Incidence, Etiology, and Risk Factors for Fever Following Acute Spinal Cord Injury

William McKinley, MD; Shane McNamee, MD; Michelle Meade, PhD; Katrina Kandra, MD; Nicole Abdul

Department of Physical Medicine and Rehabilitation, Virginia Commonwealth University, Richmond, Virginia

Received December 30, 2005; accepted June 24, 2006

Abstract

Objective: To identify the incidence, etiology, and risk factors for fevers in individuals with traumatic spinal cord injury (SCI).

Design: A retrospective review of the medical records of consecutive adult traumatic SCI patients over a 2-year period was performed.

Setting: The study was performed at a tertiary care, Level I trauma center.

Participants: Consecutive adult traumatic SCI admissions to acute care ($n = 48$) and rehabilitation ($n = 40$) were included in the study.

Main Outcome Measures: Incidence, etiology, mean maximum temperature elevation, and duration of fevers (temperature >99.9 F) were measured.

Results: The incidence of fever was 60.4% and 50% (acute care and rehabilitation, respectively). Total number of fevers was 58 and 66, acute and rehabilitation, respectively. Respiratory and urinary tract were the most common identifiable fever etiologies. Unidentified fever etiologies were numerous in both the acute and rehabilitation groups, representing 66% and 56% of cases, respectively. Significant differences ($P < 0.05$) were found between identified vs unidentified fever etiology groups for mean maximal temperature (102.5°F vs 101.1°F on acute and 101.5°F vs 100.7°F on rehabilitation), duration of fever (10.3 days vs 2.2 on acute and 2.8 days vs 1.3 on rehabilitation), fevers above 101.4°F (75% vs 29% on acute and 40% vs 8% on rehabilitation), cause of injury (gunshot wound on acute care) and completeness of injury (American Spinal Injury Association classification A on rehabilitation).

Conclusions: This study suggests that fevers occur commonly in patients with SCI, with respiratory and genitourinary system etiologies most commonly identified. Unidentified etiologies were common and were associated with lower temperature elevation and shorter fever duration. Injury etiology and completeness of injury may comprise additional risk factors. These factors should be taken into account when initiating cost-efficient fever workup in individuals with SCI.

J Spinal Cord Med. 2006;29:501–506

Key Words: Spinal cord injuries; Fever; Infection; Rehabilitation

Please address correspondence to William McKinley, MD, PO Box 980661, Richmond, VA 23298; phone: 804.828.4233; fax: 804.828.5074 (e-mail: wmckinle@hsc.vcu.edu)

This research was supported in part by a grant from the National Institute on Disability and Rehabilitation Research in the office of Special Education and Rehabilitation Services in the US Department of Education to the Regional Spinal Cord Injury Center of Virginia Commonwealth University, Richmond, Virginia (#H133N5000015).

INTRODUCTION

It has been estimated that approximately 11,000 individuals sustain traumatic spinal cord injury (SCI) in the United States each year and then undergo acute care and subsequent rehabilitation requiring several weeks of hospitalization (1). With this in mind, an increased understanding of the clinical challenges associated with their care is very important. Increased morbidity as a result of secondary SCI-related conditions or associated medical complications can play a significant role in their ongoing clinical management, length of stay, and cost of care (2–6).

Fever is a frequent occurrence among patients with SCI, especially during initial hospitalization, and often constitutes an early sign of underlying morbidity (7–11). Several SCI-related secondary medical conditions, as well as underlying risk factors, predispose patients to both infectious and noninfectious etiologies for fever (12–17). These conditions include prolonged immobilization, respiratory muscle weakness, neurogenic bladder, steroid administration for acute SCI, surgical (spinal or other) procedures, and prolonged hospitalization (with exposure to nosocomial bacteria). Previous studies have identified respiratory infections and urinary tract infections (UTI) as the most frequent etiologies for fevers (7–11). Colachis identified febrile events in 85% of patients with SCI, the majority of which correlated with UTIs and lower respiratory tract infections (11). Other commonly identified infectious fever etiologies following SCI include pressure ulcers, wound infections, and osteomyelitis, as well as viral infections (18–20). Noninfectious etiologies that can result in fevers include thromboembolism, heterotopic ossification, thermoregulatory dysfunction, and medication-related (drug) fevers (18,21,22).

