Rates, Variability, and Predictors of Screening for Obesity: Are Individuals with Spinal Cord Injury Being Overlooked?

Dan Eisenberg\(^a,\,b\) Sherri L. LaVela\(^c,\,d\) Susan M. Frayne\(^a,\,e\) Rui Chen\(^b\)
Nicolas B. Barreto\(^b\) Justina Wu\(^a\) Andrea L. Nevedal\(^a\) Kristen Davis\(^b\)
Katherine D. Arnow\(^b\) Alex H.S. Harris\(^a,\,b\)

\(^a\)Center for Innovation to Implementation, VA Palo Alto Health Care System, Palo Alto, CA, USA; \(^b\)Stanford-Surgery Policy Improvement Research & Education Center, Stanford School of Medicine, Stanford, CA, USA; \(^c\)Center of Innovation for Complex Chronic Care, VA Edward Hines Jr., Hines, IL, USA; \(^d\)Department of Physical Medicine and Rehabilitation, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA; \(^e\)Department of Medicine, Stanford School of Medicine, Stanford, CA, USA

\textbf{Keywords}  
Obesity · Screening · Spinal cord injury · Veterans

\textbf{Abstract}  
\textbf{Introduction:} Individuals with spinal cord injury (SCI) are vulnerable to obesity. Annual obesity screening using body mass index (BMI) is the standard of care mandated by US Veterans Health Administration (VHA) guidelines. Our objective was to determine the rates, variability, and predictors of guideline-concordant annual screening for obesity, given potential challenges of height and weight measurements in individuals with SCI. \textbf{Methods:} This is a cross-sectional retrospective study using US national VA databases. We identified all VHA patients with chronic SCI in the fiscal year (FY) 2019, their treating facility and frequency of recorded height and weight. We applied mixed-effects logistic regression models to assess associations between annual BMI screening and patient- and facility-level characteristics. \textbf{Results:} Of 20,978 individuals with chronic SCI in VHA in FY19, guideline-concordant annual BMI screening was lacking in 37.9%. Accounting for facility-level factors (geographic region, SCI facility type, volume of patients with SCI treated at the facility), a mixed-effects logistic regression model demonstrated that lack of annual obesity screening was significantly associated with older patient age ($p < 0.001$) and fewer outpatient encounters ($p < 0.001$) but not other patient-level factors such as sex, race, level of injury, or rurality. The rate of obesity screening among different facilities within VHA varied widely from 11.1% to 75.7%. \textbf{Conclusion:} A large proportion of persons with SCI receiving care in VHA do not receive guideline-concordant annual obesity screening, an especially acute problem in some facilities. Older patients with fewer outpatient encounters are more likely to be missed. To inform the design of interventions to improve identification and documentation of obesity, further study is needed to assess potential barriers to obesity screening in the population with SCI.

\textbf{Introduction}  
Obesity is a chronic disease that is an independent risk factor for multiple medical conditions and burdens public health and healthcare systems [1–7]. Not surprisingly,
overweight and obesity are associated with increased utilization of physician visits, prescription drugs, and risk of death in both women and men [8–10].

Modern care of individuals with spinal cord injury (SCI) extends beyond acute life-saving intervention, into the long-term management of secondary conditions and chronic conditions, including obesity and its comorbidities. Body composition changes significantly after SCI as the percent of lean tissue mass decreases, while fat tissue increases in arms, legs, trunk, and total body, compared with gender-, age-, height-, and weight-matched able-bodied controls [11–13]. At the same time, energy balance is impacted by SCI, such that conventional methods to predict caloric needs overestimate actual needs. Even though recommendations for caloric intake after SCI is overall reduced, energy expenditure is likely reduced by an even greater margin [14]. Thus, obesity is a significant problem in the population with SCI and reported prevalence of overweight and obesity in the population with SCI, as measured by conventional body mass index (BMI) thresholds, varying between 45% and 75% [15–20]. Moreover, it is likely that conventional BMI thresholds underestimate clinical obesity in this population, and some have recommended SCI-specific BMI guidelines [21, 22].

