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ARTICLE

Factors influencing providers' decisions on management of bone health in people with spinal cord injury

Frances M. Weaver[1,2] · Beverly Gonzalez[1,3] · Cara Ray[1] · Bella Etingen[1] · Alan Schwartz[4] · Stephen Burns[5,6] · Brian Le[7] · Hammad Aslam[8] · Michael Priebe[9] · Laura D. Carbone[7,9]

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Abstract

Study design Survey.

Objectives Managing osteoporosis in persons with chronic spinal cord injury (SCI) is difficult as little evidence exists regarding effective strategies. We examined the effect of key factors on providers' bone health management decisions in persons with SCI.

Setting USA.

Methods Providers reviewed blocks of 9 hypothetical cases that varied on four factors: osteoporosis, osteopenia, or normal bone mineral density using dual-energy X-ray absorptiometry (DXA); DXA region of interest (lumbar spine, hip, knee), prior lower extremity fracture; and no or limited ambulation. They indicated how likely they would recommend pharmacological management, what treatment(s) they would recommend, and whether they would request another DXA before treatment.

Results Eighty-two healthcare providers completed the survey. Treatment recommendations for bisphosphonates and Vitamin D/calcium supplements, respectively, were more likely if there was a prior fracture (OR: 2.65, 95%CI: 1.76–3.99, $p < 0.0001$; OR: 2.96, 95%CI: 1.40–6.26, $p = 0.004$) and if a DXA scan found osteopenia (OR: 2.23, 95%CI: 1.41–3.54, $p = 0.001$; OR: 6.56, 95%CI: 2.71–15.85, $p < 0.0001$) or osteoporosis (OR: 12.08, 95%CI: 7.09–20.57, $p < 0.0001$; OR: 4.54, 95%CI: 2.08–9.90, $p < 0.0001$). Another DXA scan was more likely to be requested if there was a prior fracture (OR: 1.75, 95%CI: 1.10–2.78, $p = 0.02$) but less likely if the person was nonambulatory (OR: 0.41, 95%: 0.19–0.90, $p = 0.03$).

Conclusions Prior fracture and DXA findings influenced treatment recommendations for bone health management in SCI. Reliance on lumbar spine scans to determine bone loss and treatment identifies a knowledge gap for which future education is required.

Introduction

Following a spinal cord injury (SCI), persons rapidly lose bone mineral density (BMD) below the level of the injury. In the first several months following injury ~1% of BMD is lost per week [1]. Significant loss of BMD is predictive of bone fracture [2, 3]. Bisphosphonates have been shown to reduce nonvertebral fracture risk by ~40% in the able-bodied

✉ Frances M. Weaver
frances.weaver@va.gov

1 Center of Innovation for Complex Chronic Healthcare, Hines VA Hospital, Hines, IL, USA

2 Parkinson School of Health Sciences and Public Health, Loyola University, Chicago, IL, USA

3 Department of Psychiatry & Behavioral Sciences, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

4 Department of Medical Education, and Department of Pediatrics at the University of Illinois at Chicago, Chicago, IL, USA

5 Spinal Cord Injury Service, VA Puget Sound health Care System, Seattle, WA, USA

6 Department of Rehabilitation Medicine, University of Washington School of Medicine, Seattle, WA, USA

7 Department of Medicine, Division of Rheumatology, Medical College of Georgia at Augusta University, Augusta, GA, USA

8 Altanta Rehabilitation Consultants, Duluth, GA, USA

9 Charlie Norwood Veterans Affairs Medical Center, Augusta, GA, USA

population [4], but have not been associated with fracture risk reduction in persons with chronic SCI [5]. There is some literature to suggest that early use of bisphosphonates after injury may maintain areal BMD at the hip and distal femur sites; [5] whether this is effective in preventing future fractures is not known. Exercise and weight bearing may have a small positive effect on BMD for persons with SCI, but that effect is likely lost if/when the activity stops [6, 7].