Diagnosis of infectious etiologies can be problematic in individuals with SCI. Depending on the neurological level and completeness of injury, patients with SCI may present with diminished clinical signs and symptoms to assist in the diagnostic workup. Reasons for this include weakness of the abdominal muscles leading to diminished cough, and decreased sensation of painful symptoms (such as dysuria or discomfort from wound or bone infections). Oftentimes, identification of fever etiology is difficult to establish, such as with concomitant infections, rapidly resolving viral infections, or transient thermoregulatory dysfunction. In patients with SCI at or above the midthoracic region, there is an increased risk for poikilothermia (inability to self-regulate internal body temperature because of diminished sympathetic regulation) and susceptibility for thermoregulatory dysfunction (either hyperthermia or hypothermia) (22).

Given the potential etiologies and risk factors for infectious and noninfectious fever etiologies, as well as SCI-related difficulties with their presentations, it becomes important to design a cost-effective fever workup. Currently, there exists little information to guide clinicians in their approach to prioritizing febrile episodes in individuals with SCI. Diagnostic workups can be costly, interfere with ongoing rehabilitation, and may prolong length of stay (or lead to discharge at lower functional levels secondary to ever-shortening length of stays) (1).

The objectives of this study were to evaluate the incidence and etiology for fever following acute SCI, and to evaluate associated risk factors (such as the level and completeness of injury) that may predispose to fever. We explore factors that may lead to unidentified fever etiologies, in addition to fever profiles for identified and unidentified etiologies. This information will further assist

with assessment, clinical care, and quality of life for individuals with SCI.

METHODS

Medical records of consecutive adult traumatic SCI patients over a 2-year period were reviewed for both acute care and rehabilitation admissions to a tertiary care, level 1 trauma center. Data collection for demographic and injury characteristic data was undertaken, including sex, age, etiology of injury, neurological level of injury (cervical, thoracic, lumbar), and completeness of injury, as defined by the American Spinal Injury Association Impairment Scale (AIS) (23,24).

Records were reviewed for febrile episodes documented on daily nursing vital sign “flow sheets.” A febrile episode was defined as any recorded temperature greater than 99.9°F (37.7°C) (25). The number of consecutive days that the temperature exceeded that threshold was defined as the “fever duration.” The highest maximal temperature during the entire episode was subsequently recorded.

Each febrile episode was reviewed for its underlying etiology. Etiologies documented within the medical records were reviewed and verified based upon the following criteria. When episodes did not meet these criteria, the label of “unidentified etiology” was applied. Urinary tract infection was indicated by a urinalysis with >8 white blood cells/high-powered field (WBC/hpf) and a urine culture with >10,000 colony-forming units (cfu)/mL. Respiratory tract infection criteria included documentation of chest radiograph findings. The criteria for deep venous thrombosis (DVT) included positive results with venous Doppler ultrasound. Pulmonary embolus (PE) criteria included symptoms (tachypnea and hypoxia) along with a positive diagnostic test (such as spiral computed tomography [CT] or ventilator-perfusion scan). Drug-induced febrile episode criteria included fevers whose resolution corresponded with initiation and discontinuation of specific medications. Gastrointestinal infections (GI) criteria included symptoms (diarrhea, nausea, vomiting) as well as positive diagnostic tests (such as *Clostridium difficile* cultures), if suspected. Wound infection criteria included documented wound examination findings (such as erythema, tissue necrosis) in the setting of fever. Criteria were also set for osteomyelitis, bacteremia, heterotopic ossification, thermoregulatory dysfunction, and viral infections; however, no febrile episodes in this study were attributed to these etiologies.

Statistics, including proportions, means and standard deviation were compiled for all demographics and outcome measures. Independent sample *t* tests were used to examine between group differences on continuous variables. Those nominal and ordinal variables were analyzed using nonparametric statistics (Kruskal-Wallis chi square).

Table 1. Incidence and Etiology of Fevers in Spinal Cord Injury*

	Acute Care (n = 48)	Rehabilitation (n = 40)
Patients With Fever	29 (60%)	20 (50%)
Total Fevers	58	66
Average Maximal Temperature	101.6°F	101.1°F
Average Fever Duration	4.9 Days	1.9 Days
Identified Etiologies	26 (45%)	34 (53%)
Respiratory	14 (24%)	6 (9%)
UTI	6 (10%)	21 (32%)
DVT	3 (5%)	0
PE	2 (3%)	2 (3%)
Drug	0	1 (2%)
Wound	0	3 (5%)
GI	1 (2%)	1 (2%)
Unidentified Etiologies	32 (55%)	32 (47%)

*UTI, urinary tract infection; DVT, deep venous thrombosis; PE, pulmonary embolus; GI, gastrointestinal infections.

