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ORIGINAL ARTICLE

Patterns of change in prehospital spinal motion restriction: A retrospective database review

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Abstract

Background: Acute management of trauma patients with potential spine injuries has evolved from uniform spinal immobilization (SI) to spinal motion restriction (SMR). Little research exists describing how these changes have been implemented. This study aims to describe and analyze the practice of SMR in one emergency medical services (EMS) agency over the time frame of SMR adoption.

Methods: This was a retrospective database review of electronic patient care reports from 2009 to 2020. The effects of key practice changes (revised documentation and a collar-only treatment option) were analyzed in an interrupted time series using the rate of SI/SMR as the primary outcome. Secondary outcomes included patient age, sex, acuity, mechanism of injury, treatment provided, cervical collar size, and positioning. These were assessed for changes from year to year by Poisson regression. Associations between patient and treatment characteristics were investigated with binomial logistic regression.

Results: There were 25,747 instances of SI/SMR included. Among all patients, the median age was 40 (interquartile range 24–56), 58% (14,970) were male, and 20% (5062) were high-acuity. The rate of SI/SMR declined from 31.2 to 12.7 treatments per 100 trauma calls per month. The proportion of high-acuity patients increased by 9.6% per year on average (95% CI 8.7%–10.0%). When first available, collar-only treatment was provided to 47% of patients, rising by 6.3% per year (95% CI 3.2%–9.5%) to 60% in 2020. Collar-only treatment (compared to board-and-collar) was more likely to be applied to low-acuity patients (as compared to high): odds ratio 3.01 (95% CI 2.64–3.43).

Conclusions: This study shows decreasing SI/SMR treatment and changing patient and practice characteristics. These patterns of care cannot be attributed solely to formal protocol changes. Similar patterns and their possible explanations should be investigated elsewhere.

Presented at the National Association of EMS Physicians Scientific Assembly, San Diego, CA, January 2022. Those data have been reanalyzed and constitute original work in the current article.

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INTRODUCTION

International training guidelines teach the treatment of potential spine injuries as a core skill in both the emergency department and the prehospital environment.[1,2] During the past decade, however, these guidelines have been substantially revised. Past practice, termed spinal immobilization (SI), most often positioned patients at risk of spine injury supine on a long, rigid backboard and immobilized them with straps, a rigid cervical collar, and head blocks. More recently, spinal motion restriction (SMR) acknowledges the adverse effects of immobilization as well as the limitations of its potential benefits and typically allows more leeway in treatment options depending on patient presentation.[3,4] Despite widespread adoption of the principles of SMR, practices and specific guidelines vary. The role of the cervical collar, for example, differs widely among jurisdictions,[5–11] and it remains unclear which devices and procedures are most effective at limiting potentially harmful motion.

Within the existing research on SMR, studies describing practice changes around the implementation of new protocols have confirmed expected decreases in the use of the long backboard and increases in alternatives, such as collar-only treatment and devices such as the vacuum mattress.[12–14] Others studies have compared different treatment techniques and found a range of factors and scenarios that influence patient motion apart from the specific device applied, including driving habits,[15,16] extrication,[17] and patient behavior.[18,19] Additional research has examined patient characteristics and outcomes after introducing new guidelines, observing not only substantial undertreatment among patients who met criteria for precautions but also increases in the number of patients with confirmed injuries who received no treatment from emergency medical services (EMS).[20,21] While a small number of additional studies using high-level population data have observed no increase in a final diagnosis of spinal cord injury after SMR,[22,23] the prospects of variable practice, ineffective interventions, and patients not receiving the treatment intended for their injury remain a concern.

If standards for the acute management of spine injuries are to progress, treatment must continue toward optimizing patient protection while avoiding further harm.[24] In general, there is scant research describing prehospital patients who receive treatment for potential spine injuries and whether that treatment corresponds to local guidelines[25,26]; there is less that describes these patients and their treatment during the period of practice change. This information, however, is necessary to begin to understand how SMR guidelines have been integrated into frontline care and how future guidelines might be improved. Therefore, the purpose of this study is to describe and analyze the practice of SMR in one urban, North American EMS agency over the time frame of SMR adoption, with specific attention to the rate of treatment and patient and practice characteristics.

METHODS

Reporting of this study follows The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[27]

Design, setting, and background

This is a retrospective review of records of the Winnipeg Fire Paramedic Service (WFPS) from April 2009 through February 2020, a period determined by the availability of electronic patient care reports (ePCRs) and the onset of COVID-19. Ethical approval was obtained from the local research ethics board (HS24193 [H2020:376]).

The WFPS serves an urban population of approximately 750,000 and employs basic life support (BLS) first response and combined BLS and advanced life support (ALS) follow-up care and transport. Its BLS and ALS personnel (termed primary and advanced care paramedics, respectively) are trained to national standards at each level, with ALS providers trained additionally in prehospital trauma life support.[2] In common with many similar agencies, local treatment guidelines for potential spine injuries have been revised in several ways. (1) In March 2009, the service implemented a selective immobilization protocol resembling others deployed in the prehospital setting and similar to the NEXUS criteria.[28–30] Under this protocol, any patient who has experienced trauma with the potential to cause a spine injury receives SI/SMR if any of six indications are present: a reduced level of consciousness or altered mental status, signs of head trauma, signs of intoxication, a distracting painful injury, spine tenderness, or a focal neurologic deficit. (2) In an effort to increase rates of documentation, the service implemented a logic rule in the ePCR in July 2012 that obliges attending paramedics to record the indications for SI/SMR in all cases where it was considered or applied or to confirm that a traumatic mechanism of injury (MOI) was not sufficient to cause a spine injury. (3) Cases of isolated penetrating trauma were exempted from SI/SMR in November 2014.[2,31] (4) In April 2016, treatment guidelines were revised to allow for collar-only treatment in low-risk scenarios (defined as the patient being ambulatory prior to paramedic arrival).[32] Other elements of treatment remained the same, including direction to secure the patient to the stretcher in the supine position.

