occurring 24.5 days TSI, and ventilator failure (22%) occurring 4.5 days TSI.

As with other SCs, the level of injury is a significant factor for respiratory complications occurring among 84% of patients with C1-C4 lesions in comparison to 60% of persons with a C5-C8 level of injury and 65% of persons with a T1-T12 level of injury. The incidence for pneumonia, ventilator failure, and atelectasis among persons with a C1-C4 injury was 63%, 40%, and 40%, respectively. For those with a C5-C8 level of injury, the same three complications were the most frequently occurring; however, atelectasis occurred most frequently (34%), followed by pneumonia (28%), and ventilator failure (23%). For those falling within the T1-T12 level of injury group, atelectasis was reported at 37% while aspiration developed sooner 2 ± 3.8 days TSI than any other condition for all cervical and thoracic groups. Aspiration was documented as one of the least occurring respiratory complications with an incidence of 1.2% to 7.3% for all groups (i.e., cervical and thoracic).

Dysphagia increases the risk for aspiration due to the difficulty with swallowing. Researchers Chaw, Shem, Castillo, Wong, and Chang (2012) conducted a study to identify the risk factors associated with this condition and respiratory dysfunction. A total of 68 participants (57 males and 11 females) were involved in the study with levels of SCI as follows: C1-C4 complete (*n* = 28); C4-C8 incomplete (*n* = 40) with an average of 31.8 days TSI. Among all participants, a total of 21 patients (30.9%) were diagnosed with dysphagia as assessed by the bedside swallowing evaluation (BSE) with 4 (5.9%) diagnosed with aspiration. The level of injury and gender was not a risk factor for dysphagia, although those diagnosed with this complication had acquired pneumonia (56%) in comparison to those without (16.7%) and had lengthier hospital stays (48 days vs. 39 days).

Individuals with spinal cord injuries are at an increased risk for frequent hospitalizations as well as for hospital-acquired infections (HAI). According to the Centers for Disease Control and Prevention (CDC) National Nosocomial Infection Surveillance System (NNIS), a HAI is defined as "a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s) that was not present on admission to the acute care facility" (Centers for Disease Control and Prevention, 2014, p. 2). Evans et al. (2008) completed a retrospective review of 226 medical records of veterans with SCI and examined the risk for contracting a HAI during hospitalization. The sample was composed of 224 males and two females with a mean age of 58.3 years. The ethnicity distribution included: non-Hispanic white, (126; 56%); African American, (*n* = 75; 33%); Hispanic, (*n* = 7; 3%); and unknown, (*n* = 18; 8%). The mean duration of injury was noted at 20.9 years while the levels of injury consisted of tetraplegia, (*n* = 113; 50%); paraplegia, (*n* = 103; 46%); and unknown, (*n* = 10; 4%). A total of 657 HAIs occurred during the study, and 6.5% (*n* = 43) of the cases accounted for respiratory infections. Furthermore, the incidence rate for respiratory infections was noted at 2.3 (per 1,000 patient-days). The level of injury, duration of injury, and ethnicity yielded no significant differences on HAI status.

Frankel et al. (1998) conducted a 50-year longitudinal study among 3,179 SCI survivors and examined the causes of death over the decades following the injury from 1943 through 1990. The demographic characteristics included 81.4% males and 18.6% females with age ranging from 1-61 years and over. The study utilized the Frankel classification scale to determine the level of injury and included: tetraplegia, C1-4 ABC (*n* = 133; 4.2%); tetraplegia, C5-8 ABC (*n* = 795; 25%); paraplegia, ABC (*n* = 1,402; 44.1%); and all D (*n* = 849; 26.7%) level injuries. Researchers found pneumonia, influenza, and other respiratory conditions (not specified) as the leading causes of mortality (incidence of 23%) throughout the 50-year study. In earlier decades of the study (1943 through 1972), respiratory deaths accounted for 19% in comparison to 34% in the period of 1973 through 1990. Moreover, data demonstrated individuals with tetraplegia and paraplegia are 4.67 and 2.07 times more likely to die from pneumonia, influenza, and other respiratory diseases than individuals classified as Frankel D injured at the same age.

Garshick et al. (2005) studied a sample of 361 males with SCI for at least one year after injury and assessed the mortality risk for respiratory disease. The racial distribution included: Caucasian (93%), African American (5%), and other races (2%). The mean age among the participants was 50.6 ± 15 years and the time since injury was noted at 17.5 ± 12.8 years. Of the participants, 92% of SCI were due to traumatic injuries. The level of injury among the participants included: cervical, (*n* = 75; 20.7%); T1-T4, (*n* = 52; 14.4%); T5-T12, (*n* = 47; 13%); others, (*n* = 38; 10.5%); cervical ASIA C, (*n* = 41; 11.3%); cervical ASIA D, (*n* = 42; 11.6%); other ASIA C, (*n* = 31; 8.5%); and other ASIA D, (*n* = 35; 9.6%). The participants completed a respiratory health questionnaire centered on the ATS DLD-78 adult respiratory questionnaire (Ferris, 1978), a history of respiratory symptoms, cigarette usage, and comorbid medical conditions. Additionally, individuals participated in a pulmonary function test and a neurological exam. At the completion of the study, a total of 37 participants were deceased. The authors discovered respiratory systems accounted for 24.3% of underlying and contributing cause of death among the participants. Other findings indicated specific respiratory deaths included: pneumonia (*n* = 4), chronic airway obstruction (*n* = 3), pleural effusion (*n* = 1), and unspecified respiratory complications (*n* = 1).

To further examine the incidence of pneumonia and atelectasis, two additional studies were investigated. A five-year longitudinal study among 11,113 veterans with a SCI revealed incidence for pneumonia was reported at 3% to 3.5% per 1,000 veteran patients, while lower respiratory infections ranged between 2.19% and 3.2% per 1,000 (Smith et al., 2007). McKinley, Jackson, Cardenas, and DeVivo (1999) found the percentage of pneumonia and/or atelectasis ranging between 1.3% and 2.1% among persons with paraplegia in comparison to 9.9% for persons with tetraplegia; this was a 20-year longitudinal study in which data was reviewed from the National SCI Statistical Center. Although level of injury was investigated and resulted in higher incidence rates, both aforementioned studies did not find a probability (>51% incidence) threshold among this sample population. See Table 2 for a summary of respiratory dysfunction study findings.

Table 2

Respiratory Dysfunction (Including Pneumonia, Aspiration, and Atelectasis)

Author	Gender	Age	TSI	Level of Injury	Respiratory Incidence n (%)	Pneumonia Incidence n (%)	Aspiration Incidence n (%)	Atelectasis Incidence n (%)
Chaw et al. (2012)	M: 57 F: 11	*M* = 43	31.8 days	C1-C4 Comp & C4-C8 Incom (Total: n = 68)	N/A	25 (37.8%)	4 (12.1%)	N/A
Evans et al. (2008)	M: 224 F: 2	*M* = 58.3	20.9	Tetra (n = 113; 50%); Para (n = 103; 46%) & UK (n = 10; 4%)	43 (6.5%) of 657 HAI cases	N/A	N./A	N/A
Frankel et al. (1998)	M: 2,588 F: 591	1-60+ Yrs.	NS	Tetra (C1-C4; N = 133; 4.2%); Tetra (C5-C8; n = 795; 25%); Para (n = 1,402; 44.1%); All D (n = 849; 26.7%)	N = 205 (23%) of 886 deceased participants	N/A	N/A	N/A
Garshick et al. (2005)	M: 361	50.6 ± 15 Yrs.	17.5 ± 12.8 Yrs.	Comp (n = 212); Incom (n = 149)	n = 9 (24.3%) of 37 deceased	n = 4 (10.8%) of 37 deceased	N/A	N/A
Jackson and Groomes (1994)		*M* = 29.1	24.5 ± 1.7	C1-C4 (n = 56) C5-C8 (n = 123) T1-T12 (n = 81)	47 (84%) 74 (60%) 53 (65%)	36 (63.2%) 34 (27.6) 12 (14.8)	5 (8.8%) 9 (7.3) 1 (1.2)	23 (40.4) 42 (34.2) 30 (37.0)

Note: TSI = Time since injury; Comp = Complete; Incom = Incomplete; F = Females; M = Males; UK = Unknown; Tetra = Tetraplegia; Para = Paraplegia; HAI = Hospital acquired infection; NS = Not specified.

Metabolic Disorders

Osteoporosis and heterotopic ossification (HO) are two of the most common metabolic disorders among people with SC. The incidence of osteoporosis is estimated to be above 70% among people with SCI, while reports of fractures below level of injury are estimated at 31% and 33% (Eser, Frotzler, Zehnder, Schiessl, & Denoth, 2005; Frisbie, 1997; Vestergaard, Krogh, Rejnmark, & Mosekilde, 1998). A study conducted to identify the incidence and management of osteoporosis among 128 medical practitioners (i.e., physicians, nurses, physician assistants, etc.) by Morse et al. (2008) indicated a probability rather than possibility of this secondary condition of occurring. Findings revealed 54% of practitioners had ordered medication for treating bone-loss associated with SCI and 78% had ordered physical therapy as a preventative measure for osteoporosis. Moreover, 79% reported treating patients for osteoporosis fractures following acute SCI while 72 respondents reported treating between one and 10 patients for fractures within the past year since time of study.

To further explore the nature of this complication, Lazo et al. (2001) conducted a study that included 41 male patients to assess for decreased bone density and fractures after acute SCI. Of the 41 participants, 61% (n = 25) met the criteria for osteoporosis, 19.5% had acquired a decrease in bone mass not considered within normal range, although not significant enough to be classified as osteoporosis (osteopenic), and 19.5% did not meet the symptoms of any bone disorder. Age was shown to be a factor for those not meeting the criteria for osteopenia as this particular group tended to be significantly younger (median age = 45) while those meeting the criteria had a mean age of 59.75. Lastly, 34% (n = 14) had acquired a fracture following acute SCI with 84.6% occurrence within the lower limbs, 62.5% below the knee with falls reported as the primary cause of fractures; however, of the 14 participants, 85.7% (n = 12) had osteoporosis, and 7.1% (n = 1) had osteopenia.

Researchers Gifre et al. (2014) conducted a 10-year follow-up study after 63 patients (50 males and 13 females) had acquired a SCI with a mean of 6.4 ± 2.4 years post injury. Primary causes of fractures (70%) were due to low impact injuries; otherwise, the specific cause was unknown. Among the 63 participants, 10 participants or 16% developed 18 bone fractures with level of injury (i.e., ASIA A/thoracic level; 80%) as a predictor for increased risk of injury (cervical, n = 2; thoracic, n = 7; lumbar, n = 1) with femur and tibia as the most common site for fracture.

