



# Major risk factors for pressure ulcers in the spinal cord disabled: a literature review

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Pressure ulcers remain a dominant health problem for persons with spinal cord injury despite abundant published research describing risk factors. Although information on these factors is plentiful, its usefulness to the spinal cord disabled is limited by three problems. First, the sheer volume is overwhelming; more than 200 risk factors for pressure ulcers have been described in the published literature. For most health care professionals, finding, no less reading and evaluating, the hundreds of articles published on this topic would be difficult. Second, most studies focused on elderly patients in nursing homes. Pressure ulcer risk factors for the spinal cord disabled are often different from those for the elderly; yet many findings from studies of the elderly provide valuable information. Third, inadequate sample sizes often hamper the usefulness of research on the spinal cord disabled. Drawing valid conclusions from these small studies, especially concerning potential risk factors is difficult. To address these three problems, we critically evaluated the medical, nursing, and nutritional research literature that pertained to risk factors for pressure ulcer development. The purpose of this paper is to provide a review of published reports on the principal risk factors for pressure ulcers in persons with spinal cord injury.

**Keywords:** pressure ulcer; decubitus ulcer; spinal cord injuries; paralysis; risk factors; spinal cord injury complications

## Introduction

Pressure ulcers are an underestimated healthcare problem, particularly for individuals with spinal cord injury.<sup>1,2</sup> Prevention of pressure ulcers, therefore, has not been given the appropriate high priority.<sup>2a</sup> Each year in the United States, pressure ulcer-related complications cause 60,000 deaths.<sup>3</sup> Among spinal cord injured individuals, between 7% and 8% will die of these complications.<sup>4,5</sup>

The annual incidence of pressure ulcers among individuals with SCI is between 23%<sup>6</sup> and 30%,<sup>7</sup> but up to 85% of SCI individuals develop a pressure ulcer at some point during their lifetimes.<sup>8–12</sup> More than 70% of SCI patients with a pressure ulcer have multiple ulcers.<sup>13</sup>

Because a spinal cord injury drastically alters a person's physiology,<sup>5,7,14–21</sup> an understanding of the most appropriate risk factors for this population is required. Moreover, the cutoff points reflecting the unique thresholds for each of these risk factors must be established.<sup>22–24</sup>

This review focuses on the major risk factors (Table 1) for the development of pressure ulcers in spinal cord injured individuals.<sup>25</sup> Additional risk factors, described in the published literature, are listed in Tables 2–7. Discussion of these additional risk factors is beyond the scope of this review. Readers interested in the additional factors can refer to the original sources, or the more general review of pressure ulcers provided by Yarkony.<sup>78b</sup>

## Pressure ulcer risk assessment scales

The overwhelming number of risk factors reported in the literature poses a challenge in clinical applications. To focus attention on the major risk factors various scales for assessing pressure ulcer risk have been proposed. Unfortunately these scales have been of uncertain application for SCI patients.

The Norton Scale,<sup>79</sup> one of the first of these pressure ulcer scoring systems, was developed in 1962, based on 250 geriatric patients. For the following 33 years, researchers refined and tested the Norton Scale on various types of patients.<sup>3,45,80–82</sup> It

accurately predicts pressure ulcers in orthopaedic patients<sup>83,84</sup> but its use in other patients has resulted in only limited success.<sup>85-91</sup>

In 1973, the Gosnell Scale was developed using 30 elderly patients.<sup>28,29</sup> The Braden Scale, developed in 1987, based on 199 patients,<sup>47</sup> proved an accurate predictor in several studies,<sup>30,31,92</sup> yet validation studies<sup>32,53,70,74,86,93,94</sup> did not confirm these results. In fact, one study showed that nurses could intuitively predict which patients would develop pressure ulcers more accurately than the Braden Scale.<sup>32</sup> Although many other pressure ulcer scales and assessment systems have been mentioned in the literature,<sup>26,39,58,95-107</sup> none have been proven effective in the SCI population.