As accepted terminology remains variable, this study will use SI to denote the practice of immobilizing a patient on a long spine board with a combination of a cervical collar, head blocks, and straps. SMR will refer to treatment after 2016, when providers gained to option to treat either as previously or with only a cervical collar. Since this study straddles the adoption of SMR principles, the intervention will be described as SI/SMR unless specifically discussing one or the other. "Selective immobilization" refers to the clinical decision protocol that determines the need for SI/SMR in the presence of an MOI with the potential to cause a spine injury (the term "immobilization" has been kept since SI was the standard treatment when the protocol was adopted).

Data selection, outcomes, and analysis

Cases were drawn from the database of ePCRs based on the documented presence of SI/SMR as an intervention. Paramedics in this service document care in the ePCR using a laptop computer

(Panasonic Toughbook, Panasonic Canada Inc.), where all information is entered manually either by keyboard or by touchscreen. A system of logic rules supports data quality by forcing completion of essential fields with valid entries.

The primary outcome is the rate of SI/SMR during the study period. Rates of splinting and wound care were also collected as proxy measures of the incidence of trauma care over time. Secondary outcomes include patient- and practice-related factors associated with potential changes over time. Patient-related factors include age, sex, acuity, MOI, and indications for treatment. Patients were classified as high acuity if they were transported emergently or if they met criteria for diversion to the local trauma center. Trauma center criteria follow guidelines published by the Center for Disease Control and Prevention in collaboration with the American College of Surgeons and feature sections based on vital signs, anatomical injury, and MOI.[33] The record of MOI consists of both a preset list and a free-text field. Neither is mandatory to complete documentation. Entries were collected in main categories: fall, motor vehicle accident (MVA), assault, sports-related, and other. The "other" category included all items that were not easily grouped, such as injuries related to fire, lightning, drowning, and machinery accidents. Blank fields were marked as "not reported." Factors related to practice include cervical collar size, patient positioning, the proportion of collar-only use (after protocol change), and the rate of treatment of penetrating trauma. Among these, cervical collar size has not been previously reported in detail. However, sizing a cervical collar to a patient is described as proper technique to ensure adequate restriction and is specified in clinical guidelines.[2,5] A small body of research has investigated the effects of under- or oversized collars in simulated settings, and improper sizing has been reported in a large proportion of simulated applications.[34–36] Cervical collar size has been included here to describe and analyze practice in field conditions.

The primary outcome and comparison interventions were summarized as monthly counts and expressed in terms of 100 trauma calls per month. Any call record with a primary impression related to trauma was included in the denominator.[37] The rate of each intervention was analyzed by segmented regression in an interrupted times series using the 2012 documentation change and the 2016 SMR treatment change as interruptions. The implementation of selective immobilization marks the start of the study period (determined by the availability of ePCR data). The exemption of isolated penetrating trauma was considered outside of the interrupted times series due to the small number of cases at any time.

Data from each treatment was plotted as a time series over the 131 months of the study period. Figure 1 illustrates the raw SI/SMR rate as well as the portion of treatments attributable to a constant monthly seasonal effect over the study duration. Seasonally adjusted rates were then used to develop models for segmented regression of