There are 25 regional US Veterans Health Administration (VHA) SCI specialty care centers that are linked to approximately 130 SCI spoke sites at other VA Medical Centers nationally, together forming the largest integrated single network of SCI care in the USA [23, 24]. Meanwhile, screening of patients for obesity by primary care providers is typically based on BMI thresholds; positive screens then trigger a graded, guideline-driven clinical response for obesity risk reduction that can include dietician and/or physician counseling, laboratory investigations to screen for comorbidities, lifestyle modification programs, pharmacotherapy, and even surgery. Therefore, the VHA and other regulatory bodies recommend annual screening for overweight and obesity using BMI thresholds in all adults enrolled in the VHA healthcare system. Specifically, VA facilities are expected to screen adult patients to establish a diagnosis of obesity by assessing height, weight, and calculated BMI and to do so at least annually [25]. While evidence indicates rates of BMI assessment are high in VHA [26], numerous factors make measuring height and weight among individuals with SCI difficult, which may yield lower rates of BMI assessment in this population.

In this study, we hypothesized that due to challenges measuring height and weight in persons with SCI, obesity screening rates in this population will be low. Furthermore, we suspected that there would be facility-level variation in screening rates within the health system of care. Understanding the rates, variability, and predictors of guideline-concordant screening in individuals with SCI could support future study to identify vulnerable sub-populations that may be overlooked for mandated obesity assessments and may identify facilities that need improvement, as well as those with best practices which can serve as a model for systems-wide improvement.

**Materials and Methods**

After Institutional Review Board approval, we performed a retrospective cross-sectional study in which we identified individuals with chronic SCI receiving care within the VHA, defined as at least one healthcare encounter in the fiscal year (FY) 2019 with an associated SCI diagnosis code and at least one additional SCI diagnosis code documented at least 2 years prior. Veterans were excluded if they had diagnosis codes for acute or progressive central nervous system disease (such as multiple sclerosis, amyotrophic lateral sclerosis) or if they were treated in facilities with fewer than 30 total annual patient encounters with persons with SCI (low-volume centers), to minimize the risk of including data from facilities that have less than minimal contact with patients with SCI.

All data were derived from the VHA Corporate Data Warehouse, a nationwide relational database of VHA healthcare records, and VA Observational Medical Outcomes Partnership common data model. Covariates were determined a priori and included sex (male, female), race (White, Black/African American, Asian, Native Hawaiian/Other Pacific Islander, American Indian or Alaska Native, unknown), ethnicity (Hispanic, not Hispanic), age, disability level (paraplegia, tetraplegia/quadruplegia), and rurality (urban, rural, highly rural, unknown). The home facility for each patient was defined as the VA healthcare system (by station ID) in which the greatest number of healthcare encounters occurred within FY16–19. The presence or absence of a specialty SCI center (“hub”) associated with each facility was noted. In addition, the geographic region of the home facility was determined (Southeast, Continental, North Atlantic, Midwest, Pacific). Facilities in the top quartile of screening rates were designated high-performing facilities; those in the lowest quartile were designated low-performing.

**Statistical Analysis**

To determine overall rates of using BMI for guideline-concordant obesity screening in FY19, we considered any weight recorded during FY19 in the healthcare record (not self-reported) or within 6 months of a SCI administration encounter in FY19 wherever they occur within VHA and the presence of any reproducible height in the healthcare record within the 3-year observation period (FY16-FY19). We compared demographic and clinical characteristics of patients with annual screening to patients without annual screening using χ² tests for categorical variables and t tests for continuous variables. A mixed-effects logistic regression was used to examine the association between veteran-level factors and facility-level factors on odds of veterans receiving guideline-concordant BMI assessment. To determine statistical significance, the alpha level of 0.05 was used.
Facility-level rates of annual obesity screening were determined for FY19, as well as change in performance from 3 years prior (FY16) to assess variation in screening rates across VHA facilities as well as improvement or deterioration in performance. The distribution of initial performance (FY16) and subsequent improvement or worsening in FY19 was visualized with a delta plot [27].

**Results**

We identified 20,978 individuals with SCI within VHA in FY19. After exclusion for low-volume facilities, the patient sample was 20,642. The majority of patients were male (94.8%), most were White (68.9%), 21.5% Black, or African American and 5.6% Hispanic or Latino (shown in Table 1). There was approximately the same number of individuals with a diagnosis of paraplegia (47.5%) as tetraplegia (45.7%). Persons with SCI were receiving care in 130 medical centers within VHA, of which 23 were low volume. Approximately half (46.9%) primarily received care at a facility designated as a veterans affairs SCI specialty center (“hub”).