**Table 1** Major risk factors for pressure ulcers

<i>Severity of Spinal Cord Injury</i>	
1.	Decreased level of activity
2.	Immobility
3.	Completeness of the SCI
4.	Urine incontinence/moisture
5.	Autonomic dysreflexia/severe spasticity
<i>Preexisting Conditions</i>	
6.	Advanced age
7.	Tobacco use/smoking
8.	Pulmonary disease
9.	Cardiac disease/abnormal electrocardiogram
10.	Diabetes/poor glycemic control
11.	Renal disease
12.	Impaired cognitive function
13.	Residing in a nursing home/hospital
<i>Malnutrition and Anemia</i>	
14.	Hypoalbuminemia/hypoproteinemia
15.	Anemia

**Table 2** Potential physical risk factors

Male gender <sup>7,26</sup>
Nonwhite race/ethnicity <sup>7,12,27</sup>
Hypotension <sup>11,28-35</sup>
Elevated skin temperature <sup>36</sup>
Chronic illness <sup>37,38</sup>
Dry or scaling skin/skin condition <sup>39-41,190</sup>
Foley catheter <sup>42</sup>
Circulatory disorders <sup>22</sup>
Fecal incontinence <sup>22,41,43</sup>
History of a previous pressure ulcer <sup>26,44</sup>
Acute fracture <sup>44</sup>
Paraplegia <sup>26</sup>
Transferred from another hospital <sup>26</sup>
Alcoholism <sup>26</sup>
Edema
Pain/periodic pain <sup>39</sup>
Infection <sup>35,38,43,45,46</sup>
Elevated body temperature/fever <sup>21,28,29,31,33,34,43,47-50</sup>

The variables in current risk assessment scales have been criticized as 'peripheral to the issue, subjectively determined and not correlated with the development of a pressure ulcer'.<sup>85</sup> These scales often depend on vaguely defined and arbitrarily weighted risk factors. Although these pressure ulcer scales have been used for SCI individuals,<sup>45</sup> we are not aware of any scale that was specifically designed for the SCI group.

Few SCI care givers want another scoring system. Most realize, however, a need to focus on major risk factors specific to the SCI population: without properly accounting for these major risk factors or the patient mix, predicting the high-risk subgroup will remain inaccurate. Researchers know that without proper adjustment for these major risk factors, evaluating methods of preventing pressure ulcers will be inefficient.<sup>8,108-116</sup>

Much of the published research on predicting those at risk for pressure ulcers, especially in persons with SCI, is limited. Small sample sizes, inadequate follow-

**Table 3** Potential nutritional risk factors

Negative nitrogen balance <sup>37,51</sup>
Hypocholesteremia <sup>52</sup>
Low body mass index/thinness <sup>31,32,37,41,50,53-56,190</sup>
Inadequate fluid intake/dehydration <sup>33,37,57,58</sup>
Poor nutritional intake <sup>43</sup>
Cachexia/pronounced emaciation <sup>33,57</sup>
Obesity <sup>59</sup>
Inadequate serum ascorbic acid <sup>60-65</sup>
Inadequate serum zinc <sup>60,65,66</sup>
Ideal body weight below normal <sup>31</sup>
Triceps skinfold thickness below normal <sup>31,41,190</sup>
Inadequate protein intake (as percent of RDA) <sup>31,52,67</sup>
Vitamin deficiencies in general <sup>68</sup>
Low levels of serum calcium <sup>15</sup>
Low levels of magnesium <sup>15</sup>
Vitamin D deficiencies <sup>15, 65</sup>
Vitamin E deficiencies <sup>65</sup>

**Table 4** Potential movement risk factors

Prolonged immobilization immediately after SCI <sup>11,69</sup>
Prolonged time on spinal board <sup>11</sup>
Friction <sup>5,70,189</sup>
Shearing of skin surfaces <sup>37,70-72</sup>

**Table 5** Potential socioeconomic risk factors

Low level of education <sup>7,26</sup>
Low level of income <sup>26</sup>
Poor hygiene <sup>38,45,73</sup>
Medicare/Medicaid <sup>7</sup>

**Table 6** Potential psychological risk factors

Patient noncompliance with pressure ulcer prevention <sup>74</sup>
Uncooperative behavior <sup>39</sup>
Emotional stress <sup>75,76</sup>
Marital status of single/unmarried <sup>7</sup>
Poor responsibility in skin care <sup>77</sup>
Low satisfaction with activities of life <sup>77</sup>
Low self-esteem <sup>78</sup>