Although Lazo et al. (2001) conducted a significant study in identifying the incidence of this complication occurring, a lack of female participants was a limitation of their research. However, the majority of patients with SCI tend to be male limiting researchers the ability to identify differences between gender and complications.

Vestergaard et al. (1998) conducted a study to identify fracture rates and predicting causes for fractures among persons with SCI. When comparing 438 individuals with SCI (n = 129 females and n = 309 males) versus 654 without a SCI (n = 322 females and n = 332 males), males with SCI had a minimally higher rate of osteoporosis in comparison to their counterpart (13 versus 6). Overall, findings revealed a fracture rate of 2% a year for persons with SCI in comparison to 1% a year for those without a SCI. No differences were found in relation to gender and SCI rate.

Melton, Chrischilles, Cooper, Lane, and Riggs (1992) led an epidemiologic study to define the incidence of osteoporosis among men and women without SCI. Their findings revealed 39.7% of white women age 50 had developed osteoporosis-related fractures in comparison to white males at 13.1%. Melton et al. (1992) reported fractures occurring were due to a decrease in bone mass. For people with SCI, bone mineral density (BMD) decreases within weeks following injury regardless of gender or age, which increases the risk for osteoporosis and related fractures (Biering-Sorensen, Bohr, & Schaadt, 1990; Chantraine, Nusgens, & Lapiere, 1986; Garland et al., 1992; Wilmet, Ismail, Heilporn, Welraeds, & Bergmann, 1995). Complications associated with fractures and management can lead to enlarged costs, lengthy hospitalizations, and increased severity of the disability (Lazo, et al., 2001).

To further examine the incidence of BMD loss and fractures, Zehnder et al. (2004) led a study with SCI participants ranging from 3 months to 30 years since time of injury. Demographic characteristics consisted of 100 men with paraplegia with total motor and sensor loss (T1-L3; stage A of the Frankel scale; n = 94) and those with total motor and partial sensory loss (T1-L3; stage B of the Frankel scale; n = 6). Participants' mean age was 38.0 ± 0.97 with time since injury at a mean of 10.4 ± 0.79 years; reported mean time of hours sitting in a wheelchair was 13.5 ± 0.3 with 51% involved in some form of weight-bearing activity (i.e., using a standing device). The outcome of their research detected mean time for acquiring their first fracture was 8.9 ± 1.4 years since time of injury; progression of fracture incidence increased from 1% within the first year to 4.6% after 20 years; mean incidence of fractures was reported at 2.2% a year. Location of site, specifically lower extremities, was correlated with BMD loss and occurred within 1 to 3 years post injury. See below Table 3 for a summary of bone fracture study findings.

Table 3

Fracture incidence in spinal cord injured patients

Author	TOS	TSI	Male	Female	Age	Incidence
Comarr, Hutchinson, and Bors (1962)	X-sect.		1,363 total			11%
Frisbie (1997)	X-sect.	21.1 ± 12.1 years	120		20-79	33%
	Follow-up					25% (Cerv., n=2; Thor., n=7 (80%); Lumb., n=1)
Gifre et al. (2014)		6.4 ± 2.4 years	50	13	36±20	
Ingram, Suman, and Freeman, (1989)	X-sect.	> 1 years	526		13-70	5%
Lazo et al. (2001)	X-sect.	1.1 – 43.1 years	49		27-83	34%
Ragnarsson and Sell (1981)	X-sect.	9 years (mean)	578		4-71	4%
Vestergaard et al. (1998)	X-sect.		309	129	17-80	2%/year
Zehnder et al. (2004)	X-sect.		100		18-60	
		< 1 year	16			1%/year
		1-9 years	38			1.3%/year
		10-19 years	31			3.4%/year
		20-29 years	13			4.6%/year

Note. Reprinted/Adapted from "Osteoporosis after spinal cord injury," by S. D. Jiang, L. Y. Dai, and L. S. Jiang, 2005, *Journal of Osteoporosis International, 17*, p. 184. Copyright 2014 by Springer Publishing.

When addressing the frequency of HO and SCI, a majority of studies conducted focus primarily on prevention and treatment. However, of those focusing on treatment, some have addressed the rate of persons acquiring HO. Specifically, occurrence of HO towards those who have acquired a SCI is estimated at 20% (van Kuijk, Geurts, & van Kuppevelt, 2002; Wittenberg, Peschke, & Bötel, 1992). However, various reports by researchers have given a range of 5% and 60% diagnosed with HO depending on the nature of the study, time since injury, age, and additional demographic factors (i.e., level of injury) with multiple joints involved (Bravo-Payno, Esclarin, Arzoz, Arroyo, & Labarta, 1992; Riklin, et al., 2003; Silver, 1969; Stover, Niemann, & Tulloss, 1991; Wittenberg, Peschke, & Bötel, 1992).

Location of HO primarily tends to occur below level of injury, specifically, the anterior and interior hip region (60%) as demonstrated by Genêt et al. (2011). Researchers retrospectively surveyed patients between years 1993 and 2009 for HO-related occurrences after central nervous system (CNS) damage involving 539 surgeries among persons with traumatic brain injury (TBI), stroke, SCI, and cerebral anoxia. Their findings revealed the primary cause for HO-related surgeries were due to patients with TBI (n = 199; 55.7%), followed by patients with SCI (n = 86; 24.1%; males, n = 81; females, n = 5; paraplegic, n = 56; tetraplegic, n = 30). Specific to persons with SCI, primary location for HO-related surgeries were of the lower limbs (total = 129) and is indicated as follows: hip surgery (n = 96; 74.4%) and knee (n = 19; 14.7%); incidence of HO sites within the anterior and internal hip region was highest among those who had sustained a stroke (74.4%), followed by persons with SCI (70.7%). The upper-limb HO surgical site was highest for those with SCI with elbow (*n* = 12; 9.3%) and shoulder (*n* = 2; 1.6%).

Riklin et al. (2003) conducted a retrospective study from 1998 to 2000 to determine the incidence of deep vein thrombosis (DVT) and HO. Researchers sought to compare differences among two groups: those who had been newly diagnosed with paralysis as "first rehabilitation" (specifics towards time since injury not disclosed) and participants requiring treatment at least two months post injury as "re-rehabilitation." Of the 1,209 patients identified with a SCI, findings revealed 275 participants as "first rehabilitation" (mean age, 49.7) and 934 participants as "re-rehabilitation" (mean age, 45.6). The incidence for all participants whom acquired HO was 1.82% (i.e., first rehabilitation and re-rehabilitation) while those who had been recently diagnosed with SCI had an incidence of 8%. Specifics towards gender, time since injury, and rate of complication were not addressed.

Additional research conducted by Jaovisidha et al. (1998) revealed similar findings. After the removal of participants due to confounding demographic variables (e.g., hip replacement), a total 107 SCI patients remained in the study. The overall incidence of HO was 18% (*n* = 19) and highest among persons aged 20 and 39 years (14/19; 73%). Overlapping locations of HO among the 19 patients was reported as follows: femoral neck (*n* = 15; 79%), followed by trochanteric (*n* = 14; 74%), and Ward's triangles (*n* = 7; 37%).

These findings are similar with a case-control study conducted by Citak et al. (2012) as they discovered a 21.9% incidence among 111 males (84.1%) and 21 females (15.9%). Patients who had sustained a traumatic SCI between years 2002 and 2010 were utilized as part of the study with 110 having complete level of injury and 22 incomplete. Persons under the age of 18, those having a non-traumatic SCI, and time since development of HO (more than 125 days from injury), were removed from the analysis. Lastly, the authors reported age, gender, level of injury, particular secondary complications (i.e., DVT and pressure sores), and length of time hospitalized were not factors for the development of HO. However, spasticity (*n* = 56 with HO vs. 34 without HO; 2.12 Odds Ratio [OR]), pneumonia (*n* = 76 with HO vs. 33 without HO; 4.07 OR), trauma to the thoracic region (*n* = 63 with HO vs. 17 without HO; 1.28 OR), tracheostomy (*n* = 83 with HO vs. 33 without HO; 4.52 OR), UTI (*n* = 128 with HO vs. 105 without; 8.23 OR), and patients who abused nicotine was at increased risk towards the development of HO (*n* = 26 with HO vs. 7 without HO; 2.82 OR). See Table 4 for a summary of heterotopic study findings.

Table 4

Incidence of heterotopic ossification in spinal cord injured patients

Author	TSI	Males	Fem.	Age	Incidence n (%)
Banovac and Gonzalez (1997)	27 ± 14 days	59	4	28 ± 9 yrs.	36 (57)
Citak et al. (2012)	< 125 days	111	21	Mean 43.4 yrs.	21.9%
Damanski, M. (1961)	54 admitted within 14 days of SCI	Total: 162		47 (29%)	
Genêt et al. (2011)	*M* (2 years)	81	5	Mean 27.1 yrs.	Incidence of surgery site: Hip, n = 96 (14.7); knee, n = 19 (14.7); shoulder n = 2 (1.6); elbow, n = 12 (9.3)
Jaovisidha et al. (1998)	31.1 ± 15.9 years	107		20-78	19 (18)
				When aged 20 - 39	14/19 (73)
Riklin et al. (2003)	*M* (113 days)	877	322	Mean 46.6 yrs.	1.82% all patients
	X-sectional	275 acute SCI		Mean 49.7 yrs.	8% acute SCI

Note. *M* = Mean; yrs. = Years; Fem. = Females; TSI = Time since injury; X-sectional = Cross sectional.

Cardiovascular Disease

Several contributing factors leading to cardiovascular disease (CVD) among individuals with SCI have been outlined throughout the literature. These include, but are not limited to: obesity, sedentary lifestyle, loss of physical functioning as a direct result of paralysis, disturbance of the autonomic cardiovascular control mechanisms, hypertension, hyperlipidemia, autonomic dysreflexia (AD), low HDL cholesterol, increased body fat, smoking, psychosocial factors (e.g., depression), and deep vein thrombosis (Bauman, Kahn, Grimm, & Spungen, 1999b; Mathias & Frankel, 1988; Ragnarsson, 2010). Complications surrounding heart disease develop through a process called atherosclerosis. Atherosclerosis primarily affects the coronary arteries and occurs as plaque builds up along the walls of the artery restricting blood flow and increasing the risk for a heart attack or stroke (American Heart Association, 2014).