Of the veterans with SCI who utilized VHA in FY19, 7,941 (37.9%) lacked guideline-concordant annual BMI screening. Patient-level factors that were positively associated with missed annual obesity screening included male sex (95.2% vs. 94.5%, \( p = 0.014 \)), White race (70.5% vs. 67.8%, \( p < 0.001 \)), paraplegia or unknown level of injury rather than tetraplegia (49.2% vs. 46.6% and 7.8% vs. 6.2%, respectively, \( p < 0.001 \)), fewer outpatient visits (mean 30.4 vs. 45.8, \( p < 0.001 \)), and living in a rural environment (31.3% vs. 29.7%, \( p = 0.003 \)). Further analysis accounting for facility characteristics demonstrated that lack of screening was significantly positively associated with older patient age (aOR 1.05, 95% CI [1.03, 1.08], \( p < 0.001 \)) and fewer outpatient encounters in the health system (aOR 0.26, 95% CI [0.24, 0.28], \( p < 0.001 \)) but not other patient-level factors (shown in Table 2).

The facilities in which veterans with SCI received care were dispersed among 5 geographic regions (North Atlant-
tic, Southeast, Midwest, Continental, Pacific). The Southeast region had significantly higher rates of screening than facilities in other regions. Facilities in the North Atlantic and Pacific geographic regions had lower rates of screening relative to the referent region (aOR 1.60, 95% CI [1.08, 2.37]; aOR 1.86, 95% CI [1.22, 2.84], \( p = 0.045 \)). Both high- and low-volume centers were represented in both high- and low-performing facilities. On average, high-performing facilities were treating a higher volume of patients compared to low-performing facilities, but this difference was not significant (aOR 1.00, CI [0.99, 1.01], \( p = 0.960 \)).

Overall, there was high variability in facility performance and rates of missed annual obesity screening ranged from 11.1% to 75.7%, signified by the black dots as shown in Figure 1, in which the size of the dot represents facility volume. The ICC for the mixed-effects model was 0.41 among 117 facilities treating >30 patients annually, suggesting that much of the variability in obesity screening performance was at the facility level. As represented by the green bars in Figure 1, there were 23 facilities (19.7%) that showed improvement in obesity screening performance of at least 10% relative to previous years.

### Discussion

The US Preventive Services Task Force concluded that annual screening for obesity is beneficial in adults [28]. However, despite the high prevalence of obesity in individuals with SCI [29], the frequency and magnitude of BMI screening in this population that is especially vulnerable to obesity has not been well studied. The results
in this study highlight an important gap in guideline-concordant care. Only approximately 62% of individuals with SCI treated in VHA are receiving guideline-concordant annual obesity screening. This is much lower compared to established annual obesity screening rates in VHA patients without SCI, which have been shown to exceed 90% [26]. Further study is needed to better understand provider behavior in the setting of obesity screening as it is possible that because fat and muscle in individuals with SCI are distributed differently, visual cues are missed, and therefore, BMI is not assessed. In fact, in a primary care cohort, it was found that in 40% of cases, physical cues were the main factors that prompt general practitioners to assess BMI [30]. Since appropriate detection and management of obesity in individuals with SCI relies on consistent measurement of height and weight to determine BMI and proper interpretation of BMI when it is assessed, the implication of this finding is that the diagnosis of obesity may be missed in the population with SCI, and thus, their chronic disease may not be appropriately managed.

Tailored interventions for the targeted management of obesity have been shown to be important in persons with SCI [31]. However, this often depends on an adequate recognition of disease. In a study of primary care patients, only 16% reported being aware of their own BMI, and 70% reported no discussion of BMI with their physician [32]. Furthermore, in a recent qualitative study, SCI healthcare providers identified lack of integration and inconsistent weight management support within the healthcare system and difficulties obtaining weight measurement as two major barriers to obesity management among individuals with SCI [33]. Others have shown that persons with SCI are at risk for lacking preventive healthcare in general [34], suggesting that obesity may be only one of several diseases that are not adequately screened in this population.