**Table 7** Potential medication risk factors

Medication in general <sup>29,37</sup>
Sedatives <sup>28,39</sup>
Tranquilizers <sup>28</sup>
Analgesics <sup>28</sup>
Steroids <sup>50</sup>
Anti-inflammatory drugs
Anesthesia
Cardiotonics <sup>28</sup>

ups and insufficient control of confounding variables make generalizing difficult. Yarkony and Heine-mann<sup>116a</sup> provide a notable exception in their large, long-term study of pressure ulcers. They showed that admission to a 'Model SCI Center' may significantly reduce the incidence of pressure ulcers.<sup>7,116a</sup> If pressure ulcers are to be prevented, understanding the major risk factors and using a system that accurately predicts the high-risk group among SCI individuals is critical.

### Severity of spinal cord injury

*Level of activity* is a primary risk factor for pressure ulcer development.<sup>1,27-29,37,42,43,47,49,58,60,70,74,78,79,92,117-120,189</sup> However, because approximately 90% of SCI patients use a wheelchair,<sup>25</sup> this variable by itself is not a good discriminator.

*Level of mobility* is another important risk factor, independent of level of activity.<sup>12,22,27-29,33,37,38,41,45,47-49,57,58,70,74,78,79,89,121,122-125,190</sup> The risk of ulcer formation in SCI patients, in the 'slightly' and 'very limited' mobility groups is similar.<sup>25</sup> These ambiguous categories have been a major source of reliability errors,<sup>85</sup> and in SCI patients they may not be essential for establishing the level of risk.

Completeness of spinal cord injury is a major risk factor.<sup>7,9,26,44,69,126-128</sup> Young *et al.* reported 'the completeness of the injury appears to be a much more powerful determinant of pressure ulcer occurrence than level of the lesion'.<sup>7</sup> This may be a function of the higher *level of activity* in paraplegics. Whether the risk of pressure ulcers is higher in tetraplegics or paraplegics remains unresolved.<sup>9,129</sup> Many clinicians believe that *higher* spinal cord injuries (ie, cervical) are associated with higher risk of pressure ulcers. The

weight of evidence does not support this.<sup>9,60,77,126,130</sup> In fact, our experience suggests that patients with thoracic lesions are at the highest risk for pressure ulcers.<sup>25</sup> Because of these inconsistencies regarding paraplegia as a risk factor we did not include it as a major risk factor in Table 1. Instead, it is listed in Table 2 with other potential physical risk factors.

Incontinence and moisture have been consistently associated with pressure ulcers.<sup>4,27,33,37,43,47,49,56-58,62,70,74,78,79,81,92,94,118,122,125,131-139</sup> Urinary incontinence may be a more accurate predictor of pressure ulcers than fecal incontinence among the SCI patients.<sup>25</sup> Unlike geriatric patients, fecal incontinence may not significantly increase the risk of pressure ulcers (independently of urinary incontinence) for SCI persons. Therefore, it also is listed in Table 2 with other potential physical risk factors rather than major risk factors in Table 1.

Autonomic dysreflexia is a condition that affects individuals with spinal cord injuries at level T6 and higher. This condition is the result of increased autonomic activity resulting from reflex hyperactive sympathetic responses to various provoking stimuli. Autonomic dysreflexia and spasticity<sup>4,7,14,38,45,68,132,140-143</sup> are both more common in patients who develop pressure ulcers, but the causal effect relationship is poorly understood.

### Preexisting conditions

Age is a risk factor for pressure ulcers in the non-SCI population.<sup>27-29,31,32,34,37,42,57,60,79,84,120,127,144,145,190</sup>

The age cutoff point, however varies widely in the literature (>40,<sup>26</sup> >50,<sup>123</sup> ≥60,<sup>44</sup> ≥65,<sup>43,49,123,144</sup> >70,<sup>27,33,40,70,119,120,134</sup> >75,<sup>41,190</sup> >80,<sup>49,146</sup>) and may not be appropriate for SCI patients. The risk of pressure ulcers in SCI patients may increase after age 35 and again after age 65.<sup>25</sup> For the pressure ulcer risk in the SCI population, age may have a bimodal curve.