RESULTS

Acute Care

Information was available for 48 patients from the acute care setting. Patients were more often male (85.4%), white (50%), and injured in a motor vehicle crash (38.3%). The average age at injury was 40.8 years (SD = 17.3 years). Twenty-nine individuals (60.4%) had at least 1 fever (total fever episodes = 58) during their acute care course. The average maximal fever temperature for fevers during acute care was 101.6°F (SD = 1.3°F); average duration of fevers was 4.9 days (SD = 6.8 days). Fever etiologies were identified in 26 cases (45%) with the most common etiologies including respiratory, 14 (24%), and UTIs, 6 (10%). Fifty-five percent of fever etiologies recorded in acute care were “unidentified” (see Methods section). In 75% of fever episodes, maximal temperatures were $\geq 101.5^\circ\text{F}$ (Table 1).

Significant statistical differences were found between fevers with identified vs unidentified etiology. Fevers with identified etiologies had a higher mean maximal temperature (102.5°F vs 101.1°F ; $X^2 = 11.24$; $P = 0.002$), longer fever duration (10.3 days vs 2.2 days; $P < 0.001$), and a higher percentage of fevers $> 101.5^\circ\text{F}$ (75% vs 29%; $X^2 = 11.043$; $P < 0.001$) than those fevers with unidentified etiology (Table 2). In addition, there was a significant difference between the groups (identified vs nonidentified fevers) regarding the number of fevers above 101.5°F and those associated with gunshot wound etiology of injury (70% vs 32%; $X^2 = 6.064$; $P = 0.014$).

Inpatient Rehabilitation

Information was available for 40 patients who were admitted to inpatient rehabilitation. Patients were more

commonly male (87.5%), white (52.5%), and with motor vehicle accident injury etiology (47.4%). The average age at injury was 42.2 years (SD = 17.5 years).

Twenty individuals (50%) had at least 1 fever (total fever episodes = 66) during rehabilitation. The average maximal fever temperature was 101.1°F (SD = 0.94°F); average duration of fever was 1.9 days (SD = 2.1 days). Fever etiologies were identified in 34 cases (52%) with the most common etiologies including UTI, 21 (32%) and respiratory, 6 (9%). In 48% of the fever episodes, no etiologies were recorded during inpatient rehabilitation. In 40% of fever episodes, maximal temperatures were $\geq 101.5^\circ\text{F}$ (Table 1).

Significant statistical differences were also found in the rehabilitation setting between fevers with identified vs unidentified etiology. Once again, fevers with identified etiologies had a higher mean maximal temperature (101.5°F vs 100.7°F ; $t = 3.92$; $P < 0.001$), longer fever duration (2.67 days vs 1.26 days; $t = 2.93$; $P = 0.005$), and a higher percentage of fevers $> 101.5^\circ\text{F}$ (40% vs 8%, $X^2 = 11.05$; $P < 0.001$) than those fevers with unidentified etiology (Table 2). Finally, fevers with identified etiologies and those without identifiable etiology were once again found to have significant differences related to gunshot wound etiology of injury (32% vs 17%; $X^2 = 4.839$; $P = 0.028$) and AIS A upon admission (87% vs 57%; $X^2 = 7.022$; $P = 0.008$).

DISCUSSION

This study reports that 50% to 60% of individuals had fever episodes during their acute care and rehabilitation hospitalization. An increased understanding of fever incidence, etiologies, and risk factors can allow for improved preventative care, timely diagnosis, patient/caregiver education, and management. Our incidence is slightly lower than those noted in most previous reports (7–11). Advances in SCI education and clinical care may have contributed to this reduction in fever incidence, as more aggressive prevention of secondary morbidities (such as pneumonia, UTI, pressure ulcers, etc) have become standard care following new onset SCI (10,19). In addition, shorter lengths of stay seen more commonly in both acute care and rehabilitation, for patients with new-onset SCI, could affect overall fever incidence (1,26).