A number of patient factors, including demographic (race, female over age 50) and SCI-related (complete injury, traumatic SCI, longer duration) characteristics, use of certain medications (opioids, anticonvulsants), and history of prevalent fractures are predictive of increased fracture risk in persons with SCI [8, 9]. Osteopenia and osteoporosis are also risks for fracture [10]. Because of limited evidence on available treatment options, health care providers often use multiple strategies to address osteoporosis in SCI. They may rely on guidelines for the able-bodied population [11], as well as their own experiences along with input from other SCI providers to determine treatment.

One theoretical model that may offer insight into how providers make clinical decisions is Fuzzy Trace Theory (FTT) [12]. While dual process models of decision making emphasize both cognition and emotion, or facts and experiences in decision making, FTT goes beyond complementary methods to show how facts and experiences interact. There are verbatim representations—exact numbers, words, percentages; and there is gist—the essential meaning of the information, shaped by emotion, knowledge, experience, and culture. FTT describes how the way decisions are made varies by the extent of provider expertise with the specific condition/population of interest. Based on FTT, Reyna hypothesizes that decision makers who are less experienced will rely more on verbatim information while experts will reply more on gist [13].

The objective of this study was to identify factors associated with provider treatment decisions for managing bone health in persons with an SCI, and to assess the relationship between provider experience and level of detail needed to formulate a treatment plan. We hypothesized that providers who work with persons with SCI would utilize fewer details about a patient's situation to make these decisions, while those providers less experienced in SCI or bone health likely use more details from the case.

Methods

Providers were presented with brief scenarios of persons with chronic SCI who may be at risk of fracture. Four characteristics were manipulated across cases; (a) prior DXA findings (normal BMD, osteopenia, osteoporosis), (b) location of DXA scan (lumbar spine, hip, distal femur/proximal tibia—hereafter referred to as knee), (c) ambulatory status (none v. limited), and (d) existence of a prior fracture (yes/no). Other characteristics were held relatively constant (e.g., age, duration, and level of injury, informal support).

We utilized a factorial design ($3 \times 3 \times 2 \times 2$) to develop the cases. To minimize respondent burden, we employed a fractional factorial design to reduce the number of cases from 36 to 27 and divided the cases into 3 blocks of 9 cases each (see Table 1). This allows us to examine two-way interactions. However, incomplete data resulted in nonconvergence of some models, so some interactions could not be examined. To assess the FTT hypothesis, we asked respondents to check off, from a list of case characteristics that we provided, what they used to make decisions for cases 1, 4, and 7 in the block. The checklist was used to prime verbatim processing by directing respondents' attention to specific characteristics of each case. The checklist included patient age, race, level of injury, and caregiver situation in addition to the 4 variables we varied (ambulatory status, prior fracture, DXA result, DXA location).

For the gist cases (2, 5, and 8), we asked respondents to indicate using open-ended written responses what case characteristics they used prior to making their treatment decisions. Eleven characteristics were included in the case (the 8 items from the checklist above plus prior treatment, duration of injury, and gender). One case in each block was a female; it included additional information that the woman had undergone menopause a few years prior. The remaining three cases within each block did not pose a question related to the characteristics used for decision making.

After reviewing each case, providers were asked to (1) rate how likely they would be to recommend pharmacological management on a 5-point likert-type scale from not at all likely to very likely, (2) select which medication(s) they would recommend for treatment (bisphosphonates, other FDA-approved osteoporosis medications, calcium, and vitamin D supplements, hormones), and (3) whether they would order another DXA scan prior to treatment. Since providers may have wanted additional information to make decisions, we asked them to identify what else they would have wanted to know about each case.

The final part of the survey included demographic questions. In addition, questions about clinical role (e.g., nurse practitioner), specialty (e.g., rehabilitation medicine, endocrinology), work environment (i.e., Veterans Health Administration (VA), SCI model systems programs, other), and time spent working with persons with SCI were posed.

Institutional review board approvals for waivers of informed consent and HIPAA were obtained from the investigators' institutions. Participation in the survey was voluntary and no PHI was collected.

Table 1 Block 1 configuration of 9 cases[a].