Within the United States, CVD is one of the primary causes of mortality with over one million deaths in 1995 alone; one in six of these deaths occurring among a population under the age of 65 (American Heart Association, 2014; Groah, Weitzenkamp, Sett, Soni, & Savic, 2001). Cardiovascular disease affects more than 58 million Americans while coronary heart disease (CHD) affects more than 14 million with an increased risk for those with SCI (American Heart Association, 2014; Groah et al., 2001). As activity level becomes an apparent concern for this population, so does the risk for developing SCs. For individuals with reduced physical activity, the incidence of cardiovascular disease CVD is increasingly higher, in particular for individuals with SCI (Dishman, Heath, & Lee, 2013). As such, the physical inactivity leads to muscle atrophy and increased body fat that become contributing factors of CVD (Groot, Post, Snoek, Schuitemaker, & van der Woude, 2013; Kocina, 1997). Two additional factors that contribute to CVD and result from the latter include dyslipidemia (abnormal amount of lipids) and obesity, a common occurrence among persons with SCI when compared to the general population (Groot at al., 2013). Furthermore, individuals with SCI tend to be at an increased risk for developing CVD due to blood pressure irregularities (Steins, Johnson, & Lyman, 1995).

Groot et al. (2013) determined risk factors of CVD within the first five years post SCI among 130 participants (70% male and 34% female) with an average age of 40.1 ± 13.8 years. Lesion characteristics were assessed according to the International Standards for Neurological Classification of Spinal Cord Injury; neurological levels below TI were defined as paraplegic and levels at or above T1 were defined as tetraplegia. Levels of injury among the participants included paraplegia (66%; n = 86) and tetraplegia (34%; n = 44). Furthermore, 65% of the participants were classified as AIS A&B and considered motor complete injuries in comparison to 35% classified as AIS C&B motor incomplete. The study found high body mass index (BMI) or high density lipoprotein (HDL) as contributing factors of CVD. High BMI among the participants (63-74%) was at greater risk of CVD along with high density lipoprotein (HDL) found in 66-95% of the participants, although this percentage tended to drop after patients were discharged five years from inpatient rehabilitation. The authors recommend focusing on improving BMI as an intervention or preventative measure of CVD along with early education on risks of obesity among the SCI population. Lastly, when investigating "self-care" items, those who reported maintaining an exercise regimen and/or maintaining an active lifestyle had a favorable lipid profile. A favorable lipid profile is one in which all cholesterol levels are within a healthy range and does not create blockage of the arteries causing a concern for CVD.

Davies and McColl (2002) investigated the correlation between lifestyle risks factors (i.e., alcohol and cigarette usage, physical activity, body mass index) and cardiovascular disease by conducting a cross-sectional study of 97 participants with SCI. The sample population was comprised of 87 males and 10 females with a mean age of 47.5 years. The levels of injury included: paraplegia (n = 57; 55%); quadriplegia (n = 41; 42%), and undetermined (n = 1; 1%). The time since injury was noted at 15.9 (M) years. Cardiovascular morbidity was assessed using the London School of Hygiene Questionnaire on Chest Pain and Intermittent Claudication (LSH-QCPIC). The LSH-QCPIC questionnaire revealed 13.4% of the participants reported a cardiovascular morbidity. Subsequently, the authors found the prevalence CVD increased in SCI patients at 3.7% with each additional year of age and 3.1% with each year of cigarette smoking. Individuals who smoked for a longer period of time were at greater risk for developing CVD than non-smokers with spinal cord injury. Additional findings indicated physical activity, body mass index (BMI), and alcohol consumption were not substantial predictors of CVD in this study.

Seeking to explain why individuals with SCI appear to be at an increased risk for developing cardiovascular disease, Groah et al. (2001) conducted a study among 545 individuals with subgroups divided by level of injury according to the Frankel/ASIA scale: tetraplegia ABC (18%), paraplegia ABC (52%), and all D level injuries (30%). All participants were at least 20 years post-injury with a gender distribution of 86% males and 14% females. Of the gender subgroup, there were 458 recorded CVD events during the 20-year period; 24% involving coronary heart disease, 21% hypertension, 16% dysrhythmias, 15% peripheral vascular disease, 8% congestive heart failure, 7% valvular disease, and 2% atrial fibrillation. Subsequently, the age-adjusted rate of CVD by neurologic category was noted as follows: tetraplegia ABC (35.2), paraplegia ABC (29.9), and all D groups (21.2) per 1,000 individuals with SCI. Those with tetraplegia, revealed a 16% increase in all CVD, were five times more likely to develop cerebrovascular disease (decrease in blood supply to the brain); however, 70% were less likely to have CHD in comparison to individuals with paraplegia. Furthermore, age tended to be a contributing factor as the incidence of CVD increased among all subgroups with greater risks for the tetraplegia ABC and paraplegia ABC group (statistically significant at the .04 level) and evident by age 40 in comparison to the All D group. Those with a complete level of injury (i.e., total loss of function) were at a 44% greater risk for CVD.

In a similar study to evaluate whether a correlation exists between CVD and SCI, Cragg, Noonan, Krassioukov, and Borisoff (2013) compiled data from 60,959 individuals utilizing the national Canadian Community Health Survey (CCHS), with a proportionate gender sample of 49.3% males and 50.8% females. Findings revealed 72% of cases with CVD accounted for individuals over the age of 60 with a prevalence of heart disease higher for individuals with SCI (17.1%) in comparison to those without a SCI (4.9%). The lack of neurological level, completeness of injury, and class of heart disease were a primary limitation of the study. Consequently, heart disease was four times greater among individuals with SCI; however, after adjusting for age and gender (males at greater risk), the odds were 2.72 greater in comparison to people without SCI.

In terms of mortality from cardiovascular causes, large cohorts of participants with SCI have been observed. Whiteneck et al. (1992) reviewed 843 medical records with a post injury time of 30 or more years to assess long-term health complications in the SCI population. Participants were separated into groups based on survival status to assess for mortality and morbidly outcomes; results indicated n = 362 (43%) of the participants had expired during the study. Demographically, 87% were males and 13% females with an age distribution of 15 to 55 years old at the time of injury. The level of injury was noted as cervical (31%), thoracic (52%), and lumbar/sacral (17%) with a Frankel classification of paraplegia ABC, tetraplegia ABC, and All D or E level injuries. Data revealed that among the 362 participants who had expired during the study, n = 84 (23.2%) were associated with CVD (n = 38 myocardial infarctions, n = 31 other diseases of the heart, n = 10 cases of cerebrovascular disease, and n = 5 cases of other circulatory problems). Furthermore, CVD was the leading cause of death for individuals with paraplegia ABC (n = 48; 23.2%), followed by All D & E levels (n = 28; 28.3%), and tetraplegia ABC (n = 8; 14.1%). Subsequently, CVD-related deaths in SCI patients became more frequent with aging and time since injury, accounting for 46% of all deaths for individuals 30 years post injury and 35% of all deaths in individuals over 60 years of age. The incidence of heart/circulatory diagnoses increased with age (episodes per 100 cases per year): participants <30 years of age showed an incidence of 2.0%; for individuals aged between 30 and 39 years, an incidence of 2.9%; an incidence of 5.2% for those aged 40-49 years; an incidence of 8.1% for those aged 50-59; and lastly, 19.3% for those aged 60+ years. (See Table 5 for a summary of cardiovascular disease study findings).

Table 5

Cardiovascular disease (CVD) incidence in spinal cord injured patients

Author	TSI	Age	Males	Fem.	LOI	Incidence
Cragg et al. (2013)	Not Spec.	Med = 40-44 yrs.	Total = 354		Not Specified	n=60 (17.1%)
Davies & McColl, (2002)	*M* = 15.9 yrs.	*M* = 47.5yrs.	n=87 (90%)	n=10 (10%)	Quad, n=41 (42%); Para, n=55 (57%); UNDETM=1(1%)	n=13 (13.4%)
Groah et al. (2001)	29 ± 6 yrs.	27 ± 9 yrs.	n=469 (86%)	n=76 (14%)	Tetra, ABC n=99 (18%) Para, ABC n=285 (52%) All D n=161 (30%)	Tetra ABC n=64; Adj. Rate 35.2 Para ABC n=279; Adj. Rate 29.9; All D n=115 Adj. Rate 21.2
Groot et al. (2013)	Immed. after D/C	*M* = 40.1	n=91 (70%)	n=39 (30%)	Tetra n= 44 (34%) Para n=86 (66%)	n=125 (63%) at risk for CVD/BMI; n=124 (95%) at risk for CVD/HDL
	1 yrs.					n=116 (68%) at risk for CVD/BMI; n=109 (88%) at risk for CVD/HDL
	5 yrs.					n=97 (74%) at risk for CVD/BMI; n=74 (66%) at risk for CVD/HDL
Whiteneck (1992)		15–60+ yrs.	n=726 (87%)	n=108 (13%)	Cervical n=258 (31%) Thoracic; n=431 (52%), Lumbar/Sacral n=145 (17%)	
	<10 yrs.					n=24 (2.9%)
	10-19 yrs.					n=45 (5.4%)
	20-29 yrs.					n=83 (10.0%)
	30+ yrs.					n=118 (14.2%)

Note. TSI = Time Since Injury; Immed. = Immediately; X – Sect. = Cross Sectional; Long. = Longitudinal Study;Yrs. = Years; Avg. = Average; LI= Level of Injury; SD=Standard Deviation; *M* = Mean; Med = Median; CVD=Cardiovascular Disease; BMI= Body Mass Index; HDL=High-Density Lipoprotein; T = Tetraplegia; Para = Paraplegia; Comp = Complete; Inc = Incomplete; LOI = level of injury; TOS = type of study

Autonomic Dysreflexia (AD)

Autonomic dysreflexia (AD) occurs most often among individuals with a traumatic SCI injured at T6 and above (some incidence reported in SCI as low as T8 to T10; Hagen, Faerestrand, Hoff, Rekand, & Gronning, 2011; Myers, Lee, & Kiratli, 2007; Popa et al., 2010). According to the Autonomic Standards Committee established by the American Spinal Injury Association (ASIA) and International Spinal Cord Society (ISCoS), AD is defined as a rise of blood (20 mmHg) above the baseline in SCI patients; the associated symptoms of AD include headache, nasal congestion, nausea, flushing and sweating above level of injury, vasoconstriction below lesion level, bradycardia, cardiac arrhythmia, and anxiety; however, AD can also be asymptomatic (Erickson, 1980; Krassioukov et al., 2007; Lindan, Joiner, Freehafer, & Hazel, 1980; Ma & Bryce, 2010; Mathias & Frankel, 2002). In life-threatening cases, paroxysmal hypertension (symptom of AD) has been found to occur among 50% and 90% of persons with tetraplegia and paraplegia levels of injury, respectively (Rabchevsky, & Kitzman, 2011; Vaidyanathan et al., 2012). As a result, the symptom can trigger loss of consciousness, cerebral and spinal hemorrhaging, seizures, and pulmonary edema (Rabchevsky, & Kitzman, 2011; Vaidyanathan et al., 2012).