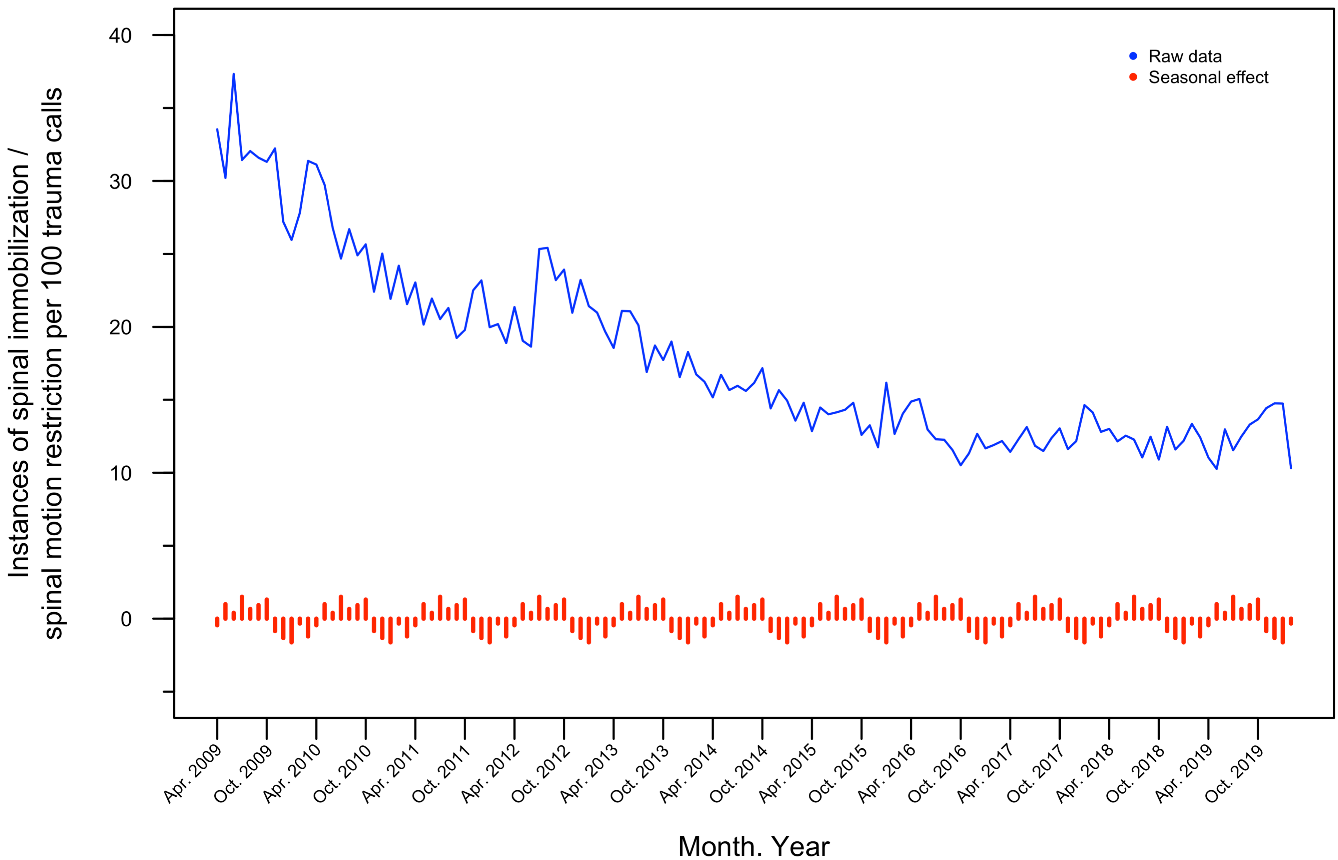

FIGURE 1 Time series of prehospital SI/SMR. Raw data plotted by month, 2009–2020. Seasonal effect averaged for each month over the study period, showing the monthly maximum (1.4, July) and minimum (−1.6, January). SI, spinal immobilization; SMR, spinal motion restriction.

the interrupted times series. This approach assumes that series values are not autocorrelated or related to themselves over time.[38,39] If present, autocorrelation can be accounted by for respecifying the model or including autoregressive or moving average terms.[38–40] In this case, preliminary testing for SI/SMR showed persistent residual autocorrelation with a linear model (Box–Ljung test, $\chi^2 = 74.7$, df = 24, $p < 0.001$). After results among different potential solutions were compared, a quadratic model with no autoregressive or moving-average terms yielded no significant residual autocorrelation: Box–Ljung test, $\chi^2 = 33.0$, df = 24, $p = 0.1$. This model also resulted in a marginally improved fit compared to the linear version: adjusted $r^2 = 0.949$ versus 0.938; Akaike's Information Criteria 507.6 versus 517.0; Bayesian Information Criteria 530.2 versus 536.8; likelihood ratio 11.42, $p < 0.001$. This model met the assumptions required for segmented regression of an interrupted times series and was used for analysis. Candidate models for the comparison trauma treatments were assessed using a similar process. These showed no improved fit with a quadratic term and linear models were applied.

Secondary outcomes are reported in terms of raw counts and percentages (or median and interquartile range [IQR] in the case of age), both overall and for each year of the study. As recent epidemiological literature has observed increasing rates of traumatic spine and spinal cord injuries among elderly women (in contrast to prior findings of higher incidence among young men),[41–43] proportions of women over 65 and men under 40 among the study population were also calculated. Changes in each factor over time were assessed using Poisson regression fitted to the factor count, with the year modeled as a continuous variable and the count denominator included as an offset.[44]

To investigate associations between treatment practices and patient characteristics, key treatments were dichotomized based on findings: treatment choice (collar-only compared to board-and-collar), patient positioning (supine compared to all others), and cervical collar size ("no-neck" compared to all others). These categories were related to patient traits by binomial logistic regression and reported as an adjusted odds ratio (OR). Treatment choice was available only after the protocol change and is therefore reported from 2016 to 2020. The same time frame was chosen for patient positioning, as the vast majority of treatments prior to 2016 were supine. Collar size was assessed for the entire study period as well as 2009–2015 and 2016–2020; with minimal difference in outcomes, calculations for the entire study period are reported. All analyses were performed in R, version 4.0.5 (Foundation for Statistical Computing). A threshold of alpha <0.05 was considered statistically significant.

RESULTS

During the study period 25,854 cases of SI/SMR were identified. Of these, 107 (0.4%) were found to be duplicates and removed, leaving 25,747 included records of treatment out of 141,445 trauma calls. Among all included cases, there were 70 (0.3%) missing an entry for sex, none missing an entry for age, and 739 (2.9%) missing valid information on acuity. These cases were excluded from summary statistics. The median (IQR) age of included patients was 40 (24–56) years and 14,970 (58%) were male. Overall, 5062 patients (20%) were classified as high acuity. The MOI was not reported in 9528 cases (37%).

Figure 2 shows the seasonally adjusted rate of SI/SMR per 100 trauma calls per month in an interrupted times series segmented by: (a) the documentation change that mandated recording the spine assessment in any case of trauma with the potential to cause a spine injury and (b) the protocol change to SMR, which allowed for collar-only treatment. Interventions for wound care and splinting are also displayed. Table 1 shows the coefficients for the level changes at each interruption and trend change during each period.

The rate of treatment with SI/SMR declined significantly during the first two time periods. The documentation change was associated with a significant level increase in the rate of SI/SMR of 5.8 treatments per 100 trauma calls (95% CI 4.6–7.1). The protocol change allowing collar-only treatment was not associated with a significant change in rate, and the final time period showed no significant trend change. In comparison, neither wound care nor splinting showed any substantial level or trend changes. Evaluating the change in the rate of each intervention between the first and last 12 months of the study period, SI/SMR declined from 31.2 to 12.7 treatments per 100 trauma calls—a 59% (95% CI 56%–62%) decrease—while instances of wound care increased from 18.6 to 19.0 treatments per 100 trauma calls (2.2%, 95% CI −3.0% to 7.1%) and splinting decreased from 12.1 to 8.6 (−28%, 95% CI −22% to −35%).