Block 1				
DXA scan location	DXA scan results	Prior fracture	Ambulatory status	CASE
Knee	Normal	prior fracture	limited ambulation	1[a]
Hip	Osteopenia	prior fracture	limited ambulation	8[b]
Lumbar spine	Osteoporosis	prior fracture	limited ambulation	10
Lumbar spine	Normal	no fracture	limited ambulation	12[a]
Hip	Osteopenia	no fracture	limited ambulation	15[b]
Hip	Normal	prior fracture	does not ambulate	19
Lumbar spine	Osteopenia	prior fracture	does not ambulate	20[a]
Knee	Osteopenia	no fracture	does not ambulate	22[b]
Lumbar spine	Osteoporosis	no fracture	does not ambulate	25

[a]For these cases, respondent was asked to check off what information they used prior to making a decision.

[b]In these cases, the respondent was asked to write down what information from the case they used to make their decision.

Blocks 2 and 3 (not shown) include the additional 18 cases used in fractional factorial design.

Survey dissemination

We targeted survey recruitment to Veterans Administration (VA) and non-VA providers including attendings, fellows, residents, nurse practitioners, and PharmDs who worked with and/or had experience caring for individuals with SCI. We disseminated the survey using multiple methods in order to reach as many providers as possible. Most surveys were completed electronically using REDCap for VA providers and SurveyMonkey for non-VA providers. A few participants completed a hard copy of the survey.

SCI physicians, fellows, and nurse practitioners at VA SCI centers and SCI outpatient clinics were invited to participate by email through VA list-servs. VA pharmacists who work with Veterans with SCI were recruited by asking SCI providers to share the survey link with these providers. Endocrinologists were recruited through the VHA Endocrinology Chiefs listserv and invited to participate if they had experience in managing sublesional osteoporosis.

In addition, we invited individuals attending the 2017 and 2018 Paralyzed Veterans of America Healthcare Summit and the Academy of Spinal Cord Injury Professionals 2017 Conference to participate. Non-VA experts were identified through the Endocrine Society Facebook page. Finally, some study team members and colleagues used snowball sampling to recruit additional SCI and osteoporosis experts.

Data Management and Analysis: Open-ended responses to the question asking what additional information respondents would have liked to have had were reviewed and grouped into six categories. These included: laboratory testing (e.g., renal function); Vitamin D and/or Calcium use/levels; medication use; lifestyle information (e.g., diet, exercise); possible secondary causes of osteoporosis (e.g., family history); and bone turnover markers.

Descriptive analyses were used to examine provider characteristics. Treatment likelihood ratings (1–5) were treated as interval variables, allowing analysis as a continuous measure. Likelihood ratings were examined by study characteristics using mixed effects regression analyses with repeated measures. This allowed us to estimate random intercepts for blocks and providers within blocks to account for observations nested within blocks; we also accounted for the effect of case to differ among providers by adding a random coefficient for case. The within- and between-person variability was addressed by specifying an unstructured covariance matrix in the models. The fit of the model and its corresponding null model were assessed via an F-statistic, and the corresponding effect size (ω^2) was reported. Where the decision was dichotomized: e.g., recommendation of a bisphosphonate, models were analyzed using mixed effects logistic regressions with repeated measures predictors; reporting odds ratios and 95% confidence intervals. All statistical analyses were conducted in StataCorp.2015 LP and validated in R Core Team [14, 15]. Examination of the number of details used to make decisions in the verbatim and gist cases was determined by calculating the average number of items identified and dividing by 3 (3 cases in each situation) and a *t* test was used to compare the verbatim and gist cases by years of experience working with SCI and by provider group.

Results

A total of 113 surveys were returned. Only surveys in which respondents completed at least 6 of the 9 scenarios within the block were included. Eighty-two surveys (72.6%) were retained for analysis.

Respondents were comprised of 54 practicing physicians (66%), 6 residents, and fellows, 7 nurse practitioners (NP)

Table 2 Characteristics of respondents.

