Derivation of an emergency department-based clinical prediction tool to identify individuals at increased risk of chronic axial pain development after motor vehicle collision.

Andrey V. Bortsov, MD, PhD[1,2], William C. Miller, MD, PhD, MPH[3,4], April Soward, MPH[1,2], Robert A. Swor, MD[5], David A. Peak, MD[6], Jeffrey S. Jones, MD[7], Niels K. Rathlev, MD[8], David C. Lee, MD[9], Robert M. Domeier, MD[10], Phyllis L. Hendry, MD[11], Samuel A. McLean, MD, MPH[1,2,12]

[1]TRYUMPH Research Program; [2]Anesthesiology, University of North Carolina, Chapel Hill, NC; [3]School of Medicine, University of North Carolina, Chapel Hill, NC; [4]Gillings School of Public Health, University of North Carolina, Chapel Hill, NC [5]Emergency Medicine, William Beaumont Hospital, Royal Oak, MI; [6]Emergency Medicine, Massachusetts General Hospital, Boston, MA; [7]Emergency Medicine, Spectrum Health System, Grand Rapids, Michigan;[8]Emergency Medicine, Baystate Medical Center, Springfield, MA; [9]Emergency Medicine, North Shore University Hospital, Manhasset, NY; [10]Emergency Medicine, Saint Joseph Mercy Health System, Ypsilanti, MI; [11]Emergency Medicine, University of Florida, Jacksonville, FL; [12]Emergency Medicine, University of North Carolina, Chapel Hill, NC

TRYUMPH Research Program
UNC Department of Anesthesiology
Trauma Recovery: Understanding Mechanisms & Promoting Healing

INTRODUCTION

- More than 4 million Americans present to the emergency department (ED) each year after motor vehicle collision (MVC). More than 90% of these patients are discharged to home after ED evaluation.
- 20-40% of these discharged patients transition to chronic musculoskeletal pain (MSP), most commonly in the axial region (neck, shoulders, and/or back).[1,2]
- Often the ED visit is the only health care visit these patients have until chronic MSP takes root, making the ED one ideal setting in which to initiate interventions and/or refer high risk patients for more intensive interventions. Treatment based on risk stratification at the time of initial presentation has been shown to be efficacious and cost-effective in primary care settings.[3]
- Such risk stratification in the ED would require a prediction tool that (1) could be easily administered by care providers in the ED (2) would identify individuals at increased risk of chronic axial pain. The goal of this study was to derive such a tool using data from a recently completed prospective study.

MATERIALS AND METHODS

- Data was obtained from a prospective multisite study which included ED assessment (Table 1) and pain outcome assessments at 6 weeks, 6 months, and 1 year.[4]
- Chronic post-MVC axial MSP was defined as MVC-related MSP ≥ 4 (on a 0-10 NRS) in one or more axial body regions 6 weeks and 6 and/or 12 months after MVC.
- Logistic regression models initially included ED assessment items (Table 1) with significant bivariate associations, model reduction was performed by removing least significant predictors and checking subsequent model fit (Akaike Information Criterion, AIC) and model performance (Area Under the Receiver Operating Characteristic Curve, AUROCC, corrected for Harrel's model optimism) until AIC and AUC indicated substantial loss of model performance. *(Continued top, right column)*

Table 1. ED assessments from which prediction tool was derived.

| Questionnaire	# of questions
Demographics	5
Collision characteristics	4
Regional Pain Scale (ED)	20
Current somatic symptoms (adapted from the Rivermead Post-Concussive Symptom Questionnaire)	11
Past pain, Regional Pain Scale	20
Past somatic symptoms	21
Peritraumatic Distress Inventory	13
Center for Epidemiological Studies Depression (CESD) Scale	20
SF-12 Health Survey	12
Trait anxiety and anger (State Trait Personality Inventory (STPI))	20
Michigan Critical Events Perception Scale	5
Trait optimism (Life Orientation Test Revised)	10
Pain Catastrophizing Scale	13
Miscellaneous questions*	24
Total number of questions (variables)	**198**

Table 4. Screening cutoffs for the developed prediction models

Probability cutoff	Proportion screened in	Sensitivity	Specificity	PPV
Females				
0.2	0.67	0.91	0.48	0.48
0.3	0.49	0.81	0.69	0.58
0.4	0.39	0.71	0.79	0.65
0.5	0.32	0.63	0.86	0.7
0.6	0.22	0.47	0.92	0.77
0.7	0.13	0.3	0.97	0.83
0.8	0.07	0.19	0.99	0.94
Males				
0.2	0.57	0.86	0.56	0.51
0.3	0.43	0.77	0.73	0.6
0.4	0.29	0.6	0.85	0.69
0.5	0.22	0.5	0.91	0.75
0.6	0.15	0.4	0.96	0.85
0.7	0.11	0.33	0.99	0.97
0.8	0.06	0.2	1	1