The prevalence of AD has shown to occur in 48% to 90% of patients with a SCI at or above the T6 level with 92% of cases occurring within the first year post-injury. However, reports of 15.4% and lower have been documented following acute SCI (Kurnick, 1956; Lindan et al., 1980; Myers et al., 2007; Ragnarsson, Hall, Wilmot, & Carter, 1995). Garstang and Walker (2011) addressed the lower incidence of AD and stated the result could be due to shorter hospital stays following acute SCI in recent years. As previously discussed, the majority of AD complications occur within the first year; therefore, detecting this particular complication can prove to be a challenge. Although AD is characteristic in the chronic stage of SCI or above the T6 level, there is evidence of early episodes in 5.2% cases appearing within the first month after injury (Claydon, Steeves, & Krassioukov, 2006; Krassioukov, Furlan, & Fehlings, 2003; Silver, 2000).

As previously stated, a critical aspect affecting the prevalence of AD in SCI patients is the degree of completeness as well as the neurological level of injury. Curt, Nitsche, Rodic, Schurch, and Dietz (1997) conducted a cross-sectional study and analyzed the occurrence of AD during urodynamic examination in a sample of 31 chronic paraplegic and tetraplegia participants less than six months post injury. The sample was composed of (81%) males and (19%) females younger than 65 years old with a level of injury noted as complete tetraplegia (n = 11), incomplete tetraplegia (n = 11), and complete paraplegia (n = 9). The authors found 42% of the aggregate sample exhibited signs of AD and no paraplegic patient (level of SCI below T6) exhibited symptoms in comparison to 59% of the tetraplegia group. Of the participants in the tetraplegia group, AD was three times more prevalent in patients with complete injuries (91%), in contrast to those with an incomplete injury (27%).

Chen, Apple, Hudson, and Bode (1999) examined the occurrence of AD during the rehabilitation phase following a SCI using a sample of 1,649 participants (79% males; 21% females) entered into the NSCISC from 1996 through 1998. The mean number of days from injury to admission was noted at 19 days. The ethnic distribution of the study population included Caucasian (59.6%), African American (28.9%), and Hispanic (11.7%) with a mean age of 36.5 years at the time of injury. The neurological level of the participants included incomplete tetraplegia (30.7%), followed by complete paraplegia (29.3%), complete tetraplegia (20.1%), and incomplete paraplegia (18.7%). Researchers found the frequency of AD was significantly greater in higher level and complete neurological injuries. Twenty-nine individuals with complete tetraplegia and (12.8%) of persons with neurological complete injuries experienced AD, followed by those incomplete with sensory preservation (8.7%), and incomplete with poor motor preservation (4.3%). Moreover, data demonstrated a higher incidence of AD among males (8.3%) in comparison to (6.4%) in females. Additional findings indicated the prevalence of individual developing AD by the year of admission was noted at 6.9% (year 1996), 9.4% (year 1997), 6.6% (year 1998), and 7.9% (accounting for all years of inpatient rehabilitation).

In a follow-up study, McKinley et al. (1999) analyzed the incidence rate of long-term medical complications among 6,776 SCI patients utilizing the NSCISC database. Participants were divided by the neurological classification and level of injury according to the ASIA scale. The authors discussed AD as the second most common SC reported during annual follow-ups and are as follows: year 1, (10.9%); year 2, (10.6%); year 5, (10.4%); year 10, (10.6%); year 15, (13.7%); and year 20, (17.6%). Additionally, participants using indwelling and condom catheters reported more AD than those utilizing an intermittent catheterization program (ICP).

In addition, studies reveal consistent findings to the aforementioned research and/or additional factors that may contribute to the increased risk for AD. For example, bladder distention, which is considered to be the most occurring of all associated factors (75%-80% of cases), noxious stimulus (damages tissue and may cause pain) below the level of injury, over-distended bladder as a result of Foley catheter kinking, and insufficient replacements of intermittent catheterization (Krieger & Krieger, 2000). Multiple studies have examined the AD reaction during urodynamic evaluation and actual bowel program among the SCI population (Furusawa et al., 2007; Furusawa et al., 2009; Giannantoni et al., 1998; Linsenmeyer, Campagnolo, & Chou, 1996).

Utilizing 571 SCI patients from the Rosai Hospital registry, Furusawa et al. (2011) investigated the relationship among the different bowel and bladder management methods and the prevalence of AD during hospitalization. The demographic characteristics included (81.6%) males and (18.4%) females with a mean age of 52.3 ± 18.8 at discharge. The level of injury among the participants included: C1-C4 (31.7%; n = 181), C5-C8 (60.6%; n = 346), T1-T4 (1.7%; n = 27), and T5-T6 (3.0%; n = 17). Participants were also classified utilizing the AIS impairment scale and included: ASI A (29.4%; n = 168), ASI B (6.1%; n = 35), ASI C (22.2%; n = 127), and AIS D (42.2%; n = 241). The authors noted a 24.7% prevalence of symptomatic AD from the total sample, accounting for 24.2% (n = 113) in men versus 26.7% (n = 28) in women. Others findings revealed AD was diagnosed in participants with SCI above the T5 segment; it was most common among participants with ASI A lesion (43.5%), followed by ASI B (40%), ASI C (25.2%), and ASI D at (10%). In relation to bladder management methods, the highest incidence of symptomatic AD was seen in patients who used reflex voiding (43.3%), followed by indwelling-supra-pubic catheterization (40%), and indwelling urethral catheterization (35.4%). Conversely, the highest incidence according to bowel management included patients using manual removal of stool (39.4%), followed by those on rectal medications (27.4%).

Patient and caregiver education related to secondary complications following a SCI, such as AD, is a vital component for an effective transition. Schottler, Vogel, Chafetz, and Mulcahey (2009) conducted a cross-sectional study investigating the awareness and incidence of AD in 215 patients with SCI and their caregivers. In this study, participants were assessed based on the level of injury, severity of injury, injury etiology, gender, and race. The sample population was composed of 59% males and 41% females, with a race distribution of Caucasian (76%), Hispanic (11%), African-American (2%), and Asian (2%). The type of injury among the participants included 54% tetraplegia and 46% paraplegia, with a level of injury of T6 and above (78%) and below T6 (22%). The authors stated 40% of patients and 44% of caregivers reported the patient did experience or was symptomatic for AD. Respectively, there was no substantial association found between incidence of AD and gender, race, or time since injury. However, AD was significantly more prevalent in traumatic etiologies (44%), in injuries at or above T6 (48%), and in participants injured between 14 and 21 years of age (56%). See Table 6 for a summary of autonomic dysreflexia study findings.

Table 6

Incidence of autonomic dysreflexia in spinal cord injured patients

Author	TSI	Age	Males/Fem.	LOI	Incidence
Chen et al. (1999)	Yr. 1996	*M* 36.5 SD 16.9	Total: 702	Inc. Tetra (30.7); Comp. Para (29.3); Comp. Tetra (20.1) Inc. Para (18.7)	48 (6.9%)
	Yr. 1997		Total n=716		67 (9.4%)
	Yr. 1998		Total n=231		15 (6.6%)
	All Yrs.		Total n=1,649		130 (7.9%)
Curt et al. (1997)	>6 Mon.	<65	M = 25 (81); F = 6 (19)	Comp. Tetra 11 (35.5); Inc. Tetra11 (35.5) Comp. Para, 9 (29)	13 (42%)
Furusawa et al. (2011)	4 Mon.	*M* ±SD age at discharge 52.3±18.8	M = 466 (81.6) F = 105 (18.4)	ASIA A n=168 (29.4) B n=35 (6.1) C n=127 (22.2) D n=241 (42.2)	141 (24.7) ASIA; A, 73 (43.5%) B, 14 (40%) C, 32 (25.2%) D, 22 (10%)
McKinley et al. (1999)	Yr. 1	1-60+	Total: 6,776	NS	717 (10.9%)
	Yr. 2		Total: 5,744		585 (10.6%)
	Yr. 5		Total: 4,100		412 (10.4%)
	Yr. 10		Total: 2,339		242 (10.6%)
	Yr. 15		Total: 1,285		168 (13.7%)
	Yr. 20		Total: 500		85 (17.6%)
Schottler et al. (2009)	4.3 Yrs.	9.1 *M*	M = 127 (59) F = 88 (88)	T6 and above 168 (78) Below T6, 47 (22)	86 (40%) T6 and above, 81 (48) Below T6, 5 (12%)

Note. TSI = Time Since Injury; Immed. = Immediately; X – Sect. = Cross Sectional; Long. = Longitudinal Study;Yrs. = Years; Avg. = Average; LI= Level of Injury; SD=Standard Deviation; *M* = Mean; Med = Median; Tetra = Tetraplegia; Para = Paraplegia; Comp = Complete; Inc = Incomplete;

Syringomyelia

Syringomyelia is a condition in which a cyst (syrinx) forms and expands within the spinal cord creating pressure within the intracranial space and spinal column (Brodbelt & Stoodley, 2003). Various symptoms associated with this complication include pain, muscle rigidity, loss of bowel and bladder function, pain, weakness, and the inability to feel extreme temperatures (i.e., hot and cold) throughout the body (Klekamp & Samii, 2002; Ko et al., 2012). The incidence for this SC tends to be low with reports falling within the range of 0.3% and 3.4% (Umbach & Heilporn, 1991; El Masry & Biyani, 1996). Currently, few studies have focused on the prevalence of syringomyelia; however, attention has been given to the treatment and management (i.e., surgery and medications), diagnosis (i.e., magnetic resonance imaging, MRI), and predictive factors (i.e., level of injury).

Rossier, Foo, Shillito, and Dyro (1985) conducted a study to identify the rate of syringomyelia among 951 persons with SCI. Overall findings resulted in n = 22 (4.5%) of 488 individuals with paraplegia as the reported level of injury in contrast to n = 8 (1.7%) of 463 individuals with tetraplegia. In a related study, El Masry and Biyani (1996) studied 815 patients with traumatic SCI between 1990 and 1992. Of the total participants in the study, a diagnosis of posttraumatic syringomyelia (PTS) was found in n = 9 (1.10%) persons with an incomplete SCI in comparison to 19 (2.3%) participants with a complete level of injury (total of 3.4% of 815 participants); mean time since injury and diagnosis was 6.9 and 9.4 years, respectively.