Table 2 describes patient characteristics over the study period. The age (median [IQR] 40 [24–56 years] and sex (58% male)) of patients treated with SI/SMR did not significantly change over time, but the proportion of female patients over age 65 significantly decreased by −2.8% per year (95% CI −4.0% to −1.5%). Decreasing overall treatment was accompanied by a significantly increasing proportion of high-acuity patients. These made up 11% of all treatments in 2009, but 31% in 2020, an average annual percentage change of 9.6% (95% CI 8.7% to 10.0%).

Among reported MOIs, instances of falls and MVAs were most common (each 23%), followed by assaults (15%), sports (2.0%), and other events (0.7%). During the study period, there were small but significant decreases in the proportions of falls, MVAs, and assaults, with a commensurate increase in instances of nonreporting (4.1% on average per year [95% CI 3.5% to 4.8%]). There were no significant changes in the remaining categories. Detailed information on the documentation of MOIs is available in the Table S1. Similar information on the documented indications for treatment is available in the Table S2.

Table 3 outlines the use and sizing of cervical collars. Throughout the study period, the no-neck collar was used more frequently than any other single size (65%). This was the smallest of standard available options for adult patients. (Pediatric patients receive pediatric collars unless adult collars are appropriate; documentation does not differentiate among different pediatric sizes.) No-necks accounted for 71% of all patients treated in 2009 (and peaked at 75% in 2010

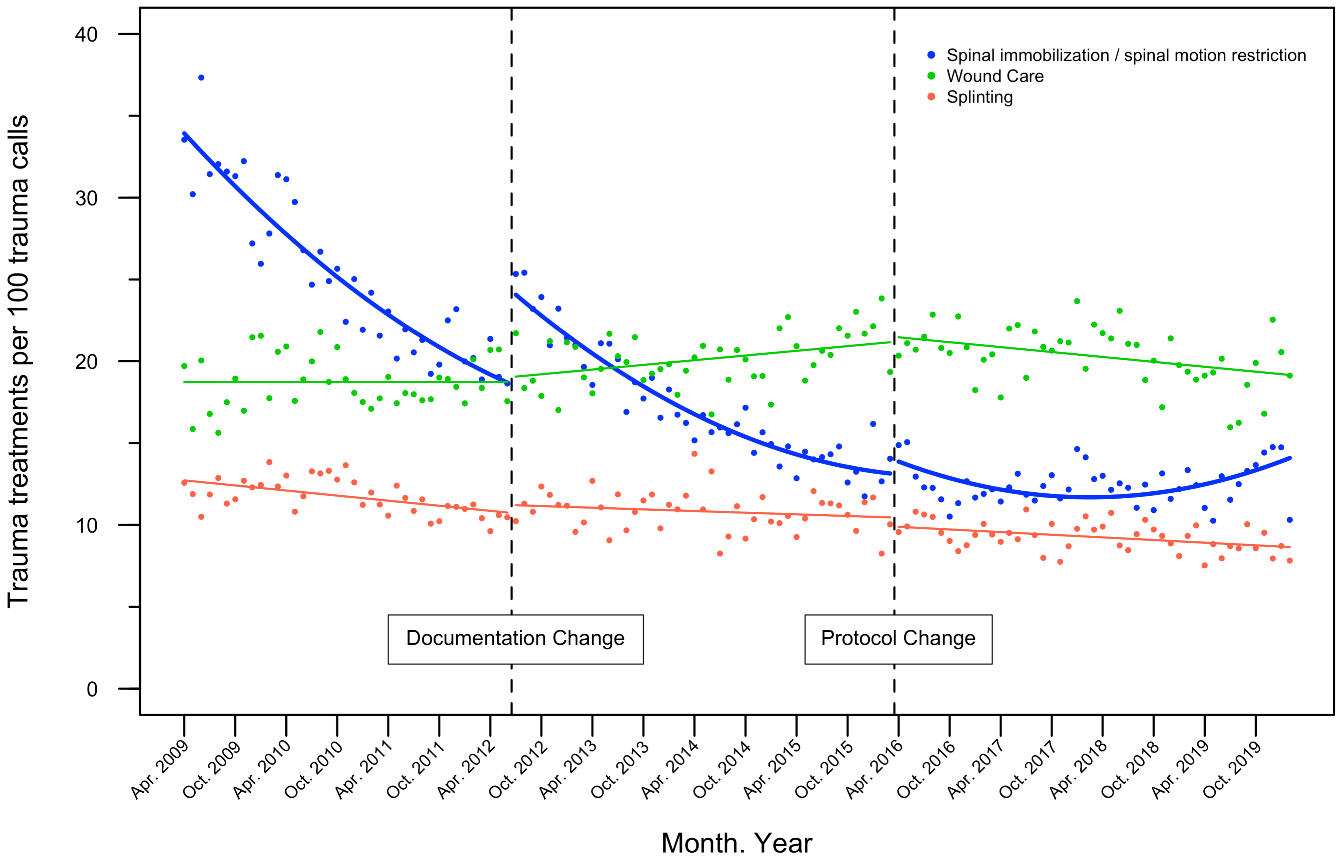

FIGURE 2 Interrupted time series of prehospital trauma treatments, 2009–2020. Seasonally adjusted data plotted by month (shown as dots), with accompanying lines of best fit for wound care and splinting (linear) and SI/SMR (quadratic). SI, spinal immobilization; SMR, spinal motion restriction.

TABLE 1 Trend and level change coefficients for the interrupted time series of prehospital trauma treatments.

