A Blood Loss Assessment and Stabilization Tool (BLAST) to Predict Blood Product Receipt Using Prehospital Data in Combat Settings

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Introduction

- Hemorrhage remains a leading cause of potentially survivable death in civilian and military trauma systems.
- Early recognition of patients likely to receive blood before hospital arrival remains challenging and inconsistent across echelons of care.
- Routinely collected prehospital physiology and injury data may support scalable decision tools for early transfusion planning.

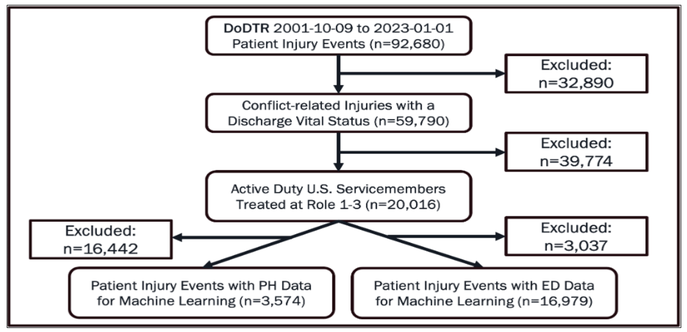
Objectives

- **Aim 1**: Identify prehospital physiologic and injury-based predictors associated with documented blood product receipt in combat casualties.
- **Aim 2**: Develop and compare interpretable and statistical prediction models for blood product receipt using DoDTR data.
- **Aim 3**: Evaluate whether BLAST could support earlier transfusion decision-making, triage, and resource allocation in austere settings.

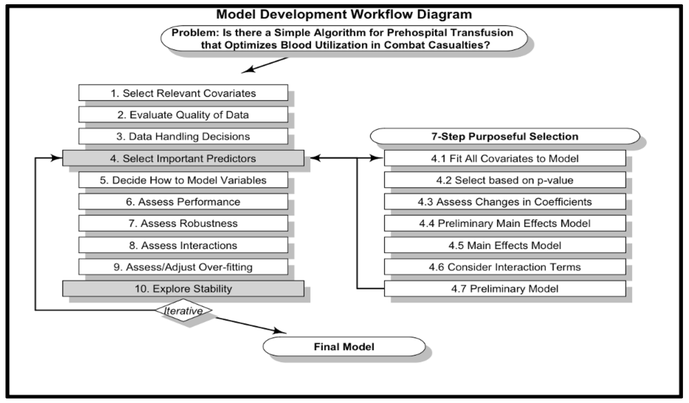
Methods

- Combat-injured U.S. service members with prehospital or Role 2/3 emergency department vital signs were identified from DoDTR.
- Candidate predictors included blood pressure, heart rate, shock index, mechanism, injury type, and AIS-derived regional injury flags.
- Fast & Frugal Trees and multivariable logistic regression were evaluated using discrimination, calibration, threshold optimization, and validation analyses.
- Models were trained and tested using stratified data partitions to preserve blood product receipt prevalence across cohorts.
- Performance was assessed with ROC-AUC, precision–recall curves, sensitivity, specificity, balanced accuracy, and calibration plots.

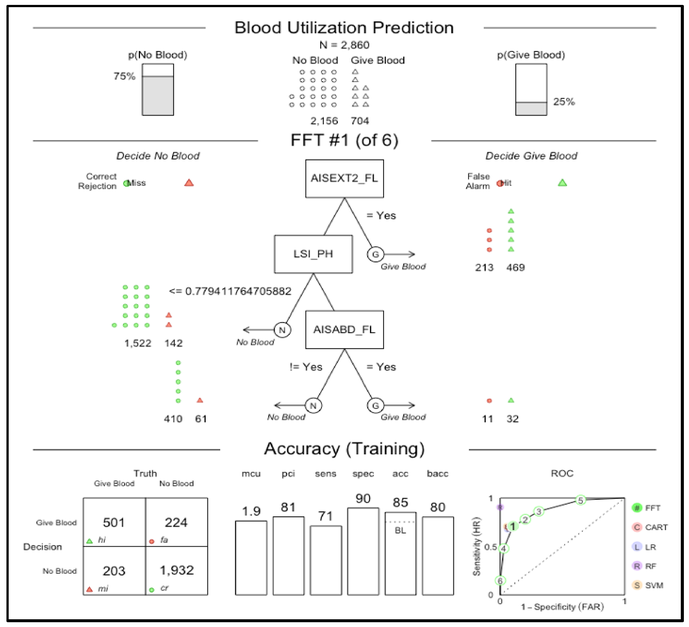
Results



Final inclusion analysis resulted in Pre and Hospital cohorts



Novel 10 step model workflow diagram



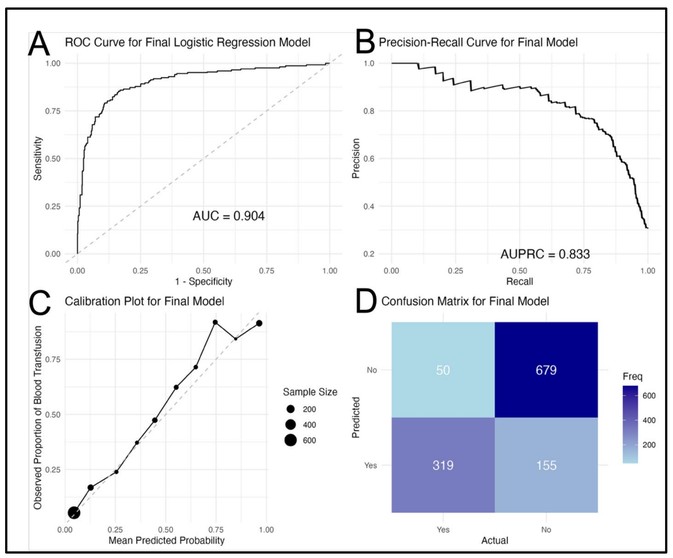
PH FFT shows performance in the high 70's