Similar findings were revealed by Schurch, Wichmann, and Rossier (1996) when investigating syringomyelia among 449 patients with tetraplegia and paraplegia. Specifics with regard to the level of injury (i.e., number and percentage of cervical, thoracic, lumbar, and sacral) were not discussed. Of the total number of participants, PTS was found in 20 (4.45%) of patients as identified by an MRI. Level and incidence for this complication included n = 16 (3.56%) and n = 4 (0.89%) participants with complete and incomplete SCI who had been diagnosed with PTS, respectively. The average time since injury and symptoms for syringomyelia was 7.2 years while diagnosis for PTS and time since injury was 9.4 years.

Through the increased use of MRI as a method of diagnosis, the incidence of PTS has been reported to range from 12% to 22% (Vannemreddy, Rowed, & Bharatwal, 2002). Utilizing a sample of 502 SCI patients who underwent follow-up MRI examinations, Ko et al. (2012) completed a retrospective study and evaluated the incidence of post-traumatic syringomyelia within five years after injury. The sample was composed of 407 (81%) males and 95 (19%) females with a mean age of 46.2 years. The level and completeness of injury was noted as cervical (n = 237; 47%); thoracic (n = 265; 53%); complete (n = 225; 45%); and incomplete (n = 277; 55%). Results indicated syringomyelia developed in 37 (7.3%) of the participants within five years after injury. In addition, syringomyelia was diagnosed as early as two months after a SCI (ranging from two to 54 months) while the mean time for diagnosis was noted at 38.8 months. Other findings indicated the incidence of syringomyelia was proportionate in terms of level (8.4% cervical versus 6.4% thoracic) and completeness of injury (8% complete versus 6.9% incomplete).

In a related study, Perrouin-Verbe et al. (1998) assessed the occurrence of syringomyelia among 75 participants with SCI. The participants included 62 males and 13 females with an average age of 41 years. Participants were categorized according to the neurological classification: tetraplegia complete, (n = 9; 12%); tetraplegia incomplete, (n = 12; 16%); paraplegia complete, (n = 45; 60%); and paraplegia incomplete, (n = 12; 16%) with a mean duration since injury of eight years. Participants completed a clinical and radiological examination (i.e., X-ray, CT scan, and MRI). The researchers discovered the prevalence of syrinx accounted for 28% of the sample population and developed higher in males (18; 86%) in comparison to females (3; 14%). Furthermore, participants with paraplegia (33.3%) were at a higher risk of developing a syrinx in comparison to persons with tetraplegia (14.2%). See Table 7 for a summary of syringomyelia study findings.

Table 7

Incidence of Syringomyelia (Including Post Traumatic Syringomyelia: PTS)

Author	Gender: n (%)	Age (M)	TSI	Level of Injury: n (%)	Incidence: n (%)
El Masry and Biyani (1996)	Gender NS Total: 815	17-45 Yrs.	8.6 Yrs. for dx	Inc. n = 390 Com. n = 425	9 (1.0) 19 (2.3)
Ko et al. (2012)	M: 407 (81) F: 95 (19)	46.2 ± 12.3 Yrs.	5 Yrs.	Cerv. 237 (47) Thor. 265 (53) Com. 225 (45) Inc. 277 (55)	Overall, 37 (7.3)
Perrouin-Verbe et al. (1998)	M: 62 (83) F: 13 (17)	41 Yrs.	8 Yrs. (*M*)	Tetra, 21 (28) Para, 54 (72)	Overall, 21 (28)
Rossier et al. (1985)	Gender NS Total: 951	NS	NS	Tetra, 463 (49) Para, 488 (51)	8 (1.7) 22 (4.5)
Schurch et al. (1996)	Gender NS Total: 449	32.2	NS	Inc. NS Com. NS	Overall, 20 (4.45) Inc. 4 (0.89) Com. 16 (3.56)

Note: TSI = M = Males; F = Females; TSI = Time Since Injury; *M* = Mean; Com. = Complete; Inc.= Incomplete; dx = diagnosis; NS = Not specified; Tetra = Tetraplegia; Para = Paraplegia; Cerv = cervical; Thor = Thoracic

Deep Vein Thrombosis

Patients with acute SCI are at an increased risk for development of deep vein thrombosis (DVT). Three factors leading to DVT according to Virchow's triad include stasis, hypercoagulability, and intimal change (Miranda & Haussoni, 2000). The incidence of DVT among acute SCI has been examined in early prospective studies with the incidence ranging between 5.4% and 90% (Green et al., 1990; Joffe, 1975; Merli et al., 1988; Perkash, Prakash, & Perkash, 1978; Rossi, Green, Rosen, Spies, & Jao, 1980; Todd et al., 1976). However, more recent and widespread studies place the incidence of DVT between 10% and 30% (Aito, Pieri, D'Andrea, Marcelli, & Cominelli, 2002; Li et al., 2012; Powell, Kirshblum, & O'Connor, 1999).

Perkash et al. (1978) conducted a retrospective review of records and analyzed the incidence of DVT in 51 males with acute spinal cord injury. The interval between the time of injury and admission ranged from four to 90 days with a level of clinical lesion varying from C4 to L3 and a segment distribution of cervical (*n* = 27), thoracic (n = 18), and lumbar (*n* = 5). Findings indicated the total incidence of DVT was 18%; however, one patient developed pulmonary embolism without detectable DVT. Therefore, the diagnosed incidence of DVT was 16%. Researchers additionally observed time frame between injury and diagnosis of DVT ranged from 10 to 160 days with 11 episodes (27%; *n* = 3) occurring 12 weeks post-injury. In addition, the study also found that age and level of injury had no correlation with DVT.

In a related study, Sugimoto et al. (2009) examined 52 patients with acute spinal cord injury who had been admitted within 24 hours after injury and assessed two to 13 days after injury (average 4.7 days) for DVT using color Doppler US. According to the American Spinal Injury Association Impairment Scale (AIS) at admission, 32 participants were grade A or B and 20 were grade C or D. The sample was comprised of 40 participants less than 70 years of age and 12 participants 70 years and older with an average age of 54 years at the time of injury. Results indicated 21% of the participants developed DVT with a higher incidence among males (24%) in comparison to females at (9%). In relation to age, 18% of the participants who were ≤69 years old had DVT in contrast to 33% individuals ≥70 years of age. Lastly, the prevalence of DVT was greater in participants with motor complete injuries ASI A or B (22%), whereas motor incomplete injuries ASI C or D were noted at 20%.

Deep vein thrombosis has been reported as early as 72 hours post-injury; the likelihood of experiencing this complication peaks within the first two weeks and reduces within three months post-injury (Green et al., 1990; Merlie, Crabbe, Paluzzi, & Fritz, 1993; Popa et al., 2010; Rossi et al., 1980). In a study by Powell et al. (1999) to determine the incidence of DVT among 189 SCI patients admitted for rehabilitation post-injury by utilization of duplex ultrasound yielded the following: at time of admission, 22 patients (11.6%) had been diagnosed with DVT. However, the level of injury was not a factor for the development of DVT. When providing prophylaxis (preventative measures) such as warfarin (medication to prevent blood clotting) and low-molecular-weight heparin (anticoagulant), prophylaxis decreased the risk of developing DVT among patients (4.1%) in comparison to those who had not received any preventative measure (16.4%). Various forms of prophylaxis have been shown to assist in decreasing the risk of DVT making it a possible rather than probable SC if preventative measures are taken immediately following injury. However, the incidence of DVT increases from 47% to 100% when no form of preventative measure is taken (Geerts, Code, Jay, Chen, & Szalai, 1994; Geerts, Heit, Pineo, & Clagett, 2001; Merli et al., 1988; Myllynen et al., 1985).

Aito et al. (2002) similarly studied a sample of 275 participants with SCI and evaluated the incidence of DVT based on pharmacological approaches in combination with mechanical methods. All participants were examined by Color Doppler Ultrasonography (CDUS) of lower limbs and pelvis on admission and again after 45 to 60 days to detect the presence of DVT. The prophylactic treatment was given to 99 of the patients within 72 hours from trauma and classified in the group of Early Admitted Patients (EAP). Whereas the second group categorized as Late Admitted Patients (LAP) initiated treatment from their date of admission, in a period fluctuating from eight to 28 days post-injury (mean 12 days). The treatment administered to all participants during the first 30 days post injury included subcutaneous nadroparine, a low-molecular-weight heparin (LMWH), early mobilization, continuous gradient elastic stockings (PGES), and external sequential pneumatic compression (ESPC) of the lower limbs. The complete prophylactic treatment lasted at least 30 days after injury and was continued by ESPC and LMWH for two months depending on the patient's progress. The authors reported the incidence of DVT in the group of participants treated early (EAP) who immediately received prophylactic protocol was 2%, while the incidence in participants treated later (LAP) was 26%. Conversely, the incidence of DVT in the LAP group was higher among males (30%) in contrast to (9%) in females. In addition, 36% of participants classified as ASIA A developed DVT, followed by ASIA B (27%), ASIA C (21%), and ASIA D (7%). Furthermore, of the DVTs that occurred, 60% were detected at the time of later admission (eight to 28 days), while the remaining 40% developed within six weeks of hospitalization. The study concluded early adoption of pharmacological approaches plus combined mechanical treatments produces a significant reduction of DVT and hospitalization cost during the early period of rehabilitation following a SCI.

Attempting to analyze the incidence of DVT among acute SCI patients who utilized physical therapy measures and therapeutic prophylaxis, Agarwal and Mathur (2009) conducted a randomized study of 297 participants who were separated into a study and control group. The study group was composed of 166 patients who received unfractionated low-dose heparin (ULDH), subcutaneously from the day of admission until three months after injury, while the 131 patients in the control group were not administered ULDH. All participants received physical therapy measures that included passive range of motion exercise and light massage therapy. In addition, participants were consecutively examined by Color Doppler study on admission and during the three month follow up to assess incidence of DVT. The majority of the sample entered into the study within 10 days after injury with a mean of eight days with a range from three to 40 days. The researchers discovered DVT was recorded in three participants (1.8%) in the study group within six to 10 days after injury; two participants were classified as ASIA grade A and one in ASIA grade D. In the control group, DVT developed in four patients (3%), within five to 28 days post-injury, and all four were classified as ASIA grade A. According to the researchers, the level of injury, ASIA grading, day of admission, as well as heparin prophylaxis did not have a significant correlation with the incidence of DVT.