	SI/SMR	Wound care	Splinting
Intercept	34.5 (33.5 to 35.5)***	18.7 (17.6 to 19.8)***	12.8 (12.1 to 13.4)***
Before period—trend change[a]	−0.57 (−0.65 to −0.50)***	0.0004 (−0.05 to 0.05)	−0.05 (−0.08 to −0.02)***
Documentation—level change	5.8 (4.6 to 7.1)***	0.27 (−1.2 to 1.7)	0.46 (−0.39 to 1.3)
Middle period—trend change[a]	−0.21 (−0.36 to −0.06)**	0.05 (−0.01 to 0.10)	0.03 (−0.001 to 0.07)
Protocol—level change	0.92 (−0.24 to 2.1)	0.35 (−1.0 to 1.8)	−0.55 (−1.4 to 0.27)
After period—trend change[a]	−0.15 (−0.30 to 0.01)	−0.10 (−0.15 to −0.04)***	−0.01 (−0.04 to 0.02)
Trend^2	0.004 (0.003 to 0.006)***	—	—

Note: All values expressed in terms of treatments per 100 trauma calls (95% CI). The "Trend^2" coefficient reflects the additional term in the quadratic model. Estimates can be derived by adding it to the trend coefficient in each period according to the formula: "Trend^2" × k^2, where k is the number of months in the period corresponding to the estimate. *p* values: *<0.05; **<0.01, ***<0.001.

Abbreviations: SI, spinal immobilization; SMR, spinal motion restriction.

[a]Trend changes denote change from the preceding value.

and 2011), but their use decreased over time by −3.8% per year (95% CI −4.2% to −3.3%) to 49% in 2020. This decrease was matched with a corresponding decrease in "short" collars and increasing use of "regular" and "tall" sizes. The largest yearly change was in the increase in collars omitted, refused, or improvised, from 2.0% in 2009 to 8.3% in 2020 or 13% per year (95% CI 11% to 15%).

As shown in Table 4, slightly under half of eligible patients (47%) were treated with only a cervical collar in 2016, the first partial year after the protocol change allowing that treatment. This proportion increased by an average of 6.3% per year (95% CI 3.2% to 9.5%), rising to 60% in 2020. Patient positioning changed significantly in all categories, with the largest changes appearing after 2016 in most (although protocol still mandated supine positioning for all patients treated with spinal precautions, whether with only a collar or board and collar). Overall, supine positioning decreased on average by −3.1% per year (95% CI −3.5% to −2.7%) while all others increased. The use of semi-Fowler's positioning increased 47% on average per year (95% CI 44% to 50%), rising from 0.8% of all patients treated in 2009 to 25% in 2020.

TABLE 2 Age, sex, and acuity of all patients treated with SI/SMR, 2009–2020.

	Cases	Age, median (IQR)	Pediatric (<16)	Geriatric (>65)	Male	Male, <40	Female, >65	High acuity
Total	25,747	39.7 (24.3–56.1)	2030 (7.9)	4142 (16)	14,970 (58)	7808 (30)	2300 (8.9)	5062 (20)
2009 (04–12)	3417	40.5 (23.5–57.6)	301 (8.8)	646 (19)	1972 (58)	1005 (29)	361 (11)	390 (11)
2010	3652	40.0 (24.3–57.0)	288 (7.9)	634 (17)	2087 (57)	1076 (30)	373 (10)	529 (15)
2011	3007	39.9 (23.2–55.9)	269 (8.9)	466 (16)	1730 (58)	904 (30)	275 (9.1)	488 (16)
2012	2985	37.9 (23.3–55.4)	239 (8.0)	477 (16)	1708 (57)	957 (32)	271 (9.1)	537 (18)
2013	2337	40.0 (23.9–55.2)	202 (8.6)	341 (15)	1302 (56)	668 (29)	199 (8.5)	441 (19)
2014	1938	40.6 (24.8–55.9)	151 (7.8)	292 (15)	1132 (58)	573 (30)	147 (7.6)	415 (21)
2015	1686	39.8 (25.1–55.1)	136 (8.1)	257 (15)	1036 (61)	541 (32)	132 (7.8)	377 (22)
2016	1622	37.7 (24.2–55.0)	127 (7.8)	217 (13)	991 (61)	541 (33)	115 (7.1)	392 (24)
2017	1632	37.9 (24.9–54.9)	125 (7.7)	236 (15)	1001 (64)	534 (33)	117 (7.2)	392 (24)
2018	1603	40.0 (26.0–57.6)	97 (6.1)	245 (15)	916 (57)	470 (29)	136 (8.5)	498 (31)
2019	1651	40.7 (26.4–57.8)	83 (5.0)	286 (17)	972 (59)	482 (22)	152 (9.2)	536 (33)
2020 (01–02)	217	44.3 (29.3–59.3)	12 (5.5)	45 (21)	123 (57)	57 (26)	22 (10)	67 (31)
Mean annual percentage change (95% CI)		0.1 (−0.1 to 0.4)	−3.3*** (−4.6 to −1.9)	−1.5** (−2.5 to −0.6)	0.5 (−0.1 to 1.0)	0.4 (−0.3 to 1.0)	−2.8*** (−4.0 to −1.5)	9.6*** (8.7 to 10)

Note: All cells reported as *n* (%) except: cases; age, median (IQR); mean annual percentage change (95% CI). *p* values: *<0.05, **<0.01, ***<0.001.
Abbreviation: IQR, interquartile range; SI, spinal immobilization; SMR, spinal motion restriction.

TABLE 3 Cervical collar documentation of all patients treated with SI/SMR, 2009–2020.

