Finding Causal Impacts of Social Determinants of Mental Health on Opioid Use Disorder from Clinical Notes

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Introduction

Opioid Epidemic:
- Over 645,000 deaths since the 1990s
- 75% of 107,000 overdose deaths in 2022 involved opioids

Objective: Investigating the role of Sociocultural Factors of Mental Health (SFOMHs) in OUD from clinical notes.

Challenges

Complex Interconnections:
- Linked to social inequalities and generational health issues.

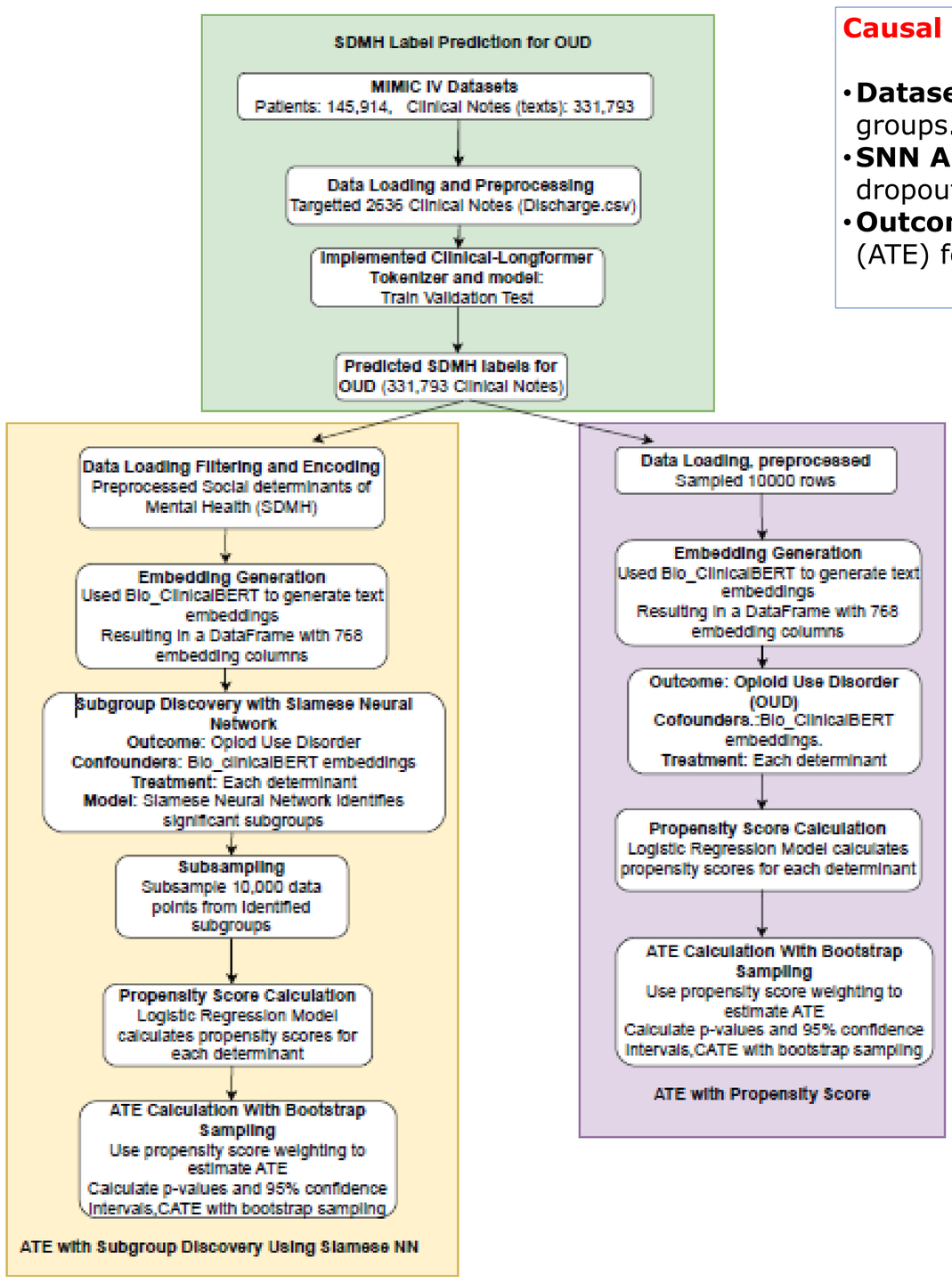
Complex Interactions:
- unemployment, housing instability

Data Limitations:
- Challenges in extracting SFOMHs from Electronic Health Records (EHR) and the limitations of LLMs (large language models) in medical applications.

Proposed Framework

Model Approach:
- **MMCL Model:** Detects and classifies SFOMHs.
- **SNN Model:** Identifies causal effects of SFOMHs on OUD.
- **New Dataset:** SFOMH-OUD-Clinic dataset created for evaluation.

Methodology:
Subgroup discovery and causal inference using Clinical-Longformer embeddings.



Overview of Social determinant of Mental Health(SDMHs) prediction for OUD and Causal inference estimates and methods for obtaining them.