In conjunction with the findings from AD by Chen et al. (1999), the authors subsequently identified that the incidence of DVT occurred in 9.8% of the sample throughout the rehabilitation phase by utilizing Doppler ultrasound. Moreover, the prevalence of DVT by the time of admission consisted of year 1996 (11.4%); year 1997 (9.8%); and year 1998 (5.2%). Other findings indicated DVT developed higher in males (10.4%) versus females (7.2%). Additionally, the prevalence of DVT was highest among participants with neurological complete injuries (13.2%), followed by (9.9%) for individuals with paraplegic injuries, and (6.5%) for participants with tetraplegia injuries (6.5%). Although the research notes the differences were not statistically significant in relation to gender and level of injury. Chen and colleagues recommend a close observation of secondary complications and improvements in preventative measures to assist individuals with SCI during their recovery process.

Table 8

Deep Vein Thrombosis (DVT) incidence in spinal cord injured patients

Author	TSI	Age	Males n (%)	Fem. n (%)	LOI n (%)	Incidence n (%)
Aito et al. (2002)	72 hours	*M*: 41.3	79 (79)	20 (21)	ASIA A n=33 (33%) B n=25 (24%) C n=20 (21%) D n=15 (15%)	2 (2)
	M: 12 days	*M*: 42.3	142 (81)	34 (19)	ASIA A n=67 (38%) B n=44 (25%) C n=36 (21%) D n=29 (16%)	46 (26)
Agarwal and Mathur (2009)	8 days	*M*: 32	Total: n=166 Study Group Total: n=131 Control Group		ASIA A-D Not Specified ASIA A-D Not Specified	3 (1.8) 4 (3)
Chen et al. (1999)	19 days	*M* 36.5 SD 16.9	1303 (79)	346 (21)	Incom. Tetra (30.7%) Com. Para (29.3%) Comp. Tetra (20.1%) Incom. Para (18.7%)	161 (9.8)
Perkash et al. (1978)	4-90 days	19-62	50	0	Cerv. 27 (54) Thor. 18 (36) Lum. 5 (10)	9 (18)
Powell et al. (1999)		*M*: 44	Total n=189	ASIA (A, B) 99 (52.4) ASIA (C, D) 90 (47.6)	22 (11.6)	22 (11.6)
Sugimoto et al. (2009)	*M*: 4.7 days	*M*: 54	41 (79)	11 (21)	AIS Grade A or B n=32 C or D n=20	11 (21)

Note: TSI = Time Since Injury; Yrs. = Years; Avg. = Average; LOI= Level of Injury; SD=Standard Deviation; M = Mean; Med = Median; Tetra = Tetraplegia; Para = Paraplegia; Comp = Complete; Inc = Incomplete; NS = not specified; Cerv. = Cervical; Thor = Thoracic; Lum. = Lumbar.

Neuropathic Pain

For individuals who acquire a SCI, neuropathic pain (NP) tends to be a significant concern and is associated with poorer health, reduced quality of life, and depression (Wollaars, Post, van Asbeck, & Brand, 2007). This SC is defined as pain acquired due to a lesion or disease from the somatosensory nervous system (Jensen et al., 2011). Persons experiencing NP describe various symptoms (i.e., burning, aching, cramping, stinging, etc.) with an incidence generally falling below 50%. After a thorough review of literature, the vast number of studies focusing on NP investigated the characteristics of pain and location (i.e., shoulder, arms, back, hip, legs, etc.) rather than the overall incidence. As a result, the report for this complication was limited; however, studies published and reported below provided significant contributions in identifying the prevalence for NP.

In a five-year retrospective study among 402 non-traumatic and traumatic SCI patients admitted for the first time within 1995 and 2000, Werhagen, Budh, Hulting, and Molander (2004) investigated predictive factors of NP. Criterion variables included age, time since injury, gender, level of injury, and complete versus incomplete with development of at level or below level of injury as the outcome variable. Mean time since injury was reported at six years, with age divided into five groups with individuals primarily falling within the 0-39 range (*n* = 291) in comparison to their counterpart aged 40-50+ (*n* = 110). Level of injury was classified as either complete (ASIA A; *n* = 157; 39%) and incomplete (ASIA B-D; *n* = 245; 61%), and paraplegia (*n* = 234; 58%) and tetraplegia (*n* = 168; 42%) was included in their report for further clarification. The operational definition for pain was classified as either at-level pain (indicating pain was at level of injury) or below-level pain (pain was described as occurring below level of injury). Of all participants who reported NP, only two indicated above-level injury pain.

Demonstrated findings by Werhagen et al. (2004) revealed 162 (40%) met the diagnostic criteria for NP; of this group, 34% were at-level pain and 66% below-level pain. With regard to age, the incidence of this condition was found primarily among persons of older age (>50; 58%) while those within the age group 0-19, NP was reported less frequently (26%). When measuring gender to predict NP, 48% (*n* = 40) of 83 females reported pain in comparison to 38% of males (*n* = 115). With regard to level of injury, 42% (*n* = 66) of persons with complete SCI (ASIA A) and 39% (*n* = 96) of individuals with incomplete SCI (ASIA B-D) reported NP. Tetraplegia NP was reported at 41% (*n* = 69 of 168) with 16% at-level pain versus 26% below-level pain. Among those with paraplegia, 40% (*n* = 94 of 234) reported 11% at-level pain versus 29% below-level pain. Age was the primary predictor for NP with no significant findings/differences among the other criterion variables. Lastly, of all individuals who had met the criteria for NP, 72% reported this condition as having an effect on their overall quality of life.

Werhagen, Hulting, and Molander (2007) enhanced their previous study in identifying the prevalence of NP among 95 non-traumatic SCI patients between the years 1995 and 2000. Using the same predictor variables (age, gender, complete versus incomplete level of injury, etc.) in addition to gathering patient's opinion of their pain in relation to their daily life, their findings were as follows: Neuropathic pain was reported among 38% (*n* =36) of the participants with 61% (*n* = 22) accounting for below-level pain and 39% (*n* = 14) at-level pain. With regard to gender, no significant differences with findings reported at 51% for women (*n* = 18 of 35) and 30% for males (*n* = 18 of 60) reported NP. In addition, there was no significant difference between age groups up to 39 years (*n* = 16; 36%) versus 40 years and above (*n* = 20; 47%). Level of injury revealed similar frequency findings between those with a complete (ASIA A; *n* = 4 of 11; 36%) and incomplete lesion (ASIA B-D; *n* = 32 of 84; 38%); no differences were found with regard to tetraplegia (*n* = 12 of 27; 44%) and paraplegia (*n* = 24 of 68; 35%) level of injury. When addressing patient's opinion of their pain in relation to their daily life, 24 of 36 (67%) indicated NP as a severe problem or a problem affecting their daily lives in comparison to those indicating no interference (*n* = 8/36; 33%). The overall report when addressing the prevalence of NP among persons with SCI was 38%, similar to the researchers' previous study.

Siddall, Taylor, McClelland, Rutkowski, and Cousins (1999) conducted a longitudinal cohort study investigating the prevalence of pain experienced by 100 SCI patients immediately following injury up until six months post injury. The study was composed of 83% males and 17% females with a mean age of 38 years. The neurological level of injury among the participants included: tetraplegia, (51%); paraplegia, (49%); cervical, (51%); thoracic, (25%); lumbar, (23%); and sacral, (1%); the degree of degree of completeness was noted at 64% incomplete and 36% complete. Participants were assessed throughout the duration of the study on the prevalence and severity of the pain utilizing the International Association for the Study of Pain (IASP) classification system. The IASP classification system identifies the main pain categories arising after a SCI injury and labels pain into the following: musculoskeletal, visceral, neuropathic at-level, and neuropathic below-level (Siddall, Yezierski, & Loeser, 2000).

Siddall et al. (1999) reported 64% of participants experienced some type of pain with the incidence varying significantly when examining time and different categories of pain. Musculoskeletal pain was noted as the most common type and was reported in 66% of the participants two weeks post-injury and tended to decrease with an incidence of 40% six months post-injury. Neuropathic at-level pain was present in 38% after two weeks and the prevalence remained constant throughout the study. The prevalence of neuropathic pain below-level was noted at 14% after two weeks and increased to 19% six months post injury.

Only 5% of the sample reported visceral pain at any stage of evaluation. Additional findings indicated a higher prevalence of musculoskeletal pain in individuals with thoracic level injuries (92%) when compared to the total sample (72%) (Siddall et al., 1999). The authors reported no other significant findings in the overall prevalence of pain and among the four categories when examining the level of lesion and completeness.

To expand upon their previous findings, Siddall, McClelland, Rutkowski, and Cousins (2003) further investigated the original participants from the 1999 study to assess the prevalence of NP five-year post injury. The same identifying categories of pain and participants (*n* = 73) were included in the study. The mean age of the participants was 40 years with a gender distribution of 82% males and 18% females. The neurological level of injury (tetraplegia: n = 36; 49%; and paraplegia: *n* = 37; 51%) and degree of completeness (complete: *n* = 28; 38%; and incomplete: *n* = 45; 62%) was similar to the original study group. Research findings indicated 59 (81%) of the participants reported the presence of some pain, (*n* = 43; 59%) experienced musculoskeletal pain, (*n* = 30; 41%) experienced at-level neuropathic pain, (*n* = 25; 34%) experienced below-level neuropathic pain, and (*n* = 4; 5%) experienced visceral pain.

Individuals with below-level neuropathic pain reported experiencing more severe or excruciating pain than individuals with at-level neuropathic pain (Siddall et al., 1999). Specifically, 60% of individuals with below-level neuropathic pain experienced severe or excruciating pain, whereas only 48% of individuals with at-level neuropathic pain experienced the same symptoms; the mean time of onset for any type of pain was 1.6 years after injury, musculoskeletal pain 1.3 years, NP at-level 1.2 years, and NP below-level 1.8 years after injury. The incidence of musculoskeletal, visceral, at-level neuropathic pain, below-level neuropathic pain, and overall pain was not related to completeness or level of injury. However, when individual pain categories were examined, neuropathic below-level pain was present in 50% of the tetraplegic group versus 18% of the paraplegic group. See Table 9 for a summary of neuropathic pain study findings.