	Cases	No-neck	Short	Regular	Tall	Pediatric	Other[a]	Not recorded
Total	25,747	16,822 (65)	3151 (12)	3450 (13)	104 (0.4)	939 (3.6)	838 (3.3)	443 (1.7)
2009 (04–12)	3416	2426 (71)	603 (18)	160 (4.7)	13 (0.4)	145 (4.2)	69 (2)	0 (0)
2010	3652	2747 (75)	499 (14)	179 (4.9)	4 (0.1)	139 (3.8)	84 (2.3)	0 (0)
2011	3008	2259 (75)	362 (12)	137 (4.6)	10 (0.3)	117 (3.9)	55 (1.8)	68 (2.3)
2012	2986	2020 (68)	404 (14)	254 (8.5)	10 (0.3)	87 (2.9)	76 (2.5)	135 (4.5)
2013	2337	1519 (65)	279 (12)	287 (12)	10 (0.4)	80 (3.4)	83 (3.6)	79 (3.4)
2014	1938	1187 (61)	210 (11)	356 (18)	9 (0.5)	62 (3.2)	66 (3.4)	48 (2.5)
2015	1686	995 (59)	192 (11)	341 (20)	11 (0.7)	68 (4.0)	49 (2.9)	30 (1.8)
2016	1622	951 (59)	160 (9.9)	368 (23)	13 (0.8)	62 (3.8)	45 (2.8)	23 (1.4)
2017	1632	915 (56)	131 (8.0)	403 (25)	7 (0.4)	61 (3.7)	92 (5.6)	23 (1.4)
2018	1603	872 (54)	152 (9.5)	381 (24)	7 (0.4)	63 (3.9)	113 (7)	15 (0.9)
2019	1650	824 (50)	140 (8.5)	523 (32)	10 (0.6)	48 (2.9)	88 (5.3)	17 (1.0)
2020 (01–02)	217	107 (49)	19 (8.8)	61 (28)	0 (0)	7 (3.2)	18 (8.3)	5 (2.3)
Mean annual percentage change (95% CI)		−3.8*** (−4.2 to −3.3)	−6.4*** (−7.5 to −5.3)	21*** (20 to 23)	8.4** (2.2 to 15)	−1.4 (−3.4 to 0.6)	13*** (11 to 15)	3.7* (0.7 to 6.7)

Note: All cells reported as *n* (%) except: cases; mean annual percentage change (95% CI). *p* values: *<0.05, **<0.01, ***<0.001.
Abbreviations: IQR, interquartile range; SI, spinal immobilization; SMR, spinal motion restriction.
[a]Includes those omitted, refused by patient, or improvised.

Consistent with international guidelines,[2,45] cases of isolated penetrating trauma were exempted from treatment in 2014. Treatment in these cases was low prior to protocol change, partly because these patients are often critically injured and prehospital spinal protocols prioritize immediate treatment and transport of threats to life over taking time to apply spinal precautions. During the study period, the rate of treatment in these cases decreased from 17% (2009) to 4.7% (2020), an average annual rate of −12% per year (95% CI −15% to −8.7%).

Table 5 presents associations between key treatment practices and patient characteristics. Collar-only treatment (compared to treatment with a backboard and collar) was significantly associated with low-acuity cases: OR 3.01 (95% CI 2.64 to 3.43). Assaults (compared to MVAs) were also significantly more likely to be treated with

TABLE 4 Documentation of patient positioning and collar-only treatment of all patients treated with SI/SMR, 2009–2020.

	Cases[a]	Supine	Semi-Fowler's	Sitting/Fowler's	Other[b]	Not recorded	Collar only[c]
Total	25,747	22,712 (88)	1428 (5.5)	475 (1.8)	406 (1.6)	726 (2.8)	3255 (51)
2009 (04–12)	3416	3218 (94)	26 (0.8)	32 (0.9)	37 (1.1)	104 (3.0)	–
2010	3652	3467 (95)	26 (0.7)	28 (0.8)	35 (1.0)	96 (2.6)	–
2011	3008	2864 (95)	22 (0.7)	28 (0.9)	50 (1.7)	43 (1.4)	–
2012	2986	2758 (92)	51 (1.7)	48 (1.6)	55 (1.8)	73 (2.4)	–
2013	2337	2165 (93)	40 (1.7)	34 (1.5)	44 (1.9)	54 (2.3)	–
2014	1938	1799 (93)	43 (2.2)	22 (1.1)	38 (2.0)	36 (1.9)	–
2015	1686	1560 (93)	50 (3.0)	14 (0.8)	31 (1.8)	31 (1.8)	–
2016	1622[c]	1282 (79)	216 (13)	50 (3.1)	34 (2.1)	40 (2.5)	584 (47)
2017	1632	1198 (73)	272 (17)	72 (4.4)	22 (1.3)	68 (4.2)	803 (49)
2018	1603	1153 (72)	275 (17)	73 (4.6)	28 (1.7)	74 (4.6)	813 (51)
2019	1650	1106 (67)	353 (21)	67 (4.1)	28 (1.7)	97 (5.9)	924 (56)
2020 (01–02)	217	142 (65)	54 (25)	7 (3.2)	4 (1.8)	10 (4.6)	131 (60)
Mean annual percent change		−3.1*** (−3.5 to −2.7)	47*** (44 to 50)	20*** (17 to 24)	4.3** (1.2 to 7.4)	7.8*** (5.4 to 10)	6.3*** (3.2 to 9.5)

Note: *p* values: **<0.01, ***<0.001.

Abbreviations: SI, spinal immobilization; SMR, spinal motion restriction.

[a]All columns describing patient positioning sum to cases by row and total by column.

[b]Includes lateral (right or left), head elevated (immobilized), Trendelenburg, and not specified.

[c]Collar-only column applies to the period after protocol change, April 2016. Cases are the sum of collar-only (as listed) and board-and-collar (not shown). Cases in 2016 after protocol change: 1251.

TABLE 5 Associations between treatment and patient characteristics in prehospital patients treated with SI/SMR.