Fever episodes often represent a sign of a related underlying disease process that may further increase clinical morbidity. When individuals with SCI present with fever, clinicians have an obligation to assess the etiology. While fevers are often infectious in nature, noninfectious etiologies may include inflammatory conditions such as deep venous thrombosis, pulmonary embolism, and heterotopic ossification. Patients with fevers need to be evaluated with adequate history, physical examination, and, (as necessary) laboratory or radiological testing to assess for underlying infection, and determine whether limitations need to be placed on patient activity or treatment.

Table 2. Comparison of Fevers in Identified vs Unidentified Etiologies

		Identified Etiology n = 26 (acute), 34 (rehab)	Unidentified Etiology n = 32 (acute), 32 (rehab)	Significance
Average Maximal Temperature	Acute	102.5°F	101.1°F	$P = 0.002$
	Rehabilitation	101.6°F	100.7°F	$P = 0.001$
Fevers > 101.4°F	Acute	75%	29%	$P = 0.001$
	Rehabilitation	40%	8%	$P = 0.002$
Average Fever Duration	Acute	10.3 Days	2.2 Days	$P = 0.001$
	Rehabilitation	2.9 Days	1.4 Days	$P = 0.005$

Fever occurrences and their ensuing clinical workup can result in significant time, effort, and cost. They can complicate and delay inpatient rehabilitation participation, thereby prolonging hospital length of stay (5). Low-grade fevers not associated with precarious physical examination findings (such as new-onset pulmonary changes, extremity swelling, or pressure ulcer) or significant patient complaints (such as pain, malaise) may enable patients to maintain their daily routines (therapy). Thus, prioritizing fever workups becomes important and will be guided by history, examination, and clinical course. Many tests (such as urinalysis, serum) and their urgency/timing (during patient therapy time vs non-therapy time) should be considered. Examples of less intensive (and possibly less expensive) diagnostic workup include urinalysis, blood tests, or blood/tissue cultures, while more time-consuming (thus, more missed therapy time because of time spent off the unit) testing might include radiographic or Doppler testing.

Commonly identified fever etiologies in this study were those involving the respiratory (pneumonia) and genitourinary (UTI) system, during both acute care and rehabilitation, a finding consistent with prior literature (13). Tetraplegia and high thoracic paraplegia result in weakness of the primary and accessory muscles of respiration, leading to reduced pulmonary efficiency, cough, and atelectasis (27). These findings, along with prolonged immobilization, are factors that increase risk for respiratory infections. Neurogenic bladder, due to diminished control to parasympathetic bladder innervation, results in urinary stasis, increased bladder pressures, and the need for catheterizations, which have been cited as risk factors for genitourinary infections.

There is a high incidence of thromboembolic disease in individuals with SCI, especially when prevention measures are inadequate. In individuals with SCI, timely, noninvasive venous assessment of limbs could be a basic part of the workup, especially when more common sites of infection, such as urinary tract and lungs, are ruled out. Ventilation-perfusion scanning or spiral chest CT imaging to rule out pulmonary embolism can be readily performed as necessary.

We also noted an association between fevers and factors such as completeness of injury and gunshot wound etiology. Individuals presenting with complete SCI (AIS A classification) are more likely to have secondary SCI-related medical conditions that increase the risk for fevers. Individuals with complete injuries (vs incomplete SCI) involving the higher thoracic or cervical regions experience greater weakness of the muscles of respiration, which may lead to increased occurrence of atelectasis and pneumonia. Individuals with complete SCI (vs incomplete injuries) are more at risk for neurogenic bladder, pressure ulcers, and thromboembolism. They have also been shown to have longer lengths of hospitalization stay, which could increase the risk for development of fever etiologies (28–30).

Individuals with gunshot wound-induced SCI are more likely to have coexisting visceral, vascular, bony, or nerve injuries that delay rehabilitation and prolong length of stay (31,32). Common gunshot wound-related medical complications include both spinal infections (most commonly meningitis, vertebral osteomyelitis, and paravertebral and epidural abscess) and extraspinal infections (abscess formation in the thoracic and peritoneal cavities, retroperitoneal space, or soft tissues).