N (%) or Mean (sd)	PMR/SCI $n = 25$	Internal Med/Family $N = 15$	Other MDs $N = 13$	Trainees $N = 6$	NP & pharmacists $N = 16$
VA employee	16 (64%)	9 (60%)	5 (38.5%)	4 (66.7%)	15 (93.75%)
Time in VA (years)	12.0 (9.9)	12.9 (6.6)	14.6 (12.9)	1.4 (2.0)	13.1 (10.9)
Years in practice	15.7 (8.6)	24.1 (13.6)	22.6 (7.9)	N/A	N/A
Board certified	24 (96%)	14 (93.3%)	13 (100%)	0 (0%)	0 (0%)
Primarily work with: Acute SCI Chronic SCI Both	0 (0%) 7 (29.2%) 17 (70.8%)	0 (0%) 8 (57.1%) 6 (42.9%)	1 (8.3%) 8 (66.7%) 3 (25%)	1(16.7%) 1 (16.7%) 4 (66.7%)	0 (0%) 5 (31.3%) 11 (68.8%)
Years working with SCI	16.4 (10.0)	15.2 (14.9)	18.0 (13.6)	3.0 (1.4)	11.3 (11.5)
Gender: Male Female	10 (40%) 15 (60%)	9 (64.3%) 5 (35.7%)	11 (84.6%) 2 (15.4%)	4 (66.7%) 2 (33.3%)	3 (18.8%) 13 (81.3%)
Age (years)	49.3 (10.3)	58.3 (9.9)	59.1 (10.1)	31.8 (2.3)	44.7 (14.1)

There were missing responses for some demographics. In addition, we did not report demographics in this table for the 7 cases that did not provide their role.

Table 3 Linear mixed effects regression with repeated measures of likelihood of prescribing any medication treatment by case characteristics.

Model	Predictors	beta	Se	*p* value	Effect size	F-Statistic
Model 1: DXA location (v. lumbar spine)	Intercept	3.84	0.12	<0.0001		
	Case	−0.009	0.01	0.51		
	Hip	0.13	0.09	0.17		
	Knee	−0.15	0.09	0.11		
Model 2: prevalent fracture (v. no fracture)	Predictors	beta	Se	*p* value	Effect size	F-Statistic
	Intercept	3.10	0.14	<0.0001		
	Case	0.06	0.01	<0.0001		
	Prevalent Fracture	0.72	0.08	<0.0001	0.33	F(1, 637) = 75.46
Model 3: ambulatory status (v. limited)	Predictors	beta	se	*p* value	Effect size	F-Statistic
	Intercept	4.12	0.23	<0.0001		
	Case	−0.04	0.03	0.14		
	Not ambulatory	−0.21	0.14	0.14		
Model 4: DXA result (v. normal)	Predictors	beta	se	*p* value	Effect size	F-Statistic
	Intercept	3.42	0.12	<0.0001		
	Case	−0.03	0.01	0.037		
	Osteopenia	0.59	0.08	<0.0001	0.28	F(2, 636) = 75.72
	Osteoporosis	0.99	0.08	**<0.0001**	0.43	

and 9 PharmDs, with 7 missing this information (see Table 2). Almost half (47%) of the physicians were trained in SCI or physical medicine and rehabilitation (PM&R), another 15 were internal medicine or family physicians. Other physicians included 7 endocrinologists, 1 rheumatologist, and 5 neurologists. Respondents averaged 11.7 years working in VA, 14.5 years working with persons with SCI, were evenly split between male and female, and were 50.5 (sd = 13.0) years old, on average.

Likelihood of prescribing medication for bone health management

The likelihood of a respondent indicating that they would prescribe medication was greater for cases with a prior fracture ($F(1, 637) = 75.46$, $p < .0001$, $\omega^2 = 0.33$), and for cases with a DXA indicating bone loss ($F(2, 636) = 75.72$, $p < 0.0001$): specifically, cases with a diagnosis of osteopenia ($p < 0.0001$, $\omega^2 = 0.28$) or osteoporosis ($p < 0.0001$, $\omega^2 = 0.43$)vs. normal BMD. Ambulatory status and anatomical location of the DXA scan were not related to likelihood of prescribing medication (see Table 3).