	Collar only, ref. backboard (2016–2020)		Other positioning, ref. supine (2016–2020)		Collar size no-neck, ref. all others (2009–2020)	
	Estimate (SE)	OR (95% CI)	Estimate (SE)	OR (95% CI)	Estimate (SE)	OR (95% CI)
Age (ref. adult 17–65)						
Pediatric (<17)	−1.36 (0.13)	0.26*** (0.20 to 0.33)	−0.90 (0.15)	0.41*** (0.30 to 0.55)	N/A	N/A
Geriatric (>65)	−0.14 (0.08)	0.87 (0.75 to 1.02)	0.07 (0.08)	1.07 (0.90 to 1.26)	0.22 (0.05)	1.24*** (1.14 to 1.36)
Sex (female, ref. male)	−0.01 (0.06)	0.99 (0.88 to 1.11)	−0.04 (0.06)	0.96 (0.85 to 1.08)	0.22 (0.03)	1.25*** (1.17 to 1.32)
Acuity (low, ref. high)	1.1 (0.07)	3.01*** (2.64 to 3.43)	1.01 (0.08)	2.74*** (2.35 to 3.20)	−0.07 (0.04)	0.93 (0.86 to 1.01)
MOI (ref. MVA)						
Assault	1.12 (0.11)	3.07*** (2.49 to 3.79)	0.52 (0.11)	1.69*** (1.37 to 2.08)	0.01 (0.05)	1.01 (0.91 to 1.13)
Fall	0.02 (0.09)	1.02 (0.86 to 1.21)	−0.08 (0.1)	0.92 (0.76 to 1.12)	0.05 (0.05)	1.05 (0.96 to 1.15)
Sports-related	−0.70 (0.25)	0.50** (0.30 to 0.80)	−0.49 (0.29)	0.61 (0.34 to 1.05)	−0.16 (0.11)	0.85 (0.69 to 1.06)
Not reported/other	0.41 (0.07)	1.5*** (1.3 to 1.74)	0.18 (0.08)	1.19* (1.02 to 1.4)	−0.15 (0.04)	0.86*** (0.79 to 0.93)
Indications (present, ref. absent)						
GCS < 15	−0.72 (0.06)	0.49*** (0.43 to 0.55)	−0.29 (0.07)	0.75*** (0.65 to 0.85)	0.19 (0.04)	1.21*** (1.13 to 1.30)
Head trauma	0.12 (0.06)	1.13* (1.00 to 1.28)	0.11 (0.07)	1.11 (0.98 to 1.26)	0.03 (0.03)	1.03 (0.96 to 1.10)
Intoxication	0.07 (0.07)	1.07 (0.94 to 1.22)	−0.09 (0.07)	0.91 (0.80 to 1.05)	0.19 (0.04)	1.21*** (1.13 to 1.30)
Distracting injury	−0.35 (0.07)	0.70*** (0.62 to 0.80)	0.00 (0.07)	1.00 (0.87 to 1.15)	−0.01 (0.03)	0.99 (0.92 to 1.06)
Spine Tenderness	−0.28 (0.06)	0.76*** (0.67 to 0.85)	−0.23 (0.06)	0.80*** (0.70 to 0.90)	0.17 (0.03)	1.19*** (1.12 to 1.27)
Neurologic deficit	−0.75 (0.13)	0.47*** (0.37 to 0.61)	−0.43 (0.15)	0.65** (0.48 to 0.86)	−0.04 (0.06)	0.96 (0.85 to 1.08)

Note: *p* values: *<0.05, **<0.01, ***<0.001.

Abbreviations: GCS, Glasgow Coma Scale; MOI, mechanism of injury; MVA, motor vehicle accident; OR, odds ratio; Ref., reference; SE, standard error; SI, spinal immobilization; SMR, spinal motion restriction.

a collar only (OR 3.07, 95% CI 2.49 to 3.79). Conversely, pediatric patients had significantly lower odds of being treated with only a cervical collar compared to a backboard (OR 0.26, 95% CI 0.20 to 0.33), as were sports-related MOIs and all indications (except for intoxication). Characteristics related to positioning other than supine follow the same pattern as collar-only treatment, although sports-related MOIs and findings of head trauma and distracting injury had no significant associations. The use of a no-neck collar was significantly associated both age over 65 (OR 1.24, 95% CI 1.14 to 1.36) and female patients: OR 1.25, 95% CI 1.17 to 1.32. No-necks were less likely to be used in MOIs marked "Not reported/other," but not in any other mechanism (all in comparison to MVAs). Their use was associated with findings of a decreased level of consciousness, intoxication, and spine tenderness.

DISCUSSION

This study summarizes patterns of prehospital care for potential spine injuries in one EMS agency during a period of practice change. Most notably, the data presented here demonstrate a significantly decreasing rate of treatment, with an apparent floor effect over the second half of the study period (Figure 2, Table 1). More detailed descriptions of patient and practice characteristics also reveal changing patterns over time. The rising proportion of high-acuity patients shows that the decrease in treatment has not been applied evenly, but more so to less seriously injured patients (Table 2). Although overall treatment has been decreasing, collar-only use has risen every year since it became an option (Table 4). Patient positioning has followed the same trend, with continuing increases in options other than supine (despite supine being mandated). Finally, the pattern of cervical collar sizing scene in these data (while not checked against neck sizes in the population) departs from what might be expected based on guidelines (Table 3).

Although there is sparse literature describing prehospital treatment of potential spine injuries, two studies provide some points of comparison. A large retrospective cohort study of data from Australia documents over 100,000 patients identified as at risk for spine injury (though not all treated with SI/SMR) from 2007 through 2012.[25] The patient group in that study was slightly older (median age 51 years), with a lower proportion of males (52.2%) and a much higher proportion of women over 65 years (23.6%) compared to the current data.[25] While 48.8% are described as meeting major trauma guidelines, study results show that 34.3% were transported to a major trauma or spinal center—a figure that approximates the proportion of high-acuity patients in this data. Falls were the most common MOI listed (46.9%), followed by traffic accidents (39.4%); "violence" accounted for 6.7% of cases (whereas assaults made up 15% in the current results). Among the listed MOIs, falls increased in frequency, from 1033 in 2007 to 2623 per million per year in 2012.[25] A similar study from the Netherlands described all patients treated with SI/SMR between 2008 and 2013.[26] Out of a total of 1082 patients, that study reported a mean (±SD) age of 43 (±18.3) years, 59% male, with 14% over the age of 65—results similar to those found here. A high proportion (69.7%) of MOIs were not reported. Among the included patients, 15.8% received nonstandard treatment according to applicable guidelines, including 5.1% treated with only a cervical collar. When present, reasons for deviation related to attempts to adapt treatment to the patients' injuries or underlying conditions.[26] Although both studies provide some comparisons for overall patient and practice characteristics, neither these nor others have investigated similar data for patterns of care over the time frame of protocol changes.