Priority should be given to prevention and education of secondary morbidities that may increase fever risk (33). Aggressive respiratory therapy (such as chest percussion, postural changes, abdominal cough, and incentive spirometry) should be encouraged for all individuals with injury above T8 level secondary to weakness of the diaphragm or accessory muscles of respiration. Hypoventilation and inability to clear secretions may predispose the patient to recurrent respiratory infections (atelectasis or pneumonia). Bladder management with sterile and/or clean catheterization, progression from indwelling to intermittent catheterization, and fluid control are undertaken to more adequately maintain the goals of a “balanced bladder” (infection-free, low pressure, and low residual). Skin protection is important and is accomplished through pressure relief, adequate nutrition, and frequent skin checks. Early patient mobilization is encouraged along with use of pressure stockings and

medications (ie, low molecular weight heparin) for prevention of thromboembolic disease.

This study also notes the predominance of fever episodes with unidentified etiologies and significant differences in characteristics between identified vs unidentified fever etiologies. Fevers with identified etiologies were more likely to be infectious, to be of longer duration, to have higher mean maximal temperatures, and to be above 101.5°F. Fevers with unidentified etiologies had lower mean maximal temperature, were of lesser duration, and were less likely to be above 101.5°F. Unidentified etiologies may well be viral in nature, which often have atypical presentation, such as lower body temperatures. In addition, inflammatory, noninfectious etiologies (such as thrombosis and heterotopic ossification) may present with lower maximal fevers. Prioritization of fever workup and consideration of patient's clinical condition may allow for less missed therapy time and, perhaps, reduced length of stay.

CONCLUSION

Fever episodes are common in individuals with acute SCI. They can reflect underlying morbidity and their subsequent workup can result in lost time and effort, and increased cost of care. A better understanding of fever incidence, etiologies, and high-risk groups can allow for increased preventative care, patient/caregiver education, and management. Unidentified fever etiologies are likely noninfectious in etiology, more frequently characterized by lower maximal temperature elevations (<101.5°F), and are of shorter duration. These factors should be taken into account when initiating timely and cost-efficient fever workup and management.

