Supplementary Information

Prompts

Prompt for Severity Assessment	
system_prompt	You are an emergency medicine expert. Analyze patient data to assess severity of illness.
user_prompt	Analyze the following patient data to assess the severity of illness: Demographics: {demographics} Conditions: {conditions} Drugs: {} Measurements: {} Observations: {} Procedures: {} Notes: {} Provide: 1. Severity Level: (Critical/Moderate/Low) 2. Summary: Brief clinical summary of key findings 3. Risk Factors: List key factors that increase risk of ED return visits that lead to hospital admissions Format your response as: Severity Level: [level] Summary: [summary] Risk Factors: [list of factors]

Prompt for RVA Prediction	
system_prompt	You are an expert in emergency medicine and predictive risk assessment. You will receive comprehensive details of a patient's emergency department (ED) visit that ended in discharge along with patient demographics, medical history, and prior healthcare utilization data. Your task is to evaluate this information and determine whether the patient will (i) return to the ED within 9 days of discharge and (ii) subsequently be admitted to the hospital following that return ED visit. This is called return visit admission (RVA). Base your judgment strictly on the provided data. If making a prediction, respond exactly as instructed in the user prompt without adding extra commentary. A prior knowledge is that RVA is pretty rare in practice.
user_prompt	You are provided with comprehensive, processed details of a patient's emergency department (ED) visit that resulted in discharge. The data may include: demographics, diagnoses, devices, medications, measurements, observations, procedures, and clinical notes.

	A prior knowledge is that RVA is pretty rare in practice. Here are examples to guide your prediction: POSITIVE EXAMPLES (Readmitted within 9 days): Example 1: Demographics: {demographics} Severity Assessment: {severity_summary}) Key Conditions: {conditions} Key Medications: {medications} Key Measurements: {measurements} Key Observations: {observations} Key Procedures: {procedures} Outcome: Yes (readmitted) Example 2: …… NEGATIVE EXAMPLES (Not readmitted within 9 days): Example 1: Demographics: {demographics} Severity Assessment: {severity_summary}) Key Conditions: {conditions} Key Medications: {medications} Key Measurements: {measurements} Key Observations: {observations} Key Procedures: {procedures} Outcome: No (not readmitted) Example 2: …… Now, based on these examples and the following patient data, predict whether the patient will return to the ED within {self.rva_interval_days} days of discharge and be admitted to inpatient care at the end of that ED evaluation. Use your clinical reasoning to weigh risk factors. Do not request additional information. Based solely on this information, respond with: - "Yes" if ED return visits that lead to hospital admissions is likely - "No" if ED return visits that lead to hospital admissions is unlikely - "I don't know" if insufficient information Respond with only one word: Yes/No/I don't know

Note classes

In our dataset, there are following classes of notes used for predicting RVA:

Addendum Document, Evaluation and management, Timeout to verify correct patient, correct site, and correct procedure, documented (PATH), Transfer of care, Report, History and physical, Assessment, Procedure note, Care provider notes, Behavioral health, Chart review by physician, Nurse, Emergency

department Note, Operation note, Hospital course Narrative, Consults, Nursing notes, Mini-Mental Status Examination, Disposition, Order, Event, Discharge note, Note, Encounter note, Care plan, Procedure, Group counseling, Triage note, Progress

Table S1. Note class percentage summary at WCM

Note Class	All %	RVA=0 %	RVA=1 %
Order	45.96	46.00	43.00
Care provider notes	23.02	23.05	20.99
Triage note	10.14	10.15	9.94
Progress	5.55	5.53	7.06
Mini-Mental Status Examination	4.10	4.11	3.78
Emergency department Note	4.04	4.01	6.16
Procedure note	2.63	2.64	1.99
Consults	2.10	2.09	2.84
Encounter note	0.76	0.75	1.15
Behavioral health	0.26	0.26	0.33
Disposition	0.22	0.22	0.50
History and physical	0.22	0.22	0.34
Assessment	0.22	0.21	0.46
Nursing notes	0.13	0.13	0.20
Event	0.12	0.12	0.23
Discharge note	0.10	0.10	0.16
Evaluation and management	0.06	0.06	0.04
Transfer of care	0.05	0.05	0.23
Report	0.05	0.05	0.22
Timeout to verify correct patient, correct site, and correct procedure, documented (PATH)	0.04	0.04	0.04
Addendum Document	0.04	0.04	0.05

Nurse	0.04	0.04	0.09
Note	0.04	0.04	0.02
Care plan	0.03	0.03	0.11
Operation note	0.02	0.02	0.01
Procedure	0.01	0.01	0.01
Group counseling	0.01	0.01	0.00
Chart review by physician	0.01	0.01	0.02
Hospital course Narrative	0.01	0.01	0.02