What explains the patterns of treatment observed in these results? While the beginning of the study period follows the adoption of a selective immobilization protocol, that alone would not be responsible for a steady and continuing decrease over the course of years (similar protocols have been implemented and evaluated after brief training sessions[30,46,47]). And, although the study straddles the transition from SI to SMR, a change in treatment options would not be expected to affect the number of people who received some form of treatment. Similarly, we might expect the use of collar-only treatment to have increased gradually over time after the implementation of new treatment options—but not for years. Rates for wound care and splinting within the same service show no similar pattern, ruling out a general decrease in all trauma treatments. The practice variety observed in these results exceeds what might be expected by protocol changes alone.

It is possible the observed decrease in treatment reflects a shift in attitudes among frontline providers. As the standard of care has evolved from uniform treatment for any patient with any possibility of injury toward a more stratified approach, practitioners have likely become less rigid in their application and interpretation of written guidelines. In this view, although the indications for treatment have not changed, the interpretation of which MOIs are sufficient to cause an injury (or one with the potential for neurologic deterioration) have. A small number of studies examining the attitudes of EMS personnel toward SI/SMR supports this interpretation. Research conducted before widespread SMR changes found that prehospital providers felt that SI was too frequently applied and that those with ALS qualifications in particular viewed it as often redundant or not helpful in certain cases.[13,48,49] The few published studies that have surveyed providers on changing standards have documented support for evolving guidelines and enthusiasm for moving beyond strict requirements and toward flexible approaches.[13,50] Respondents to a recent survey within this service have documented a belief that SMR is seen as less important than in the past as well as some skepticism toward the effectiveness, importance, and applicability of SMR.[51] Participants noted the discomfort that standard SI/SMR causes patients and reported consciously choosing smaller collars or alternative positioning to avoid aggravating patients, choices that reflect an underlying tension between balancing the need to adhere to protocols with that of providing care to diverse patients in unpredictable situations.[51] The data collected in this study illustrate these patterns. The significant increase in the proportion of high-acuity patients implies that patients with minor injuries or low-risk MOIs have received SI/SMR less frequently over time. Among patients who are treated, low-acuity and assaulted patients are more likely to receive treatment with a collar only and alternative positioning, and elderly patients and female patients are both more likely to receive a no-neck cervical collar (Table 5). Reported reasons for nonstandard treatment from prior literature also reflect adaptations based on circumstance.[26]

To the extent that the attitudes of providers during a time of change affect treatment decisions, the results of this study are relevant to the prehospital treatment of potential spine injuries in general. The available studies on provider attitudes, while limited, signal-diverse and strong views to both past practice and new standards.[13,48,49] SMR principles have been widely adopted across jurisdictions,[3,4,52,53] and it is unlikely that documented attitudes are isolated to services that have published research or that changing patterns of treatment will not be found elsewhere. The possibility of inconsistent care raises patient- and system-oriented questions that deserve investigation. Are patients with injuries not receiving SI/SMR? Decreasing rates of treatment, where they exist, should be compared against outcomes at the level of individual patients to examine the possibility of missed injuries. Are patients, whether treated or not, experiencing harm? It is equally possible that changing rates of treatment reduce overtreatment of the noninjured without compromising patient safety. This scenario, which would continue a shift away from widespread SI, might reflect a silent and uncoordinated compensation for previous "surplus safety" described in other areas.[54] Finally, if changes in patterns of care are influenced by factors beyond protocols and guidelines, how do these changes propagate throughout a service? These data show that a change in documentation was associated with a brief but significant increase in treatment before returning to an underlying trend (Figure 2, Table 1). Future research might investigate this and other ways that provider attitudes, team dynamics, and service characteristics influence decision making and the application of clinical decision rules in an environment that has been described as nonlinear, complex, and dynamic.[55–58]

Limitations

A number of limitations apply to this study beyond those associated with a retrospective, observational design. Practice standards around SMR vary by jurisdiction, and not all practices described here will be relevant in other areas. Although overall data missingness was very low, a high proportion of cases did not report the MOI, limiting the interpretation of these findings. These data relate only to cases of treatment with spinal precautions; no data were collected on either trauma patients who were not treated (whether high or low acuity) or patients later diagnosed with traumatic spine injuries. Both of these groups would provide important complementary information about SMR practices and the accuracy of prehospital identification of injuries. Finally, these findings should be interpreted in the context of the base of evidence for SMR in general. The benefits and harms of SI/SMR have not been formally quantified in randomized clinical trials, and specific practices are not supported by high-level evidence. Current and future studies aiming to improve emergency treatment of potential spine injuries must address a range of inherent limitations in applying available evidence to practice.

CONCLUSIONS

This study describes a decreasing trend in SI/SMR treatment and evolving patient and practice characteristics in one North American emergency medical services agency. These patterns of care cannot be attributed solely to formal protocol changes. Similar patterns and their possible explanations should be investigated elsewhere; in this service, ongoing research will relate these findings to patient outcomes. The optimization of the treatment for potential spine injuries will depend on future studies that not only account for previously unmeasured influences on practice but also consider how guidelines are implemented and followed in frontline settings.

AUTHOR CONTRIBUTIONS

All authors developed this study and contributed to its completion. Neil McDonald developed the research question, organized the data extraction, evaluated the data quality, and analyzed the data under the supervision of Dean Kriellaars and Rob T. Pryce. All authors contributed to the preparation of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

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