Table 2. Model selection results for Males (n=275)

|	Males Only
1	How long do you think it takes for a person to physically recover from the kind of accident you just had? (Days)
2	How did you feel during or after your motor vehicle accident?: "It was if I were watching myself" (1=Strongly agree; 5=Strongly disagree)
3	Which statement best describes your feeling about the accident? (0=My fault; 1=Another person's fault; 0=Nobody's fault)
4	Do you have this thought or feeling when you are experiencing pain?: "There is nothing I can do to reduce the intensity of the pain" (0=Not at all; 1=Slight degree; 2=Moderate degree; 3=Great degree; 4=All the time)
5	BMI (Your weight in pounds, Your height in inches)
6	Do you agree with the following statement?: "I'm always optimistic about my future" (0=Strongly agree; 4=Strongly disagree)
7	On a scale of zero to ten, where zero means no pain and ten equals pain as severe as it could possibly be, what is the intensity of your pain right now, considering any or all of your pains together?
8	How much low back pain do you have right now? (0-10 scale)
9	"I had the feeling I was about to lose control of my emotions"(0=Not true; 1=Slightly true; 2=Somewhat true; 3=Very true; 4=Extremely true)
10	Your age in years
11	During the past four weeks, how much of the time have you had any of the following problems with your work or other regular daily activities *as a result of your physical health*? "Accomplished less than you would like" (1=All the time; 2=Most of time; 3=Some of time; 4=Little of time; 5=None of time)

Figure 1. Receiver-operator characteristic (ROC) curves and calibration curves for selected models for males

AUC=0.80
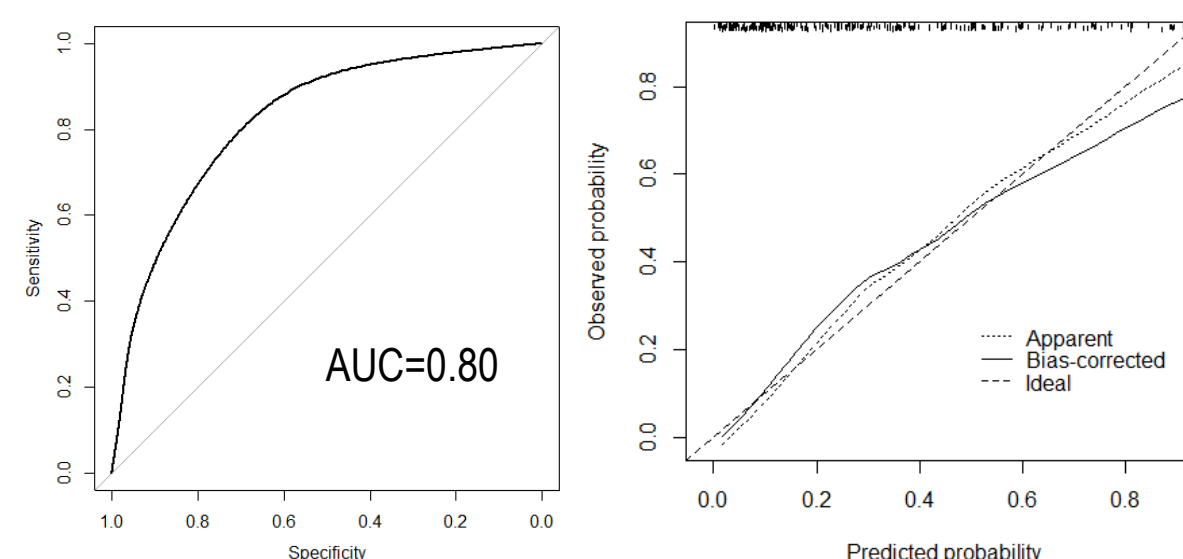
Table 3. Model selection results for Females (n=518)