Cigarette smoking plays a crucial role in the development of pressure ulcers. Current smokers are at significantly increased risk for pressure ulcers.<sup>25,40,53,147</sup> Pressure ulcers of the heel are four times more common in smokers.<sup>75</sup> In a study of 38 SCI patients, cigarette smoking (pack-years) was positively correlated ( $r=0.47$ ,  $P<0.001$ ) with a 'higher incidence and more extensive pressure ulcers'.<sup>126</sup> Fortunately, those who cease smoking may significantly reduce their risk of developing pressure ulcers and the effects of smoking may be partially reversible.<sup>25</sup>

Arteriosclerotic heart disease is another pressure ulcer risk factor.<sup>1,73,117,120,148</sup> Surprisingly, one study found a lower risk for pressure ulcers in those with heart disease. The authors that suggested this may be an artifact related to the sudden deaths in the patients with heart disease.<sup>40</sup> Researchers have generally found that the incidence of pressure ulcers is higher in patients with cardiac diseases.<sup>22,49,53,73,120,149,150</sup> This connection needs further investigation before it can be

used to predict pressure ulcers accurately. Blood pressure is routinely higher in tetraplegics than in paraplegics.<sup>6</sup> Chronic hypertension is more prevalent in SCI patients, compared with persons without spinal cord injury.<sup>19</sup> These may be compensatory mechanisms because hypotension is a well-known risk factor for pressure ulcers.<sup>11,28,30,31,34</sup>

Another preexisting condition associated with pressure ulcers is pulmonary disease, but the causal mechanism is also not fully understood.<sup>7,25,43,59,151</sup> future research should include blood gases and other methods of measuring the extent of pulmonary diseases in strong prospective designs.

SCI patients have a higher incidence of diabetes than non-SCI patients.<sup>19</sup> Diabetes has been linked to pressure ulcers in many studies,<sup>1,27,42,43,54,117,121,124,152,153</sup> but not in all.<sup>40,146</sup> A link between renal disease and pressure ulcers has been suggested but never firmly established due mainly to limited sample size.<sup>20,27,43,48,120,149,151</sup>

Many of the studies that examined preexisting conditions lacked the statistical power to show the association between these conditions and pressure ulcers. For example, in a study of non-SCI hospitalized patients, Allman, *et al.*<sup>48</sup> reported that the incidence of diabetes was twice as high (30% vs 15%) in a group of pressure ulcer patients vs controls. The *P* value was of borderline significance (0.09) due to the small sample size of 108 patients. We calculated the sample size required to achieve statistical significance (using an alpha error of 0.05 and a power of 0.80) for the increase from 15% to 30%. Such a study would require 134 patients with pressure ulcers and 134 patients without pressure ulcers. However, in smaller studies, lack of statistical significance should not be misinterpreted as proof that a variable is not a risk factor.

Another category of major risk factors involves impaired cognitive function. Unconscious patients are at a higher risk of developing pressure ulcers than are semiconscious patients.<sup>27</sup> Altered level of consciousness, history of cerebrovascular accident, and dementia have also been associated with pressure ulcers.<sup>28,29,33,42,43,48,58,79,94,96,117,120,121</sup> Although depression may be more prevalent in the SCI population, it is not related to pressure ulcers.<sup>154</sup> Others have found psychosocial factors,<sup>77</sup> such as economic self-esteem and social adjustment,<sup>155</sup> to be related to pressure ulcers in SCI patients.

SCI patients in nursing homes and hospitals commonly have conditions that place them at increased risk for pressure ulcers.<sup>7,127</sup> For non-SCI persons, the prevalence of pressure ulcers varies widely among nursing homes – independent of the population's injury severity.<sup>55,156,157</sup> The prevalence of pressure ulcers in nursing homes has been reported to range from 0% to 15%,<sup>55</sup> 16% to 35%,<sup>94</sup> 2.6% to 24%<sup>158</sup> and 0% to 78%.<sup>156</sup> In a study performed in 30 Department of Veterans Affairs nursing homes, investigators found that the injury severity of patients

was similar in the two institutions with the extreme pressure ulcer prevalence rates.<sup>55</sup> For an SCI individual, residing in a nursing home or hospital is a good indicator of risk for pressure ulcers regardless of the causal relationship.