We also examined factors associated with selection of each medication class (see Table 4). Bisphosphonates were twice as likely to be selected when there was a prior fracture vs. no fracture (OR = 2.65, $p < 0.0001$, 95% CI: 1.76–3.99), 2x more likely if the DXA indicated osteopenia (OR = 2.23, $p = 0.001$, 95% CI:1.41–3.54) and 12x more likely if the DXA indicated osteoporosis (OR = 12.08, $p < 0.0001$, 95% CI:7.09–20.57) compared to normal BMD. Selection of supplements (i.e., Vitamin D and/or calcium) for treatment was related to prior fracture (OR = 2.96, $p = 0.004$, 95%

Table 4 Mixed effects logistic regression with repeated measures for likelihood of prescribing by medication.

a. Bisphosphonates				
Model 1: DXA location (v. lumbar spine)	Predictors	OR	*p* value	95% CI
	Intercept	0.79	0.39	
	Case	0.98	0.72	
	Hip	1.09	0.66	0.72–1.66
	Knee	0.79	0.29	0.52–1.21
Model 2: Prevalent Fracture (v. none)	Predictors	OR	*p* value	95% CI
	Intercept	0.28	<0.0001	
	Case	1.09	0.03	
	Prevalent Fracture	2.65	<0.0001	1.76–3.99
Model 3: Ambulatory status (v. limited)	Predictors	OR	*p* value	95% CI
	Intercept	0.43	0.10	
	Case	1.05	0.38	
	Nonambulatory	1.53	0.21	0.79–2.97
Model 4: DXA result (v. normal)	Predictors	OR	*p* value	95% CI
	Intercept	0.37	0.002	
	Case	0.91	0.01	
	Osteopenia	2.23	0.001	1.41–3.54
	Osteoporosis	12.08	<0.0001	7.09–20.57
b. Supplements (i.e., Vitamin D, calcium)				
Model 1: DXA location (v. spine)	Predictors	OR	*p* value	95% CI
	Intercept	110.86	<0.0001	
	Case	0.79	0.08	
	Hip	1.74	0.16	0.81–3.73
	Knee	0.68	0.28	0.34–1.37
Model 2: Fracture status (v. none)	Predictors	OR	*p* value	95% CI
	Intercept	43.53	<0.0001	
	Case	0.89	0.44	
	Prevalent fracture	2.96	0.004	1.40–6.26
Model 3: Ambulatory status (v. limited)	Predictors	OR	*p* value	95% CI
	Intercept	94.48	<0.0001	
	Case	0.82	0.24	
	Not ambulatory	1.08	0.89	0.34–3.42
Model 4: DXA result (v. normal)	Predictors	OR	*p* value	95% CI
	Intercept	110.86	<0.0001	
	Case	0.72	0.06	
	Osteopenia	6.56	<0.0001	2.71–15.85
	Osteoporosis	4.54	<0.0001	2.08–9.90

CI:1.40–6.26) but not ambulatory status. Respondents were 6.5x more likely to select supplements in cases of osteopenia (OR = 6.56, $p < 0.0001$, 95% CI: 2.71–15.85) and 4.5x more likely for osteoporosis (OR = 4.54, $p < 0.0001$, 95% CI: 2.08–9.90) compared to normal BMD.

Respondents infrequently indicated that they would prescribe hormones for bone management; across all male cases, they were likely to prescribe testosterone in only 5% of the cases. For the female case, 14/82 respondents (20.6%) indicated that they would recommend estrogen.

Table 5 Likelihood of recommending another DXA.

Model	Predictors	OR	*p* value	95% CI
Model 1: DXA location (v. lumbar spine)	Intercept	1.45	0.31	
	Case	0.97	0.48	
	Hip	0.84	0.49	0.52–1.17
	Knee	0.72	0.19	0.44–1.17
Model 2: Fracture status (v. none)	Predictors	OR	*p* value	95% CI
	Intercept	0.73	0.45	
	Case	1.02	0.68	
	Prevalent Fracture	1.75	0.02	1.10–2.78
Model 3: Ambulatory status (v. limited)	Predictors	OR	*p* value	95% CI
	Intercept	4.34	0.03	
	Case	0.83	0.02	
	Not ambulatory	0.41	0.03	0.19–0.90
Model 4: DXA result (v. normal)	Predictors	OR	*p* value	95% CI
	Intercept	1.35	0.41	
	Case	0.98	0.64	
	Osteopenia	0.99	0.95	0.61–1.59
	Osteoporosis	0.65	0.41	0.66–2.77