Table S2. Percentage of visits having each note class at WCM

Note Class	All Visit %	RVA=0 Visit %	RVA=1 Visit %	Note %
Care provider notes	99.08	99.08	98.88	23.02
Order	67.60	67.54	71.77	45.96
Triage note	63.31	63.24	69.21	10.14
Mini-Mental Status Examination	25.97	25.96	26.62	4.10
Progress	22.07	21.97	29.99	5.55
Emergency department Note	19.28	19.15	29.75	4.04
Procedure note	14.44	14.46	13.15	2.63
Consults	11.49	11.43	16.76	2.10
Encounter note	3.93	3.90	6.50	0.76
Disposition	1.37	1.35	3.37	0.22
Assessment	1.34	1.32	3.21	0.22
History and physical	1.21	1.20	2.09	0.22
Behavioral health	0.87	0.86	1.04	0.26
Nursing notes	0.76	0.75	1.12	0.13
Event	0.74	0.73	1.60	0.12
Discharge note	0.54	0.54	0.96	0.10
Transfer of care	0.32	0.30	1.44	0.05

Timeout to verify correct patient, correct site, and correct procedure, documented (PATH)	0.28	0.28	0.32	0.04
Report	0.28	0.26	1.20	0.05
Evaluation and management	0.26	0.26	0.32	0.06
Note	0.22	0.22	0.16	0.04
Addendum Document	0.22	0.22	0.40	0.04
Nurse	0.13	0.13	0.40	0.04
Care plan	0.10	0.10	0.64	0.03
Procedure	0.07	0.07	0.08	0.01
Operation note	0.07	0.07	0.08	0.02
Chart review by physician	0.05	0.05	0.08	0.01
Hospital course Narrative	0.05	0.05	0.16	0.01
Group counseling	0.01	0.01	0.00	0.01

Embedding and Contrastive Learning

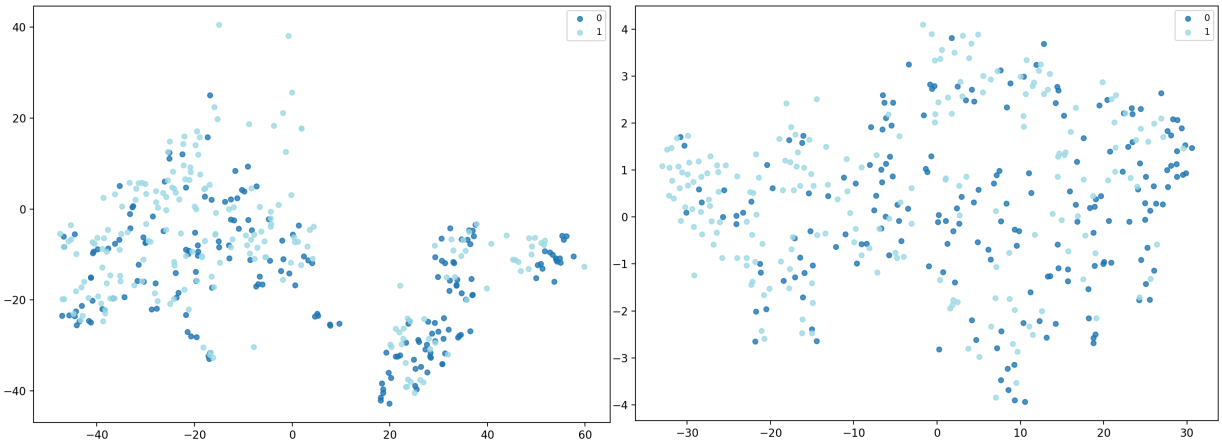

Figure S1. Plot of 500 RVA and non-RVA cases each embedded by bert-base-uncased and projected to 2-D space. Left is pure embedding, right is results using contrastive learning (WCM).

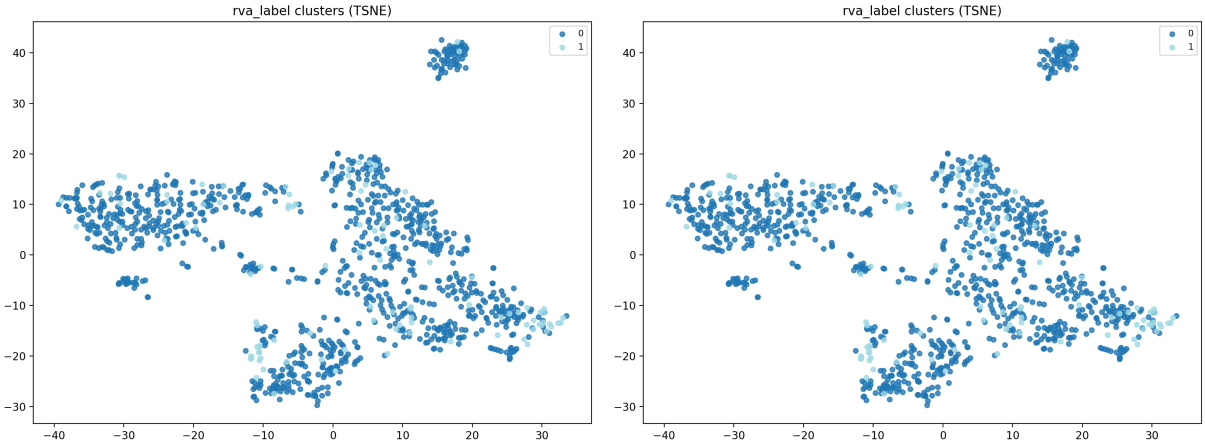

Figure S2. Plot of 1000 RVA and non-RVA cases each embedded by bert-base-uncased and projected to 2-D space. Left is pure embedding, right is results using contrastive learning (VUMC).