### Malnutrition and anemia

Pressure ulcer risk increases with poor nutrition. After pressure itself, malnutrition is one of the most important risk factors in the etiology of pressure ulcers.<sup>24,26,28,29,37,42,47,48,51,52,59,62,121,138,159–167</sup> Breslow<sup>168</sup> reviewed the research literature between 1943 and 1989 and concluded 'The literature clearly demonstrates that patients with pressure ulcers are malnourished'. In particular, the published reports show that hypoalbuminemia and anemia clearly predispose patients to pressure ulcers.

In a comparison study, physician-assessed nutritional status was not a good predictor of pressure ulcer development; low hemoglobin (<12 gm/dl) was found to be a significant predictor,<sup>40</sup> demonstrating the importance of using objective nutritional indicators. Judging that a patient has 'inadequate nutrition' may be more convenient than measuring hemoglobin or serum albumin value. Unfortunately, this subjective assessment has little predictive value.<sup>22</sup> The cost of blood analysis for objectively measuring the nutritional status of these patients is only a small fraction of the cost of treating a pressure ulcer.<sup>170</sup>

Hypoalbuminemia has been well documented as a predictor of pressure ulcers.<sup>1,22,34,42,44,48,52,60–62,82,86,92,108,117,118,121,132,133,149,160–163,170–174</sup>

Hypoproteinemia<sup>1,14,22,31,34,38,42,45,86,121,161,164,172,175–177</sup> has also been linked to pressure ulcer development. Holmes, *et al.*<sup>170</sup> studied nine patients who developed pressure ulcers after admission. They examined changes from admission to ulcer formation and found significant drops in albumin (3.1 to 2.5 gm/dl) and hemoglobin (12.6 to 8.7 gm/dl). These findings and other evidence suggest that hypoalbuminemia is an antecedent factor and not the result of a pressure ulcer.<sup>25,34,48,82</sup>

One study does not completely support this view. In 1989, Berlowitz and Wilking<sup>42</sup> found that hypoalbuminemia was significantly associated with pressure ulcers in their cross-sectional analysis, but not in their prospective analysis. Yet the lack of statistical significance in the prospective design does not – as they suggested – disprove hypoalbuminemia as a risk factor or prove a bias in the cross-sectional study. This lack of significance could be the result of too few patients with pressure ulcers ( $n=20$  compared with  $n=100$  for the cross-sectional study). It also could be attributable to the short follow-up period of 3 weeks. There is also evidence that hypoalbuminemia may be associated with deep, but not superficial pressure ulcers.<sup>73,121,161</sup> Nursing staff may provide different care (such as nutritional supplementation or more

frequent turning) to those with abnormally low albumin levels. This would obviously bias the findings of these in-hospital prospective studies.

Several reports suggest that for serum albumin a cutoff point of <3.4 gm/dl may be an appropriate threshold. Bobel<sup>173</sup> states, 'Serum albumin levels below 3.4 mg per dl are significant for protein deficiency'.<sup>170</sup> Others have recommended starting nutritional intervention to prevent pressure ulcers when the albumin level is below 3.3 gm/dl.<sup>161</sup> Holmes<sup>170</sup> et al. showed that patients with albumin levels below 3.5 gm/dl were nearly five times as likely to develop a pressure ulcer. They recommended this cutoff point for screening patients for pressure ulcer risk upon hospital admission. In a study by Vasile et al.,<sup>1</sup> serum albumin levels were below 3.5 gm/dl for all 27 patients with pressure ulcers. Moolten<sup>121</sup> found serum albumin levels below 3.5 gm/dl in 85.7% (24/28) of patients with deep pressure ulcers. SCI patients have increased albumin elimination rates<sup>16</sup> and lower serum albumin levels than non-SCI patients (3.70 vs 4.15 gm/dl,  $P < 0.001$ ).<sup>15</sup> Yet among pressure ulcer patients, SCI patients had a higher albumin level than non-SCI patients (3.40 vs 2.13 gm/dl).<sup>22</sup> Individuals with SCI require a cutoff point, specific for their condition.<sup>25</sup>