Algorithm 1 Siamese Neural Network(SNN) based Subgroup Discovery

Input: Data $\mathcal{D} = \{(X_i, T_i, Y_i)\}_{i=1}^{n}$, hidden dimension h, dropout probability p, epochs e, threshold k
Output: Identified subgroup $\mathcal{S}$
Split $\mathcal{D}$ into treatment group $\mathcal{D}_1$ and control group $\mathcal{D}_0$
Create Siamese Neural Network(SNN) model
Train SNN with $\mathcal{D}_0$ and $\mathcal{D}_1$ for e epochs
Predict outcomes $\hat{Y}_0$ and $\hat{Y}_1$ for control and treatment groups, respectively
Calculate conditional average treatment effects $\text{CATE}_i = \hat{Y}_1 - \hat{Y}_0$
Identify subgroup $\mathcal{S} = \{(X_i, T_i, Y_i) \mid \text{CATE}_i > k\}$
return $\mathcal{S}$

Results

- **SNN Discovery:** Significant causal effects on healthcare handover, obstacles to medical care, and financial uncertainty.
- **Validation with Negative Controls:** Ensures the model's robustness and consistency.
- **Model Performance:** SNN-based discovery results in better precision and identification of significant causal effects.

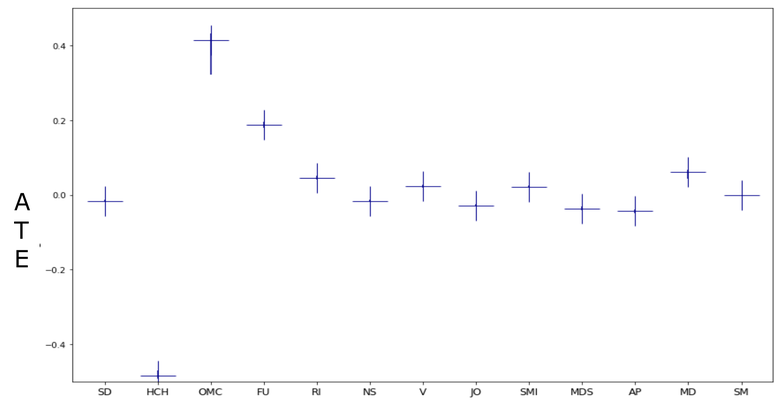
Causal Inference Methodology

- **Dataset Segmentation:** Separation of treatment/control groups.
- **SNN Architecture:** Uses a dual-network structure and dropout layers to prevent overfitting.
- **Outcome Estimation**: Identifies Average Treatment Effect (ATE) for subgroup analysis.

Model Performance Metrics

Model	Metric	T1	T2	T3
Clinical-Longformer	Acc	99.00	95.82	96.29
	F1	98.99	95.68	95.41
	Prec	99.02	95.85	96.03
	Recall	98.97	95.80	94.81

Average Treatment Effect on Social Determinants of Mental Health (SDMHs) with 95% Confidence Intervals with Siamese Neural Network(SNN)-based Subgroup Discovery



Causal Inference Results for Social Determinants of Mental Health for Opioid Use Disorder without and with using Siamese Neural Network(SNN)-based Subgroup Discovery (p<0.05=*)

SFOMHs	Correlation Coefficient	Without SNN					With SNN				
		Treated Sample Size	Untreated Sample Size	ATE	95% CI Lower	95% CI Upper	Treated Sample Size	Untreated Sample Size	ATE	95% CI Lower	95% CI Upper
SD	-0.02	3	9997	0.007094	0.007094	0.007094	4985	5015	-0.01587*	-0.01885	-0.01312
HCH	-0.47*	9905	95	0.032744*	0.032744	0.032744	4980	5020	-0.48389*	-0.4931	-0.4702
OMC	0.29*	27	9973	0.007259*	0.007259	0.007259	5100	4900	0.413967*	0.322766	0.4333
FU	-0.01	83	9917	0.00601*	0.00601	0.00601	5034	4966	0.187476*	0.179297	0.196402
RI	0.01	4966	5034	-0.001046	-0.05715	0.0562548	4984	5016	0.045997*	0.040655	0.051002
NS	-0.02	1	9999	0.008548	0.008548	0.008548	5015	4985	-0.015945*	-0.0184	-0.0134
V	-0.02	48	9952	0.008842*	0.008842	0.008842	4966	5034	0.023299*	-0.0186	0.027902
JO	0.05	4503	5497	0.016091*	0.016091	0.016091	4967	5033	-0.027919*	-0.0314	-0.024297
SMI	-0.10*	7735	2265	-0.01734*	-0.01734	-0.01734	4964	5036	0.021832*	0.019097	0.024802
MDS	0.03	9910	90	0.008605*	0.008605	0.008605	5045	4955	-0.03695*	-0.0419	-0.0319
AP	0.18*	8569	1431	0.071611*	0.071611	0.071611	5017	4983	-0.043365*	-0.0485	-0.0384
MD	0.34*	2372	7628	-0.01734*	-0.01734	-0.01734	5095	4905	0.060525*	0.044121	0.0665
SM	-0.45*	9375	625	-0.01598*	-0.01598	-0.01598	4984	5016	-0.16492*	-0.1725	-0.157

Negative Control Analysis

NCD	Treated Sample Size	Untreated Sample Size	ATE	95% CI Lower	95% CI Upper
EHA	4985	5015	-2.98E-05	-0.00277	0.00268
NSTOP	5000	5000	0.0354945	0.020837	0.048788

Conclusion & Implications

- **Key Findings:** SFOMHs significantly influence OUD outcomes.
- **Public Health Impact:** Insights guide preventive interventions and tailored treatments for OUD patients.