Table S3. Prediction performance at VUMC

Category	Method	AUC (95% CI)	Sensitivity	Specificity	Positive Likelihood Ratio
	Logistic Regression+structured data (80% training)	0.799 (0.755-0.925)	0.667	0.836	4.06
	DICE	0.635 (0.620 – 0.723)	0.833	0.599	2.079
Traditional ML baseline & additional embeddings?	CatBoost+structured data (80% training)	0.689 (0.604-0.863)	0.439	0.906	4.67
	CatBoost+embedding+structured data +notes	0.765 (0.740-0.790)	0.678	0.841	4.264
	CatBoost+embedding+structured data +severity assessment (GPT-5 Mini)	0.677 (0.657-0.697)	0.781	0.579	1.855
	CatBoost+embedding+structured data +severity assessment (Qwen)	0.656 (0.631-0.682)	0.693	0.638	1.914
Baseline	ZS-Disposition baseline (GPT-5 Mini)	0.610 (0.554 - 0.652)	0.354	0.901	3.568
	ZS-Disposition Baseline (Qwen)	0.643 (0.587 - 0.698)	0.938	0.127	1.073

Ablation study for severity assessment	GPT-5 Mini+structured data	0.591 (0.547 - 0.635)	0.042	0.993	5.8
	GPT-5 Mini+notes	0.703 (0.652 - 0.754)	0.094	0.990	9.487
	GPT-5 Mini+structured data+notes	0.722 (0.674 - 0.77)	0.135	0.990	12.967
	GPT-5 Mini+structured data+severity assessment(zero shot)	0.789 (0.744 - 0.835)	0.510	0.875	4.083
	GPT-5 Mini+structured data+severity assessment(one shot)	0.769 (0.721 - 0.817)	0.563	0.838	3.481
	GPT-5 Mini+structured data+severity assessment(two shot)	0.769 (0.726 - 0.811)	0.552	0.815	2.978
	GPT-5 Mini+structured data+severity assessment(three shot)	0.758 (0.707 - 0.809)	0.604	0.792	2.911
	Qwen+structured data+severity assessment(zero shot)	0.730 (0.683 - 0.777)	0.604	0.753	2.449
	Qwen+structured data+severity assessment(one shot)	0.684 (0.633 - 0.735)	0.688	0.565	1.579
	Qwen+structured data+severity assessment(two shot)	0.684 (0.634 - 0.733)	0.792	0.528	1.679
	Qwen+structured data+severity assessment(three shot)	0.667 (0.617 - 0.717)	0.729	0.514	1.5

Table S4. Prediction performance at WCM

Category	**Method**	**AUC (95% CI)**	**Sensitivity**	**Specificity**	**Positive Likelihood Ratio**
	Logistic Regression+structured data (80% training)	0.691 (0.655-0.727)	0.633	0.676	1.956
	DICE	0.674 (0.641-0.707)	0.680	0.636	1.869
Traditional ML baseline & additional embeddings?	CatBoost+structured data (80% training)	0.723 (0.693-0.753)	0.745	0.594	1.836
	CatBoost+embedding+structured data +notes	0.666 (0.659-0.672)	0.611	0.662	1.852
	CatBoost+embedding+structured data +severity assessment (Gemini)	0.720 (0.714-0.726)	0.666	0.682	2.138

	CatBoost+embedding+structured data +severity assessment (Qwen)	0.712 (0.707-0.717)	0.693	0.638	1.942
Baseline	ZS-Disposition baseline (Gemini)	0.672 (0.658-0.687)	0.866	0.368	1.369
	ZS-Disposition Baseline (Qwen)	0.662 (0.646-0.679)	0.966	0.067	1.036
Ablation study for severity assessment	Gemini+structured data	0.551 (0.537-0.565)	0.018	0.994	2.937
	Gemini+notes	0.645 (0.630-0.660)	0.144	0.965	4.131
	Gemini+structured data+notes	0.675 (0.661-0.689)	0.136	0.963	3.710
	Gemini+structured data+severity assessment(zero shot)	0.703 (0.686-0.720)	0.570	0.779	2.584
	Gemini+structured data+severity assessment(one shot)	0.733 (0.718-0.748)	0.697	0.687	2.225
	Gemini+structured data+severity assessment(two shot)	0.738 (0.723-0.752)	0.704	0.677	2.178
	Gemini+structured data+severity assessment(three shot)	0.746 (0.732-0.760)	0.737	0.660	2.168
	Qwen+structured data+severity assessment(zero shot)	0.683 (0.666-0.699)	0.512	0.784	2.365
	Qwen+structured data+severity assessment(one shot)	0.712 (0.698-0.726)	0.733	0.578	1.736
	Qwen+structured data+severity assessment(two shot)	0.706 (0.692-0.720)	0.735	0.567	1.695
	Qwen+structured data+severity assessment(three shot)	0.713 (0.699-0.727)	0.768	0.548	1.698