Anemia is also a well-established antecedent of pressure ulcers.<sup>1,7,14,22,33,35,38-40,42,44,45,52,61,68,75,117,121,132,170,178-181</sup> Hematocrit values of less than 36% may be useful for screening patients at risk, although the optimal hematocrit level for SCI patients may be greater than 40%.<sup>25</sup> Cutoff points of <36% for hematocrit and <12 gm/dl for the hemoglobin are supported by several published studies.<sup>40,52,68,143</sup>

The total number of pressure ulcers that a SCI person develops is inversely related to hematocrit level.<sup>25</sup> Yet average hematocrit and albumin levels are often within normal limits for SCI individuals in both groups – with and without pressure ulcers. Nevertheless these groups can be significantly different, statistically, from one another.<sup>25</sup> Several explanations for this paradox can be found. First, mild anemia is only one of many factors that predispose SCI individuals to pressure ulcers. Second, low hematocrit may be a strong risk factor for some sites (eg, trochanteric pressure ulcers) but a weak factor for pressure ulcers at other sites. Third, it is possible that SCI patients have a different hematocrit threshold for pressure ulcer development than non-SCI patients. In addition most SCI patients experience mild anemia and many have 'unpredictable fluctuations of the hemoglobin level'.<sup>165</sup>

The 'traditional' surgical cutoff point for hematocrit is <30%, and for albumin is <3.0 gm/dl. These points are not based on scientific studies involving SCI patients, but are rather designed to identify surgical patients at risk for postoperative mortality. Our recent findings suggest that these two cutoff points would not be useful for screening SCI patients for pressure ulcer risk; specificity would be 100% but sensitivity would

be below 10%.<sup>25</sup> Among SCI patients, those with 'above normal' or 'high normal' hematocrit and albumin values may be protected against pressure ulcer development. Recently, a large study of the elderly showed that, even within the normal range for serum albumin, mortality risk increases 'stepwise' with decreasing albumin.<sup>182</sup>

Hypoalbuminemia and anemia both predict length of stay for SCI patients in a rehabilitation institution.<sup>181</sup> Increasing hematocrit and albumin levels through nutritional supplementation does increase the rate of pressure ulcer healing.<sup>167,169,184,186</sup> Low hematocrit is predictive of Stage III and IV pressure ulcers, but not Stage I and II. The mean hematocrit of the pressure ulcer group (for all stages) will not provide an accurate measure of this risk factor. Several reports have shown that Stage III and IV ulcers have different risk factors.<sup>52,73,121,161,163,178,183</sup>

## Conclusions

Pressure ulcers account for one-fourth of the cost of caring for SCI patients.<sup>132</sup> Prevention of these ulcers would cost less than one-tenth the amount spent on treatment:<sup>135</sup> clearly 'more emphasis must be placed on their prevention'.<sup>128</sup> Changes in the health care system should include cost-efficient and timely prevention programs to contain these medical costs in the future.

The total cost attributable to treating pressure ulcers has been estimated at between two and five billion dollars annually in the United States.<sup>77,80,124,162</sup> During the initial hospital and rehabilitation period, it costs 66 million dollars per year to treat new SCI patients who developed pressure ulcers (40% of the 8275).<sup>11</sup>

In the US there are 200,000 SCI patients.<sup>2,186</sup> The annual incidence of pressure ulcers in SCI patients is 23%.<sup>6</sup> Thus, an estimated 46,000 SCI individuals per year develop a pressure ulcer in the US. Using a conservative estimate of \$25,000 to treat each pressure ulcer,<sup>187</sup> the potential total cost of treating SCI patients for pressure ulcers can be estimated at \$1.2 billion annually.

Although cost estimates vary, there is no question that preventing pressure ulcers is far less expensive than treating them.<sup>3,135,188</sup> Patients with multiple, major risk factors are in a high-risk group and should be enrolled in a comprehensive program for preventing pressure ulcers.<sup>109</sup> Pressure ulcer prevention in the high-risk group of SCI patients deserves a high priority in the future health care and insurance reforms.<sup>7</sup> This review summarizes the published information on the 15 major risk factors to help make such a prevention program more manageable.

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