Table 9

Incidence of Neuropathic Pain

Author	Gender: n (%)	Age	*M* TSI	Lvl. of Injury n (%)	Incidence: n (%)
Siddall et al., (1999)	M: 83 (83); F: 17 (17)	*M* 38 Yrs.	6 Mon.	Tetra 51 (51); Para 49 (49)	NP: 64 (64); NP at Lvl: 38 (38); NP blw. Lvl: 19 (19)
Siddall et al., (2003)	M: 60 (82); F: 13 (18)	*M* 40 Yrs.	5 Yrs.	Tetra 36 (49); Para 37 (51)	NP: 59 (81); NP at Lvl: 30 (41); NP blw. Lvl: 25 (34)
Werhagen et al. (2004)	M: 302 (79); F: 83 (21)	0 – 50+	6 Yrs.	Com. ASIA A: 157 (39)	NP: 66 (42); NP at Lvl: (9); NP blw. Lvl: (33)
				Inc. ASIA B – D: 245 (61)	NP: 96 (39); NP at Lvl: (15); NP blw. Lvl: (24)
				Tetraplegia: 234 (58)	NP: 69 (41); NP at Lvl: (16); NP blw. Lvl: (26)
				Paraplegia: 168 (42)	NP: 94 (40); NP at Lvl: (11); NP blw. Lvl: (29)
Werhagen et al. (2007)	M: 60 (63); F: 35 (37)	0 – 50+	9.6 Yrs.	Com. ASIA A: 11 (12)	NP: 4 (36); NP at Lvl: (9); NP blw. Lvl: (33)
				Inc. ASIA B – D: 84 (88)	NP: 32 (38); NP at Lvl: (27); NP blw. Lvl: (23)
				Tetraplegia: 27 (28)	NP: 12 (44); NP at Lvl: (30); NP blw. Lvl: (26)
				Paraplegia: 68 (72)	NP: 24 (35); NP at Lvl: (9); NP blw. Lvl: (15)

Note. *M* = Mean; TSI = Time since injury; Lvl. = Level; Blw. = Below; M = Males; F = Females; NP = Neuropathic pain; Com = Complete; Inc = Incomplete; Mon = Months

Urinary Tract Infection

Urinary tract infections (UTIs) are one of the leading causes of morbidity and mortality in SCI patients, and the method of urinary drainage has been shown to be significant risk factor for UTI development (Goetz et al., 2013). Various symptoms of UTI include testicular pain, fever, involuntary leakage, lethargy, cloudy urine, back and bladder pain, autonomic dysreflexia, dysuria (pain from urination), and spasticity (Goetz et al., 2013). The risk for developing UTIs has been associated with drainage devices (i.e., catheters). Although some devices (e.g., intermittent catheterization) have been shown to reduce the frequency for this complication, the incidence nevertheless tends to be high. The frequency of UTI identified by Whiteneck et al. (1992) within the first 50 days since time of injury for persons with SCI was reported at 22% while Singh et al. (2011) reported yearly episodes at 18.4. Studies provided below identify the incidence of UTI from five studies to determine the consistency and overall prevalence.

Esclarin de Ruiz, Garci Leoni, & Herruzo Cabrera (2000) prospectively evaluated a cohort of 128 acute SCI patients hospitalized at an average of 19 days after injury and investigated the prevalence of UTIs associated with different drainage methods. The participants included (*n* = 100 men; n = 28 women) with a median age of 32.41 years. The level of injury and degree of completeness among the participants was recorded at: C4-C8, (*n* = 48; 37.5%); T1-T6, (*n* = 22; 17%); T7-L2, (*n* = 48; 37.5%); L3-caudequina syndrome, (*n* = 10; 8%), complete, (*n* = 69; 53.5%); incomplete, (*n* = 47; 36.5%); and incomplete plus complete motor injuries, (*n* = 12; 10%). A UTI was defined as a colony count of 〖10〗^5 colony forming unites per milliliter or greater with a fever of 38° in addition with two symptoms (lower abdominal pain, urinary incontinence, increased spasticity, suprapubic pain, frequent urination, dysuria, foul smell in urine, and cloudy urine). Participants with significant bacteriuria but no fever or clinical complaints were considered to have asymptomatic bacteriuria (ASB).

Esclarin de Ruiz et al. (2000) reported “100 person-days” as an operational definition and equivalent to 100 persons followed for one day who was free of UTIs or bacteriuria throughout the day. A total of 1,717 urine cultures were performed during the study, of which 724 revealed asymptomatic bacteriuria and 183 reported UTIs. The incidence of UTIs for all drainage methods was 0.68 episodes per 100 person-days. The incidence of UTI by specific drainage method was noted at: indwelling (2.72) episodes/100 person-days, clean intermittent (0.41), condom (0.36), suprapubic catheterization (0.34), and normal voiding (0.06). In relation to level of injury, the researchers noted patients with cervical level injuries had similar frequency counts (2.99 odds ratio) to patients with injuries at all other levels. Additional findings revealed the incidence of bacteriuria for all drainage methods was 2.72/100 person-days; indwelling accounted for (5) episodes/100 person-days, clean intermittent (2.95), condom (2.41), suprapubic catheterization (0.96), and normal voiding (0.33).

Evans et al. (2008) studied 226 participants with a SCI to identify the most occurring hospital-acquired infections (HAIs). The sample consisted of 224 males (98%) with a mean age of 58.3 years with a mean time since injury of 37.0 years. Level of injury for individuals with a HAI included paraplegia incomplete and complete (19.1% and 28.2%, respectively), tetraplegia incomplete and complete (27.3% and 20.0%, respectively). Of the 226 patients, nearly half acquired at least one HAI with a mean of six HAIs. The most frequent HAI was UTI and accounted for 164 (25%) of the 657 incident cases with a rate of 8.9 per 1,000 patient-days, followed by bloodstream infections (16.9%) and bone and joint infection (15.7%).

Singh et al. (2011) investigated the prevalence of UTIs and asymptomatic bacteriuria (ASB) in 545 participants with SCI and compared the incidence in the different bladder management subgroups. The gender distribution was composed of 386 (71%) males and 159 (29%) females with a mean age of 35.4 ± 16.2 years. Participants were classified according to the American Spinal Injury Association Impairment Scale (AIS) and neurological level of injury. A total of 381 (70%) complete AIS A were recorded, followed by 164 (30%) incomplete AIS B, C, and D neurological injuries. The level of injury among the participants included: C4-C8, (*n* = 185; 34%); T1-T10, (*n* = 93; 17%); D11-L2, (*n* = 202; 37%); and below L2, (*n* = 65; 12%). The authors reported a UTI incidence of 0.64 episodes per 100 person-days in all drainage methods, whereas the ASB incidence was noted at 1.70 episodes 100 person-days, respectively. Additionally, the incidence of UTI reported by particular bladder management included: indwelling catheterization (2.68) episodes/100 person-days, suprapubic cystostomy (0.56), reflex voiding (0.44), normal voiding (0.32), clean intermittent catheterization, condom drainage, and reflex voiding (0.34). Other findings indicated a total of 1,801 positive urine cultures among the participants; Escherichia coli in 298 (16.5%), followed by Kebsiella in 217 (12%), Staphylococcus aureus in 144 (8%), and Pseudomonas aeruginosa in 144 (8%) cultures.

Togan, Azap, Durukan, and Arslan (2014) conducted a retrospective study to investigate the prevalence of UTIs among persons with a SCI. Their research involved a sample of 93 patients (*n* = 78 males; *n* = 15 females) with a mean age of 35.65. Level of injury included cervical (30.5%), thoracic (63%), and lumbar (6.5%) with 78.5% (*n* = 70) individuals identified as paraplegic and 18.3% (*n* = 17) tetraplegic. Over a one-year period, findings revealed 67.5% of patients (*n* = 93) were diagnosed with asymptomatic bacteriuria and 22.6% (*n* = 21) had acquired a UTI. Hospitalization and having a history of UTIs was found to be strongly correlated for the development of this complication; however, the authors did not indicate the percentage and correlational strength for hospitalization, history of UTI, and development of UTIs among participants.

Prior to the previously discussed studies, Reid and Howard (1997) set out to investigate whether prophylactic antimicrobial therapy reduced the frequency of UTIs in comparison to those not receiving treatment. After reviewing 30 patient files (22 males and 8 females) of individuals using intermittent catheterization, 22 participants had been prescribed antimicrobial therapy. Within 157 weeks (for individuals receiving prophylaxis) and 165 weeks (for individuals not receiving prophylaxis), the incidence of UTI was significantly lower (44 UTIs) in comparison to eight participants not receiving treatment (72 UTIs). Therefore, the findings of 72 UTIs among the eight participants in <4 years indicate a high incidence for this SC if preventative measures are not taken. Reported results did indicate gender, age, time since injury, and level of injury as a contributing factor towards increased frequency of UTIs. See Table 10 for a summary of urinary tract infection study findings.

Table 10

Incidence of Urinary Tract Infection (UTI) and asymptomatic bacteriuria (ASB)

Author	Gender: n (%)	*M* Age	*M* TSI	LOI: n (%)	Inc. UTI: n (%)	Inc. ASB
Esclarin et al. (2000)	M:100 (78); F: 28 (22)	32.41 ± 14.52 Yrs.	19 days	C4-C8: 48 (37.5) D1-D6: 22 (17) D7-L2: 48 (37.5) L3-caudequina syndrome: 10 (8)	0.68 episodes /per 100 persons-days	2.72 episodes /per 100 persons-days
Evans et al. (2008)	M: 224 (98); F: 2 (2)	58.3 Yrs.	20.9 Yrs.	Tetra: 113 (50) Para: 103 (46) UK: 10 (4)	8.9 cases/ per 100 patient-days	N/A
Reid and Howard (1997)	M: 22 F: 8	38 Yrs.	N/A	Tetra: 15; Para 14; Cerv. 1	Rec. Treat. (Freq. of 44 out of 22 Patients); Non-Treat. (Freq. of 72 of 8 patients) < 4 Yrs.	
Singh et al. (2011)	M: 386 (71); F: 159 (29)	35.4 ± 16.2 Yrs.	20.6 ± 9.2 Months	C4-C8: 185 (34) D1-D10: 93 (17) D11-L2: 202 (37) Below L2: 65 (12)	0.64 episodes /per 100 persons-days	1.70 episodes /per 100 persons-days
Togan et al. (2014)	M: 78 (84); F: 16 (16)	35.65 ± 13.11 Yrs.	NS	Cervical: 28 (30.5) Thoracic: 59 (63) Lumbar: 6 (6.5)	Overall: 21 (22.6)	Overall: 63 (67.7)

Note. *M* = Mean; TSI = Time since injury; Tetra = Tetraplegia; Para = Paraplegia; Cerv. = Cervical; UK = Unknown; Avg. = Average; ASB = asymptomatic bacteriuria; Rec. = received; Treat. = treatment; Freq. = frequency; LOI = level of injury, Inc. = Incidence

Repetitive Motion Injury

Repetitive motion injury and pain is a common occurrence among persons with SCI due to the overuse of upper extremities from wheelchair transfers, propulsion, and activities of daily living. The prevalence ranges from 31-73% and can impact the quality of life among this population (Gellman, Sie, & Waters, 1988; Pentland & Twomey, 1991; Nichols, Norman, & Ennis, 1979; Sie, Waters, Adkins, & Gellman, 1992). After a thorough review of literature, a significant number of researchers have primarily focused on pain and *not* the specific cause of pain (e.g., rotator cuff tear, subacromial impingement syndrome, etc.). Therefore, it is important to make a distinction between pain and the cause. Pain can occur from daily overuse of the shoulder and can subside with time if appropriate rest is taken, whereas injury can be a long-term issue exhibiting symptoms of pain unless surgery or therapy is implemented. The literature review provided below was intended to primarily focus on injury and their cause; however, incidence of pain as a result from injury is discussed and reported.