We examined multiple patient-level factors and found older age and fewer outpatient healthcare encounters to be associated with missed obesity screening. This finding is consistent with other studies of different screening tests, demonstrating an association of health screening with ei-
ther older or younger age-groups [35, 36]. However, while a systematic review similarly showed that BMI was under-recorded in primary care patients, in contrast to our findings, the authors found that obesity screening and documentation were positively associated with older age [37]. We were not surprised that lower obesity screening rates were found in the population that interacts with the healthcare system less frequently as we would expect additional opportunities for height and weight measurement to result in better screening rates. In addition, this finding may represent a more complex interaction between patient-level factors and facility-level factors. For example, it is known that geographic proximity to healthcare facility predicts healthcare utilization in individuals with SCI [38], which could suggest a direct relationship between geography and the number of healthcare encounters. Furthermore, our finding of high variability in facility performance suggests that facility-level factors are critical to understand potential barrier to obesity screening in general and screening in persons with SCI in particular. Screening for obesity is an integral part of primary care medicine, and while other populations have been variably shown to have incomplete rates of obesity screening [39, 40], the population with SCI may be especially vulnerable to missed obesity screening due to the physical challenges of obtaining height and weight and the possible need for special equipment or additional staff to complete the screening.

It is known that individuals with SCI have low general health screening rates that may be related to varying levels of comfort of primary care physicians in treating this population [41]. Evidence suggests that individuals with SCI are vulnerable to inadequate preventive care [42]. General preventive care that includes immunizations, age- and sex-appropriate cancer screening, cardiovascular and metabolic health screening, and mental health screening may be lacking due to institutional barriers, system issues, and inadequate physician knowledge and training. This may argue that the population with SCI may be generally underserved. While the effect of obesity on persons with SCI is significant and extends beyond metabolic comorbidities, there are little data on obesity screening specifically.

In addition, in this study, we found that there is a wide variability of screening performance between different facilities and that facility-level factors account for much of the variability. Our analyses identified high-volume sites with especially high performance, as well as specific facilities that demonstrated improvement in annual screening during the course of the study. This suggests that facilities can improve performance over a relatively short period of time and that there is a need to identify and target facility-level barriers to obesity screening. Interestingly, while several facilities with higher patient volume had higher screening rates, volume in and of itself was not predictive of screening performance, suggesting that local practices are highly impactful in both high- and low-volume facilities.

**Conclusion**

A large proportion of persons with SCI receiving care in the VHA do not receive guideline-concordant annual obesity screening, and screening rates between facilities vary widely. Older patients and those with fewer outpatient encounters are more likely to be missed. Thus, the burden of obesity in persons with SCI may be underestimated.

**Statement of Ethics**

This study protocol was reviewed and approved by the Stanford University Institutional Review Board and the Veterans Affairs Palo Alto Research & Development Committee (Protocol approval number [51368]). This study has been granted an exemption from requiring informed consent by the panel on Medical Human Subjects of Stanford University, Stanford, CA.

**Conflict of Interest Statement**

The authors have no conflicts of interest to declare.

**Funding Sources**

This study was funded by Merit Review Award number IIR-17-047 (D. Eisenberg) and Research Career Scientist Award number RCS-14-232 (A.H.S. Harris) from the US Department of Veterans Affairs, Health Services Research, and Development Service. The contents do not represent the views of the VA or the US Government.

**Author Contributions**

The authors (D.E., S.L.L., S.M.F., R.C., N.B.B., J.W., A.L.N., K.D., K.D.A., and A.H.S.H.) have all contributed to study design, the conceptual framework, data acquisition and analysis, and data interpretation. In addition, all the authors contributed to drafting of the manuscript, its critical review and editing, as well as its final revision and approval.

**Data Availability Statement**

Datasets were created from available national databases. They are available upon reasonable request, subject to national restrictions.
9 Adams KF, Schatzkin A, Harris TB, Kipnis V, Wolin KY, Carson K, Colditz GA. Obesity. Tapias FS, Otani VHO, Vasques DAC, Otani and cancer. Oncologist. 2010; 15:556–65.}

10 Musich S, MacLeod S, Bhattarai GR, Wang SS, Hawkins K, Bottone FG, et al. The impact of obesity, diabetes, and obesity-related health risk factors, 2001. JAMA. 2003;289:76–9.