Parameter	Prehospital (PH) No Bood (N=2694)	Prehospital (PH) Blood Given (N=880)	p value	Emergency Department (ED) No Bood (N=13642)	Emergency Department (ED) Blood Given (N=3337)	p value
Lowest Systolic Blood Pressure	128.6 (18.6)	119.8 (23.4)	< 0.001	131.3 (17.3)	115.8 (26.2)	< 0.001
Lowest Diastolic Blood Pressure	74.3 (15.0)	67.0 (15.9)	< 0.001	71.4 (13.5)	64.0 (18.7)	< 0.001
Highest Heart Rate	88.3 (18.0)	103.3 (23.1)	< 0.001	88.4 (17.9)	109.7 (26.3)	< 0.001
Shock Index Flag (>0.9)	192 (7.1%)	294 (33.4%)	< 0.001	746 (5.5%)	1277 (38.3%)	< 0.001
Dominant Injury Type			< 0.001			< 0.001
- Blunt	1261 (46.8%)	150 (17.0%)		7400 (54.2%)	1064 (31.9%)	
- Penetrating	1433 (53.2%)	730 (83.0%)		6242 (45.8%)	2273 (68.1%)	
Primary MOI			0.002			< 0.001
- Bullet/GSW/Firearm/Knife	560 (20.8%)	227 (25.8%)		2416 (17.7%)	763 (22.9%)	
- Explosives	2134 (79.2%)	653 (74.2%)		11226 (82.3%)	2574 (77.1%)	
MAIS >1, Head Flag	661 (24.5%)	151 (17.2%)	< 0.001	2870 (21.0%)	646 (19.4%)	0.032
MAIS >1, Thoracic Flag	141 (5.2%)	257 (29.2%)	< 0.001	737 (5.4%)	892 (26.7%)	< 0.001
MAIS >1, Abdominal Flag	74 (2.7%)	279 (31.7%)	< 0.001	430 (3.2%)	984 (29.5%)	< 0.001
MAIS >2, Extremity Flag	273 (10.1%)	288 (32.7%)	< 0.001	1523 (11.2%)	2059 (61.7%)	< 0.001
Amputation Flag	24 (0.9%)	291 (33.1%)	< 0.001	164 (1.2%)	850 (25.5%)	< 0.001

GSW = Gunshot Wound, MAIS = Maximum Abbreviated Injury Score, MOI = Mechanism of Injury.
Amputation defined as any traumatic amputation (AIS-based), without proximal/distal distinction.

Parameter	Prehospital (PH) OR	Prehospital (PH) 95% CI	Prehospital (PH) p value	Emergency Department (ED) OR	Emergency Department (ED) 95% CI	Emergency Department (ED) p value
Lowest Systolic Blood Pressure	1.01	1.00, 1.01	0.200	0.98	0.98, 0.99	<0.001
Lowest Diastolic Blood Pressure	0.98	0.97, 0.99	<0.001			
Highest Heart Rate (HHR)	1.01	1.01, 1.02	0.007	1.02	1.02, 1.03	<0.001
Shock Index	6.45	2.15, 19.9	0.001	2.71	1.86, 3.98	<0.001
Dominant Injury Type, Penetrating	3.35	2.48, 4.55	<0.001	2.11	1.87, 2.39	<0.001
MAIS >1, Thoracic Flag	6.10	4.36, 8.57	<0.001	5.01	4.26, 5.89	<0.001
MAIS >1, Abdominal Flag	9.24	6.32, 13.7	<0.001	6.53	5.48, 7.81	<0.001
MAIS >2, Extremity Flag	16.4	12.6, 21.5	<0.001	10.6	9.33, 12.0	<0.001
MAIS >1, Head Flag	1.98	1.41, 2.77	<0.001	2.16	1.85, 2.52	<0.001
Assessments:						
McFadden R^2		0.46			0.41	
Nagelkerke R^2		0.60			0.53	
ROC-AUC		0.90			0.89	
AUPRC		0.83			0.79	
Accuracy		0.83 (0.81, 0.85)			0.83 (0.82, 0.84)	
Sensitivity		0.86			0.79	
Specificity		0.81			0.84	
Positive Predictive Value		0.67			0.62	
Negative Predictive Value		0.93			0.93	
Balanced Accuracy		0.84			0.82	
Kappa		0.63			0.58	

Abbreviations: AUPRC: Area Under Precision-Recall Curve, CI = Confidence Interval, MAIS = Maximum Abbreviated Injury Score, MOI = Mechanism of Injury, OR = Odds Ratio, ROC-AUC = Receiver Operator Curve – Area Under the Curve; Baseline for Injury Type is Bullet/Gunshot Wound/Firearm/Knife. Baseline for MOI.



PH AUC in the high 80's with strong probability of prediction

Conclusions

- Prehospital vital signs and anatomic injury patterns strongly predicted documented blood product receipt in combat casualties.
- Shock index, thoracic injury, abdominal injury, and extremity injury were among the strongest predictors of transfusion.
- Logistic regression demonstrated strong discrimination, while Fast & Frugal Trees provided transparent rule-based logic for field use.
- BLAST may help translate limited prehospital data into actionable transfusion guidance during austere or chaotic care.
- Future work should prospectively validate BLAST using real-time medic-observable inputs and clinically meaningful transfusion endpoints.
- Integration into prehospital reporting systems could improve handoff communication and help receiving teams anticipate transfusion needs.
- BLAST may also incentivize better point-of-injury documentation by returning direct clinical value to medics.

Acknowledgements

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References

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