Use of DXA scans in decision making

Prior fracture and ambulatory status were the only factors with significant main effects relevant to recommendations to obtain another DXA (see Table 5). Specifically, participants were more likely to recommend another DXA if the patient had a prior fracture vs. no fracture (OR=1.75, $p = 0.02$, 95% CI: 1.10–2.78). They were significantly less likely to recommend another DXA if the patient was not ambulatory (OR = 0.41, $p = 0.03$, 95% CI: 0.19–0.90). When we examined the interaction of these main effects, nonambulatory cases with a prior fracture were less likely to be recommended for another DXA (OR = 0.38, $p = 0.01$, 95% CI: 0.17–0.85).

Other information desired

Forty-five percent of respondents indicated what additional information they would have liked for some of these cases;

Table 6 Clinical expertise by number of characteristics identified for decision making: verbatim and gist conditions.

Specialty:	PMR/SCI MDs $n = 25$	Internal Med/Family MDs $N = 15$	Other MDs $N = 13$	Trainees $N = 6$	NP & pharmacists $N = 16$
Verbatim: Checklist of 8 case characteristics					
Case 1	2.96	4.07	3.00	3.00	3.69
Case 4	3.60	4.13	3.69	4.00	4.12
Case 7	3.76	4.13	3.92	4.33	4.75
Ave	3.44	4.11	3.54	3.78	4.19
Gist: Written identification of characteristics (11 possible per case)[a]					
Case 2[a]	3.36	3.13	2.31	4.33	4.06
Case 5	3.28	2.73	2.15	2.83	3.25
Case 8	2.84	2.80	2.23	3.00	3.31
Ave	3.16	2.89	2.23	3.39	3.54

[a]Female was case 2, included information on menopause status (12 characteristics in this case).

a smaller number (18%, $n = 15$) asked for additional information on every case. NPs and pharmacists most often indicated that they wanted more information ($n = 12/16$). Approximately half of the PM&R/SCI providers ($n = 12/25$) and other MDs (6/13) requested more information; while internal medicine doctors ($n = 5/15$) and trainees ($n = 1/6$) were least likely to request additional information. The most frequently requested information was medication use (34%), Vitamin D and/or calcium use/levels (31%), what secondary causes may be contributing to the patient's bone health (29%), and laboratory findings (27%).

Patient characteristics used in decision making

For the verbatim cases respondents averaged 3.76/8 characteristics checked (see Table 6). When respondents were asked to write down which characteristics they used in their decision making (gist), they identified fewer characteristics (2.96/11; $t = 7.96$, $p < 0.0001$). In the female case, menopausal status was identified by 65% of respondents.

We also compared the number of characteristics used by expertise (e.g., PM&R/SCI; nurse practitioner/ pharmacist), and by experience (years working with persons with SCI). The number of characteristics selected did not differ by clinical expertise ($p = 0.10$; see Table 6). Individuals with less than 5 years of experience, however, checked more characteristics on average than those with ≥5 years (4.33 v. 3.65; $t = 2.15$; $p = 0.035$). All respondents selected ambulatory status and history of prior fracture most often (see Table 7), while those with less experience also selected DXA results more frequently (means = 2.13 v. 1.69, t-statistic = 4.43, $p < 0.0001$).

When asked to write down what characteristics they considered when making their decision (gist), the mean number of characteristics did not differ by expertise or experience (3.26 v. 2.98 years; $t = 0.67$, $p = 0.51$). The most frequently identified characteristics included DXA result, prior fracture, and ambulatory status (see Table 7). A 2 × 2 mixed analysis of variance model confirmed the significance of the main effect of experience for verbatim cases (t-statistic = 5.94, $p < 0.0001$), but not for expertise or any interactions.