	Females Only
1	How long do you think it takes for a person to physically recover from the kind of accident you just had? (Days)
2	How did you feel during or after your motor vehicle accident?: "It was if I were watching myself" (1=Strongly agree; 5=Strongly disagree)
3	Which statement best describes your feeling about the accident? (0=My fault; 1=Another person's fault; 0=Nobody's fault)
4	Do you have this thought or feeling when you are experiencing pain?: "There is nothing I can do to reduce the intensity of the pain" (0=Not at all; 1=Slight degree; 2=Moderate degree; 3=Great degree; 4=All the time)
5	BMI (Your weight in pounds, Your height in inches)
6	Do you agree with the following statement?: "I'm always optimistic about my future" (0=Strongly agree; 4=Strongly disagree)
7	On a scale of zero to ten, where zero means no pain and ten equals pain as severe as it could possibly be, what is the intensity of your pain right now, considering any or all of your pains together?
8	How much neck pain do you have right now? (0-10 scale)
9	"I felt as if the events around the accident were happening to someone else" (1=Strongly agree; 5=Strongly disagree)
10	Have you ever had problems with back pain in the past? (0=No; 1=Yes)
11	Pain or tenderness in the head during the past month (0-10 scale)

Figure 2. Receiver-operator characteristic (ROC) curves and calibration curves for selected models for females

AUC=0.80
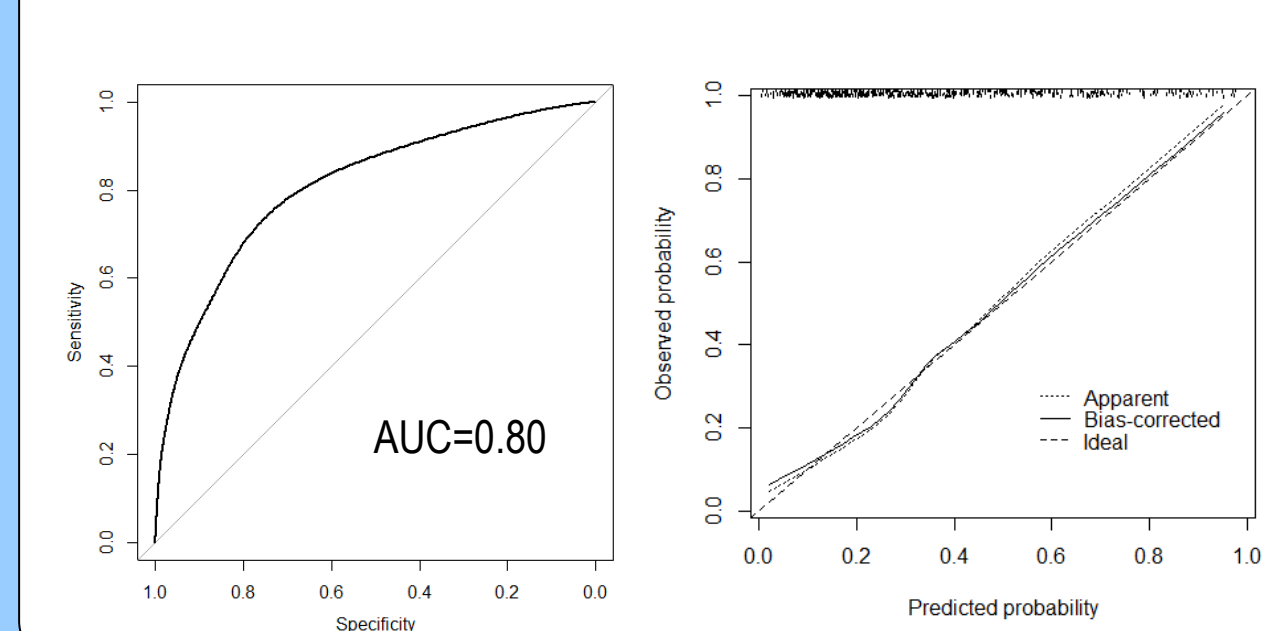
- Reduced model predictive utility (AUROCC) corrected for model overfitting and model calibration were assessed via bootstrap using *rms* and *Hmisc* packages (R software version 3.0.1).

RESULTS

- Chronic post-MVC axial MSP was present in 295/792 (37%) of participants (mean age 36 (13), 518/792 (65%) female.
- Initial modeling identified substantial differences in predictors (interactions) by sex, thus separate models were developed for men and women.
- Final reduced models for men and women had 11 predictors each and are displayed in Tables 2 and 3.
- Both tools demonstrated good discrimination and calibration (Figures 1-2).
- Table 4 displays tool sensitivity, specificity, and positive predictive value at different probability cutoffs.
- A web-based version of the tool is available: http://www.med.unc.edu/anesthesiology/research/tryumph-research-group/pain_prediction.html
- This tool may be used for validation testing or other research purposes and allows the user to set the desired probability threshold.
- The tool stops when sufficient information has been entered to determine allocation, all questions do not generally have to be answered.

CONCLUSION

- This ED-based tool evaluates the risk of chronic axial pain after MVC and has good initial discrimination and calibration. Further refinement and validation of the tool are necessary.

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