REFERENCES

1. Spinal Cord Injury Information Network. Spinal cord injury-facts and figures at a glance. Available at: <http://www.spinal-cord.uab.edu/show.asp?durki=21446>. Accessed August 2004.
2. DeVivo M, Stover S. Long-term survival and causes of death. In: Stover SL, DeLisa JA, Whiteneck GG, eds. *Spinal Cord Injury Clinical Outcomes From the Model Systems*. Gaithersburg, MD: Aspen Publishers; 1995:100–119.
3. DeVivo MJ, Black KJ, Stover SL. Causes of death during the first 12 years after spinal cord injury. *Arch Phys Med Rehabil*. 1993;74:248–254.
4. Cardenas DD, Hoffman JM, Kirshblum S, McKinley W. Etiology and incidence of rehospitalization after traumatic spinal cord injury: a multicenter analysis. *Arch Phys Med Rehabil*. 2004;85(suppl 11):1757–1763.
5. Winslow C, Bode RK, Felton D, Chen D, Meyer PR Jr. Impact of respiratory complications on length of stay and hospital costs in acute cervical spine injury. *Chest*. 2002; 121(suppl 5):1548–1554.
6. Fiedler IG, Laud PW, Maiman DJ, et al. Economics of managed care in spinal cord injury. *Arch Phys Med Rehabil*. 1999;80:1441–1449.
7. Beraldo P, Neves E, Alves C, Khan P, Cirilo A, Alencar M. Pyrexia in hospitalized spinal cord injury patients. *Paraplegia*. 1993;31:186–191.
8. Montgomerie JZ. Infections in patients with spinal cord injuries. *Clin Infect Dis*. 1997;25(suppl 6):1285–1290.
9. Sugarman B, Brown D, Musher D. Fever and infection in spinal cord injury patients. *JAMA*. 1982;248(suppl 1):66–70.
10. Cardenas D, Mayo M. Bacteriuria with fever after spinal cord injury. *Arch Phys Med Rehabil*. 1987;68:291–293.
11. Colachis SC, Otis SM. Occurrence of fever associated with thermoregulatory dysfunction after acute traumatic spinal cord injury. *Am J Phys Med Rehabil*. 1995;74(suppl 2):114–149.
12. McKinley W, Gittler M, Kirshblum S, Stiens S, Groah S. Medical complications after SCI. *Arch Phys Med Rehabil*. 2002;83(suppl 1):S58–S64.
13. McKinley W, Jackson A, Cardenas D, DeVivo M. Long-term medical complications after SCI: a multi-center analysis. *Arch Phys Med Rehabil*. 1999;80:1402–1410.
14. Waites KB, Canupp KC, Chen Y, DeVivo MJ, Moser SA. Bacteremia after spinal cord injury in initial versus subsequent hospitalizations. *J Spinal Cord Med*. 2001; 24(suppl 2):96–100.
15. Stover SL, Lloyd LK, Waites KB, et al. Urinary tract infection in spinal cord injury. *Arch Phys Med Rehabil*. 1989;70:47–54.
16. Jackson A, Groomes TE. Incidence of respiratory complications following spinal cord injury. *Arch Phys Med Rehabil*. 1994;75:270–275.
17. Fishburn MJ, Marino RJ, Ditunno JF. Atelectasis and pneumonia in acute spinal cord injury. *Arch Phys Med Rehabil*. 1990;71:197–200.
18. Chen D, Apple DA, Hudson LM, Bode R. Medical complications during acute rehabilitation following spinal cord injury—current experience of the model systems. *Arch Phys Med Rehabil*. 1999;80:1397–1401.
19. Ragnarsson K, Hall KM, Wilmot CB, et al. Management of pulmonary, cardiovascular, and metabolic conditions after spinal cord injury. In: Stover S, DeLisa JA, Whiteneck GG, eds. *Spinal Cord Injury: Clinical Outcomes From the Model Systems*. Gaithersburg, MD: Aspen Publishers; 1995:79–99.
20. Sugarman B. Infection and pressure sores. *Arch Phys Med Rehabil*. 1985;66:177–179.
21. Subbarao J, Garrison S. Heterotopic ossification: diagnosis and management. *J Spinal Cord Med*. 1999;22(suppl 4): 273–283.
22. Schmidt KD, Chan CW. Thermoregulation and fever in normal persons and in those with spinal cord injuries. *Mayo Clin Proc*. 1992;67(suppl 5):469–475.
23. Marino RJ, Barros T, Biering-Sorensen F, et al. International standards for neurological classification of spinal cord injury. *J Spinal Cord Med*. 2003;26(suppl 1):S50–S56.
24. American Spinal Injury Association/International Medical Society of Paraplegia. *International Standards for Neurologic and Functional Classification of Spinal Cord Injury*. Revised 2000. Chicago, IL: ASIA; 2002.
25. Mackowiak PA, Wasserman SS, Levine MM. A critical appraisal of 98.6 degrees F, the upper limit of the normal body temperature. *JAMA*. 1992;268(suppl 12):1578–1580.
26. Eastwood EA, Hagglund KJ, Ragnarsson KT, Gordon WA, Marino RJ. Medical rehabilitation length of stay and outcomes for persons with traumatic spinal cord injury—1990–1997. *Arch Phys Med Rehabil*. 1999;80:1457–1463.
27. Peterson P. Pulmonary physiology and medical management. In: Whiteneck G, ed. *The Management of High*

Quadriplegia. New York: Demos Medical Publishing; 1989: 35–50.

28. Kirshblum S, O'Connor K. Levels of injury and outcome in traumatic spinal cord injury. *Phys Med Rehabil Clin N Am*. 2000;11:1–27.
29. Stover S, DeLisa JA, Whiteneck GG. *Spinal Cord Injury: Clinical Outcomes From the Model Systems*. Gaithersburg, MD: Aspen Publishers;1995.
30. Ditunno JF Jr, Cohen ME, Formal C, Whitehead GG. Functional outcomes. In: Stover SL, Whiteneck GG, DeLisa JA, eds. *Spinal Cord Injury: Clinical Outcomes From the Model Systems*. Gaithersburg, MD: Aspen Publishers; 1995:170–184.
31. McKinley W, Johns J. Medical complications following violence-induced SCI. *Top Spinal Cord Inj Rehabil*. 1998; 4(suppl 3):51–61.
32. McKinley W, Johns J, Musgrove J. Clinical presentations, medical complications and functional outcomes of individuals with gunshot wound-induced SCI. *Am J Phys Med Rehabil*. 1999;78(suppl 2):102–107.
33. Cardenas DD, Hoffman JM, Kelly E, Mayo ME. Impact of a urinary tract infection educational program in persons with spinal cord injury. *J Spinal Cord Med*. 2004;27(1):47–54.