Discussion

When asked to review a set of hypothetical cases of individuals with SCI regarding bone management, the main drivers of provider treatment decisions were prior fracture and a DXA scan indicating osteoporosis or osteopenia. As these factors are predictors of the risk of subsequent fracture in SCI [10, 16], these findings are reassuring. However, ambulatory status did not influence medication decisions. This may be due in part to the fact that cases indicated either limited ambulation or nonambulatory status, which may not have been viewed to be very different in this population. Furthermore, it may be that nonambulators were considered "sicker" than able bodied persons as walking intensity is inversely related to mortality [17] and "sicker" patients may be more likely to have adverse reactions to medications [18]. We cannot ascertain whether responses would have differed had we chosen to use categories of motor complete vs. incomplete rather than ambulatory status; this is important as completeness of injury is a risk factor for fracture in SCI [10]. That the skeletal site at which the DXA was obtained did not influence decisions is of potential concern, because lumbar spine BMD may be artificially elevated in persons with an SCI [19], and only the total hip, and knee are recommended areas to assess BMD by DXA in SCI [20].

The types of medication that providers were likely to recommend were also influenced by case characteristics. The likelihood of recommending a bisphosphonate was much higher if the person had a prior fracture or if there was a diagnosis of osteoporosis based on a DXA results. Respondents were less likely to recommend a bisphosphate, however, if the DXA scan was done on either the spine or hip (vs. knee). This may be due to the fact that spine BMD

Table 7 Years experience by number of case details identified for decision making.

	<5 yrs experience with SCI $N = 23$	5 years or more experience with SCI $N = 51$	T and p value
Checklist (verbatim)			
Case 1	3.39	3.41	
Case 4	4.83	3.59	
Case 7	4.78	3.94	
Ave	4.33	3.65	$t = 2.15$; $p = 0.03$
Case details in checklist[b]			
Age	1.39	0.82	$p =$ ns
Race	0.96	0.49	$p =$ ns
Level of injury	1.61	1.51	$p =$ ns
Ambulatory status	2.43	2.45	$p =$ ns
DXA location	1.61	1.37	$p =$ ns
DXA result	2.13	1.69	$t = 4.43$, $p < 0.0001$
Prior fracture	2.57	2.43	$p =$ ns
Caregiver situation	0.30	0.18	$p =$ ns
Written (gist)			
Case 2	3.56	3.25	
Case 5	2.95	2.94	
Case 8	3.26	2.74	
Ave	3.26	2.98	$t = 0.67$; $p =$ .ns
Details included in each case[b]			
Age	1.13	0.71	$p =$ ns
Race	0.39	0.27	$p =$ ns
Level of injury	0.61	0.84	$p =$ ns
Ambulatory status	1.57	1.73	$p =$ ns
DXA location	0.57	0.51	$p =$ ns
DXA result	2.09	1.65	$p =$ ns
Prior fracture	1.87	1.59	$p =$ ns
Caregiver situation	0	0.06	$p =$ ns
Duration	0.43	0.74	$p =$ ns
Gender	0.48	0.35	$p =$ ns
Prior treatment	0.52	0.47	$p =$ ns
Menopause status[a]	0.74	0.61	$p =$ ns

[a]Only occurred in the female case, so maximum value would =1.0 if everyone identified this variable.

[b]The total number of times a person could select each characteristic (except menopause status) is 3, so the average represents the number of times the characteristic was selected over 3 cases.

Years of experience was missing for 8 respondents, so their data are not included in this table. Table 1: Block configuration of 9 cases.

levels are frequently normal in persons with SCI and do not predict the likelihood of lower extremity fractures in SCI [10, 19]. Recent guidelines published by the International Society of Clinical Densitometry recommend that persons with SCI have a DXA of the total hip and knee to assess bone health [20]. Interestingly, respondents recommended prescribing bisphosphonates in almost 45% of the cases reviewed. However, the frequency of actual prescriptions for osteoporosis medications for Veterans with SCI in our work is low (9–11%) [21]. Intention and practice are quite different in this situation.

Respondents frequently indicated that they would recommend supplements for cases with a diagnosis of osteopenia or osteoporosis and/or if there was a prior fracture. Many clinical recommendations and guidelines have supported the assessment of 25 hydroxyvitamin D levels and supplementation of Vitamin D and calcium as a treatment and/or adjunct to other therapies for preventing/managing osteoporosis [11, 22]. Although recent data suggests that calcium and vitamin D supplements are not effective in preventing fractures [23, 24], these data are based on the elderly able bodied population. A recent set of interviews with SCI providers suggests that they often prescribe higher doses of Vitamin D than is typically recommended [25]. Higher doses of Vitamin D have been associated with increased risk of falls in the elderly able-bodied population [26]. Whether this is also true in persons with an SCI is not known, indicating the need for specific research on supplements and fracture and fall risk in SCI.