To understand the consequence of shoulder pain due to injury, Samuelsson, Tropp, and Gerdle (2004) conducted a cross-sectional study among 56 individuals with paraplegia. For those who reported pain, group mean age was 52.4 ± 17.0 (*n* = 21) in comparison to a group mean age of 46.8 ± 17.4 (*n* = 35) years for those who indicated no pain. Mean time since injury for the group who reported pain was 16.2 ± 11.2 years while their group counterpart was 12.5 ± 10.5. Overall findings demonstrated a prevalence of pain at 37.5% (*n* = 21) with impingement syndrome and tendinitis listed as the primary cause for discomfort (*n* = 9, 17%; *n* = 7, 13%). The researchers' impression of the results listed activities of daily living (e.g., independent transferring) as a primary cause for repetitive shoulder injury.

Boninger, Towers, Cooper, Dicianno, and Munin (2001) conducted a study using magnetic resonance imaging (MRI), radiographs, questionnaires, and physical examinations to identify the incidence of shoulder injury among persons with paraplegia. Demographics for the sample included 28 individuals (19 males and 9 females) with a mean age and time since injury of 35 and 11.5 years, respectively. Descriptive statistics indicated 36% had reported shoulder pain (*n* = 9) within one month prior of the study, 29% (n = 8) had at some point visited a physician due to shoulder pain, and 13% (*n* = 5) had to modify their daily routine to accommodate their pain. Findings revealed no differences between age, years since time of injury, weight, or body mass index (BMI) and injury. Of the 55 shoulders examined, only one had acquired a rotator cuff tear. Additional findings revealed an incidence of 13% for osteolysis (progressive resorption/degeneration) of the shoulder. The consequences of shoulder injury, therefore, were limited to rotator cuff tear and osteolysis with a prevalence falling within the possibility threshold (<50%).

For those with a SCI, preventative measures of SCs have been recommended to avoid further difficulties associated with the injury. Various articles have briefly discussed obesity as it relates to an increased number of SCs that include repetitive motion injury. In a study to determine whether a relationship exists between obesity and SCs, Hetz, Latimer, Arbour-Nicitopoulos, and Ginis (2011) studied 695 participants using subjective measures to assess for relationships of weight and SCs. Two groups central to the study were categorized as self-reported "overweight" (*n* = 209) and "not overweight" (*n* = 483). The findings indicated a strong relationship existing among persons classified as overweight and subjective reports of overuse injuries (*n* = 115; 55%) in comparison to their counterparts (*n* = 213; 44.1%). However, the prevalence for this SC was 67.9% when combining both groups. Therefore, the overall prevalence for this SC reveals a probability threshold (i.e., ≥ 51%) regardless of weight as a predictive factor. Assessing for differences based on level of SCI and overuse injury was not reported.

Escobedo, Hunter, Hollister, Patten, and Goldstein (1997) evaluated the prevalence of rotator cuff tears (RCT) in 23 patients with paraplegia with an average of 26 years since injury utilizing MRI examinations. The mean age of the participants was recorded at 59 years old and the level of injury for all participants ranged from T3 to L2. Of the 37 shoulder images completed, 20 participants (54%) revealed rotator cuff tears. In addition, the researchers found a significant relationship of RCT and time since injury. The mean duration of a SCI was 13 years in patients showing no RCT (*n* = 17), 19 years for those with single-tendon RCT (*n* = 10), 33 years for participants with multiple tears without biceps tendon tears (*n* = 4), and 38 years for patients with multiple tendon tears and biceps tendon rupture or dislocation (*n* = 6).

Utilizing a retrospective analysis of medical records and MRI imaging, Eriks-Hogland, Engisch, Brinkhof, and van Drongelen (2013) similarly investigated the prevalence of acromioclavicular (AC) joint arthrosis in 68 SCI participants (53 males and 15 females) in relation to the able-bodied population. The mean age recorded among study population was 51 years with a time since injury (TSI) of 23 years. Participants were grouped according to the level of injury and the neurological classification according to the ASIA Impairment Scale (AIS). As a result the sample included paraplegia, (*n* = 49; 72%); tetraplegia, (*n* = 19; 28%); AIS A, (*n* = 54; 80%); AIS B, (*n* = 6; 9%); AIS C, (*n* = 5; 7%); AIS D, (*n* = 2; 3%), and unknown, (*n* = 1; 1%). Participants underwent a magnetic resonance imaging (MRI), followed by a clinical examination (i.e., palpitation of the AC joint test, cross-body adduction, lift-off, and empty-can) to assess for AC joint arthrosis and rotator cuff tears (RCT). The incidence of AC joint arthrosis and bone edema was evaluated using the Shubin-Stein classification system (Shubin-Stein, Ahman, Pfaff, Bigliani, & Levine, 2006), whereas the rotator cuff muscles and long tendons of the biceps were graded based on the tendinopathy, partial, transmural, or complete rupture.

The prevalence of AC joint arthrosis and RCT using MRI diagnosis was reported at 99% and 74%, respectively (Eriks-Hogland et al., 2013). However, during clinical examination, the prevalence for AC joint arthrosis and RCT was significantly lower at 19% and 27%, respectively. Additionally, supraspinatus muscle/tendon (SSP) was present in (*n* = 42; 62%) of the participants, followed by subscapularis muscle/tendon (*n* = 42; 62%), infraspinatus muscle/tendon (*n* = 25; 37%), and bone edema (*n* = 9; 13%). Other significant findings indicated the adjusted odds ratio of severe joint arthrosis was nearly four times higher (3.82) in persons with SCI in comparison to the able-bodied population. In relation to gender and age, the authors discovered the odds of severe joint arthrosis among people with a SCI were 72% lower in females as compared to males and increased 10% per each additional year of age. The authors reported no other significant findings in the overall prevalence of shoulder-related injuries when examining the level of lesion neurological classification, and times since injury. See Table 11 for a summary of repetitive motion injury study findings.

Table 11

Repetitive Motion Injury/Overuse Syndrome

Author	Gender: n (%)	*M* Age	*M* TSI	Level of Injury: n (%)	Incidence: n (%)
Boninger et al. (2001)	M: 19 (68) F: 9 (32)	35 Yrs.	11.5 Yrs.	Paraplegia	RCT: 1 (3.57) Osteolysis: 5 (13)
Eriks-Hogland et al. (2013)	M: 53 (78) F: 15 (22)	51 Yrs.	23 Yrs.	AIS A: 54 (80) AIS B: 6 (9) AIS C: 5 (7) AIS D: 2 (3) Unknown: 1 (1)	AC joint arthrosis: 67 (99) RCT: 50 (74) SSP: 42 (62) ISP: 25 (37) SSC: 42 (62) BO: 9 (13)
Escobedo et al. (1997)	Total: 23	56 Yrs.	26 Yrs.	Para: 23 (100)	RCT: 20 (54) of 37 shoulders images
Hetz et al. (2011)	M: 531 F: 164	46.3 ± 13.4	15.29 ± 11.1	C1-C4: 75 (10.8) C5-C8: 184 (26.5) T1-S5: 255 (36.7)	OS: Overall: 328 (69.7)
Samuelsson et al. (2004)	M: 44 (79) F: 12 (21)	49 ± 18	13.9 ± 10.8	N/S	Pain: 21 (37.5) IS: (17) Tendinitis: (13)

Note. M = Mean; TSI = Time since injury; OS = overuse syndrome; NS = not specified; acromioclavicular = (AC); RCT = rotator cuff tear; SSP = supraspinatus muscle/tendon; ISP = infraspinatus muscle/tendon; SSC, subscapularis muscle/tendon; BO = bone oedema; Para = paraplegia; Tetra = tetraplegia.

Discussion

The purpose of the literature review encompassing the aforementioned SCs among persons with a SCI was to provide life care planners with a guide as to the overall incidence rate with the empirical research previously discussed. These SCs are long-term medical problems that result after a SCI and play an important role in the continuum of care. However, as the empirical research demonstrates, not all SCs meet the probability threshold; contributing factors (i.e., age, gender, time since injury, etc.) may increase the likelihood of a SC occurring and should be considered when developing a life care plan for persons with a SCI.

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About the Authors

Dr. Noel A. Ysasi is currently an assistant professor at the University of Kentucky within the Department of Early Childhood, Special Education, and Rehabilitation Counseling. Dr. Ysasi's professional work experience involves over 7 years of teaching in higher education,

forensic rehabilitation, and working with the veteran population. He was recently awarded the Dissertation of the Year by the Foundation of Life Care Planning.

Shelby Kerwin is currently a graduate student at the University of Kentucky and is a research assistant for Dr. Noel Ysasi. Her research interests and background includes working with individuals with disabilities.

Dr. Irmo Marini is currently a professor in the School of Rehabilitation at the University of Texas-Rio Grande Valley. He has numerous journal, book chapters and book publications as well as numerous university and national awards in teaching, research, and service. He currently maintains a forensic rehabilitation practice.

Bradley McDaniels is a doctoral student in Rehabilitation Counseling, Department of Early Childhood, Special Education, and Rehabilitation Counseling, at the University of Kentucky and is a research assistant for Dr. Malachy Bishop. His research interests include chronic neurologic conditions, psychosocial adaptation, and issues related to quality of life for individuals with chronic illness and disability.

Ms. Danielle Leigh Antol is a recent graduate of the Rehabilitation Counseling program at the University of Texas-Pan American. Ms. Antol has years of experience in mental health, the legal arena, and is currently a forensic rehabilitation associate with Marini & Associates.