11 Wolin KY, Carson K, Colditz GA. Obesity and cancer. New Engl J Med. 2006;355:763–78.

12 Tapias FS, Otani VHO, Vasques DAC, Otani TZS, Uchidae RR. Costs associated with depression and obesity among cardiovascular patients: medical expenditure panel survey analysis. BMC Health Serv Res. 2021;21:433.

13 Adams KF, Schatzkin A, Harris TB, Kipnis V, Wolin KY, Carson K, Colditz GA. Obesity and cancer. Oncologist. 2010; 15:556–65.

14 Musich S, MacLeod S, Bhattarai GR, Wang SS, Hawkins K, Bottone FG, et al. The impact of obesity, diabetes, and obesity-related health risk factors, 2001. JAMA. 2003;289:76–9.

15 Wolin KY, Carson K, Colditz GA. Obesity and cancer. New Engl J Med. 2006;355:763–78.

16 Gater DR Jr, Farkas GJ, Berg AS, Castillo C. Effects of spinal cord injury on body composition and metabolic profile: part I. J Spinal Cord Med. 2011;92:391–8.

17 Laughton GE, Buchholz AC, Martin Ginis KA, Goy RE; SHAPE SCI Research Group. Lowering body mass index cutoffs better identifies obese persons with spinal cord injury in relation to body mass index. Arch Med Rehabil. 2011;92:391–8.

18 Gupta N, White KT, Sandford PR. Body mass index in spinal cord injury: a retrospective study. Spinal Cord. 2006;44:92–4.

19 Buchholz AC, Bugaresti JM. A review of body mass index and waist circumference as markers of obesity and coronary heart disease risk in persons with chronic spinal cord injury. Spinal Cord. 2005;43:513–8.

20 Spinal Cord Inj Rehabil. 2001; 6(3): 22–36.

21 Buchholz AC, Bugaresti JM. A review of body mass index and waist circumference as markers of obesity and coronary heart disease risk in persons with chronic spinal cord injury. Spinal Cord. 2005;43:513–8.

22 McMillan DW, Maher JL, Jacobs KA, Nash MS, Gater DR. Exercise interventions targeting obesity in persons with spinal cord injury. Top Spinal Cord Inj Rehabil. 2021;27(1):109–20.

23 U.S. Department of Veterans Affairs. Veterans Health Administration. About VHA. [cited 2021 Sept 8]. Available from: https://www.va.gov/health/aboutVHA.asp.

24 U.S. Department of Veterans Affairs. Spinal cord injuries and disorders systems of care. VA’s spinal cord injuries and systems of care. [cited 2021 Sept 8]. Available from: sci.va.gov/VAs_SCID_System_of_Care.asp.

25 U.S. Department of Veterans Affairs and U.S. Department of Defense. VA/DoD clinical practice guideline for screening and management of overweight and obesity. [cited 2021 Sept 8]. Available from: https://www.healthquality.va.gov/guidelines/CD/obesity/CPSManagementOfOverweightAndObesi tyFINAL2011.pdf.

26 Littman AJ, Damschroder LJ, Verchirina L, Lai Z, Kim HM, Hoerster KD, et al. National evaluation of obesity screening and treatment among veterans with and without mental health disorders. Gen Hosp Psych. 2015;37:7–13.

27 Harris AHS, Hagedorn HJ, Finlay AK. Delta studies: expanding the concept of deviance studies to design more effective improvement interventions. J Gen Intern Med. 2021;36(2):280–7.

28 Fruehbeck G. Screening for the evident in obesity. Nat Rev Endocrinol. 2012;8:570–2.

29 Gater DR Jr, Farkas GJ, Berg AS, Castillo C. Prevalence of metabolic syndrome in veterans with spinal cord injury. J Spinal Cord Med. 2019;42:86–93.

30 Critchlow N, Rosenberg G, Rumgay H, Petty R, Vohra J. Weight assessment and the provision of weight management advice in primary care: a cross-sectional survey of self-reported practice among general practitioners and practice nurses in the United Kingdom. BMC Fam Pract. 2020;21:111.

31 McMillan DW, Maher JL, Jacobs KA, Nash MS, Gater DR. Exercise interventions targeting obesity in persons with spinal cord injury. Top Spinal Cord Inj Rehabil. 2021;27(1):109–20.