With respect to repeat DXA testing, respondents were less likely to recommend an additional DXA scan prior to indicating treatment for patients who were not ambulatory but more likely if the patient had a prior fracture. However, if a patient was nonambulatory and had a prior fracture, respondents were less likely to order another DXA scan. These data suggest that if a patient was not ambulatory that repeating a DXA would not be useful. However, a prior fracture, if the patient was ambulatory was indicative of getting another DXA. These providers may have wanted to monitor progression of bone loss. The presence of a fragility fracture alone, is diagnostic of osteoporosis [27, 28]. However, unlike reports from the able-bodied population, in whom often the importance of fragility fractures to osteoporosis are not recognized and further investigation not initiated [29], respondents in this survey recommended repeat DXAs for cases with a fracture.

The need for further information on menopausal status to determine bone health management in women with SCI was identified by a minority of respondents. The menopausal transition and menopause itself are well established risk factors for bone loss in able-bodied women [30]. Older women with an SCI are at high risk for fracture; [8] detailed studies of the effects of the menopausal transition on osteoporosis in these women have not been done.

Our hypothesis regarding clinical experience requiring fewer case details was partially supported. When the case characteristics were provided in checklist form, respondents with 5+ years working with persons with SCI used fewer details to make decisions vs. those with fewer years. Similarly, PM&R/SCI physicians, our clinical experts, trended toward selecting fewer details than other respondents. However, when these same respondents were asked

to write down what characteristics they used to make decisions, there were no differences. Overall, the average number of characteristics identified in writing decreased across all providers regardless of experience. The requirement to think about and then write down what was considered in decision making may have been more effort than respondents wanted to make for these hypothetical cases.

Clinical practice guidelines are not intended to provide definitive rules for how providers should make decisions, but rather, are designed to reduce clinical uncertainty by standardizing approaches to care provision. How guidelines are translated to actual provider behavior is not simple and should take practice variability into account [13]. Furthermore, when the evidence is weak or limited, as it is in bone health management for SCI, clinical experience will likely take on a bigger role in the process. The study findings point to the need for additional research and improved education efforts regarding fracture risk factors and use of DXA scanning results in persons with SCI.

There were limitations to this study. We do not have information on our response rate as we did not track the number of invitations that were sent. Our word-of-mouth and other efforts to get as many and varied respondents as possible, while not ideal, allowed us to reach a relatively large number of providers who provide bone health care to persons with SCI. Missing data resulted in our inability to test some 2-way interactions in our models. Our list of characteristics for the checklist did not include all of the information from the cases (8 of 11 characteristics), and therefore, we may have not listed characteristics that were particularly important. This does not seem to be a big concern however, because these characteristics (prior treatment, duration of injury, gender) were infrequently identified when the respondent wrote down the information they used. Finally, we used hypothetical cases with limited information, which does not represent real life situations. Nonetheless we did have a variety of providers with varied experience with SCI complete the survey.

Conclusion

Our results suggest that providers understand the importance of BMD results obtained by DXA and prior fracture as predictors of future fracture to target high risk individuals for pharmacological therapies for osteoporosis. Similarly, they recognize the importance of workups for secondary causes of osteoporosis in these patients including use of medications and secondary medical conditions that cause bone loss and laboratory studies to determine other disorders that might contribute to bone loss/fracture risk. However, many providers in our sample did not appear to be aware that lumbar spine BMD results are not useful to diagnose low bone mass in persons with an SCI and should therefore not be used to guide treatment decisions. This particular "gap area in knowledge" might be important both to target future educational initiatives and on a larger scale, to implement guidelines at DXA testing centers such that lumbar spine BMD is not measured in persons with an SCI.

Data archiving

Data are available upon request and completion of a data use agreement.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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