



Use of a Machine Learning Model to Classify Subtypes of Mild Traumatic Brain Injury for Suicide Risk Detection in Combat Veterans: A LIMBIC-CENC study



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Introduction

- Recent studies show suicide rates are higher in veterans than in the total population.
 - As of 2023, veteran suicide rate reported was 35.2 per 100,000 veterans.
 - Suicide rates for veterans with a TBI diagnosis were 77.6 per 100,000.
- Suicide is a complex issue that is exacerbated by traumatic brain injury (TBI).
- Mild TBI is significantly associated with higher mental health burden that can lead to greater risk for suicide.
- Veterans and service members are at greater risk for TBI.
 - Over 185,000 veterans have been diagnosed with at least one TBI.

Objective: Investigate the association between machine learning (ML) derived clusters of mild TBI and suicide ideation (SI), even after controlling for sociodemographic, behavioral and neurological covariates.

Methods

Participants: Combat veterans (n=2,948) with a history of no more severe than mild TBI completed LIMBIC-CENC baseline and follow up visits.

Outcome Measure

- SI was measured by item 9 in the PHQ-9:
 - “Thoughts that you would be better off dead or of hurting yourself in some way.”

Covariates

- **PHQ-9:** Severity of depressive symptom burden.
- **PCL-5:** Severity of PTSD symptom burden.
- **DRRI-2 Combat:** Combat exposure during deployment.
- **DRRI-2 Social Support:** Perceived social support during deployment.
- **PSQI:** Sleep quality.
- **AUDIT-C:** Alcohol misuse.
- **Demographics:** Age, sex, race/ethnicity, education, marital status, and health insurance status.

- **NSI:** Neurobehavioral symptom burden
- **TBI-QOL:** Functioning, pain, anxiety, resilience, and social aspects of quality of life.
- **Vital signs:** BMI, blood pressure, heart rate
- **Lab results:** Testosterone, TSH, IGF-1
- **Neuropsychological tests:** Working memory, verbal memory, executive functioning, processing speed.
- **Head Injury:** Positive TBI exposure and post-concussive event exposure to include blast.

Analysis:

- K-prototypes unsupervised clustering algorithm classified mild TBI clusters using baseline sociodemographic and neurobehavioral data without considering specific outcomes.
- Multivariable logistic regression to test the association between cluster membership and SI outcome.
- All analyses were run in R 4.4.2.

Results

Table 1. Demographics for Sample

Variable	(N=2948; %)
Biological Sex	
Male	2582 (87.6%)
Female	366 (12.4%)
Age	
Mean (SD)	43.4 (10.8)
Median [Min, Max]	42.0 [22.0, 83.0]
Ethnicity	
Not Hispanic or Latino	2447 (83.0%)
Hispanic or Latino	501 (17.0%)

Variable	(N=2948; %)
Race/Ethnicity	
American Indian/Alaska Native	42 (1.4%)
Asian	56 (1.9%)
Black	520 (17.6%)
Other	176 (6.0%)
Pacific Islander	24 (0.8%)
White	2130 (72.3%)
Health Insurance Coverage	
No	202 (6.9%)
Yes	2746 (93.1%)

Variable	(N=2948; %)
Education	
High school or GED	339 (11.5%)
Some college	1126 (38.2%)
Bachelor's degree or higher	1483 (50.3%)
Marital Status	
Never married	396 (13.4%)
Member of unmarried couple	48 (1.6%)
Married	1816 (61.6%)
Separated	123 (4.2%)
Divorced	545 (18.5%)
Widowed	20 (0.7%)

Figure 1. Analysis Plan

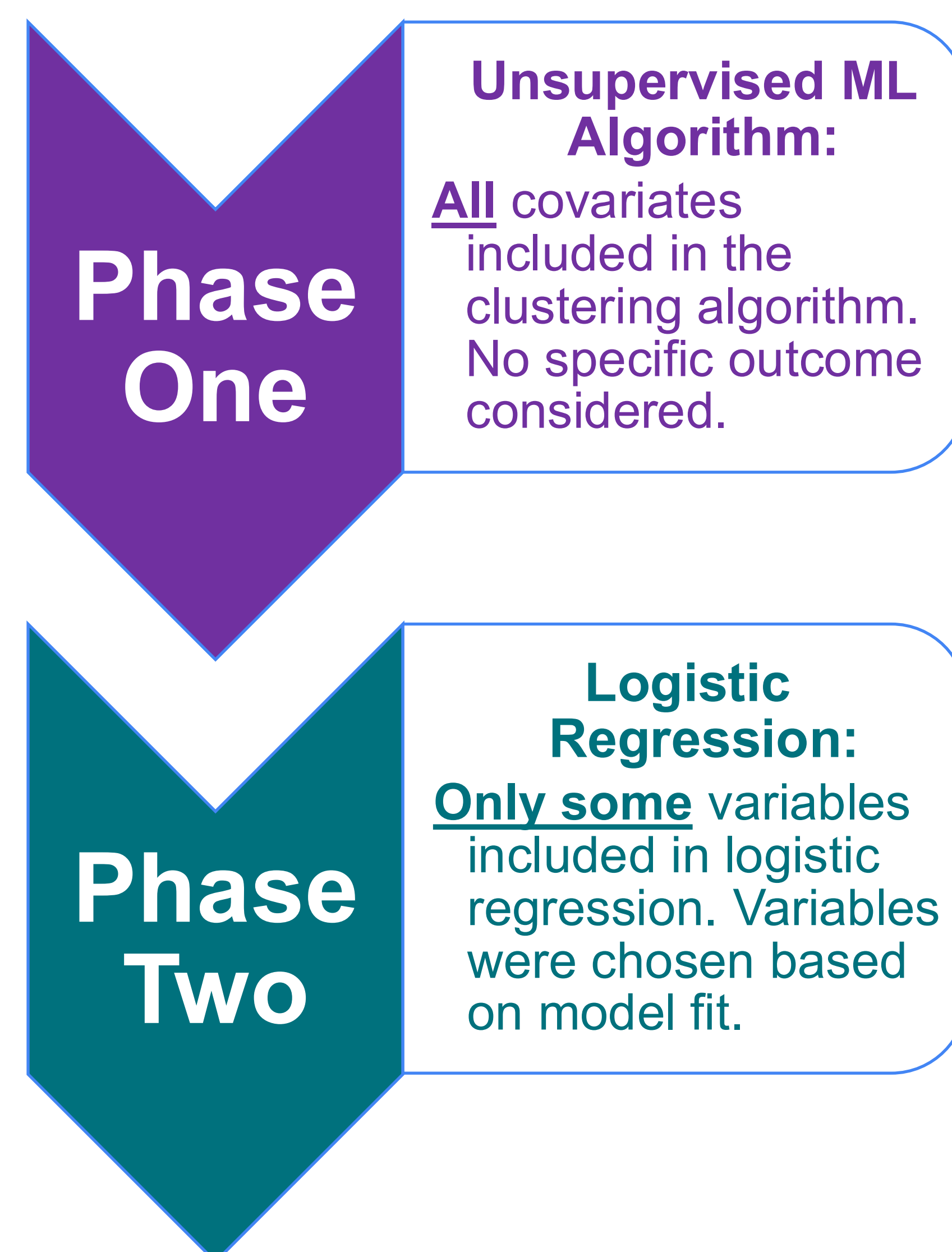
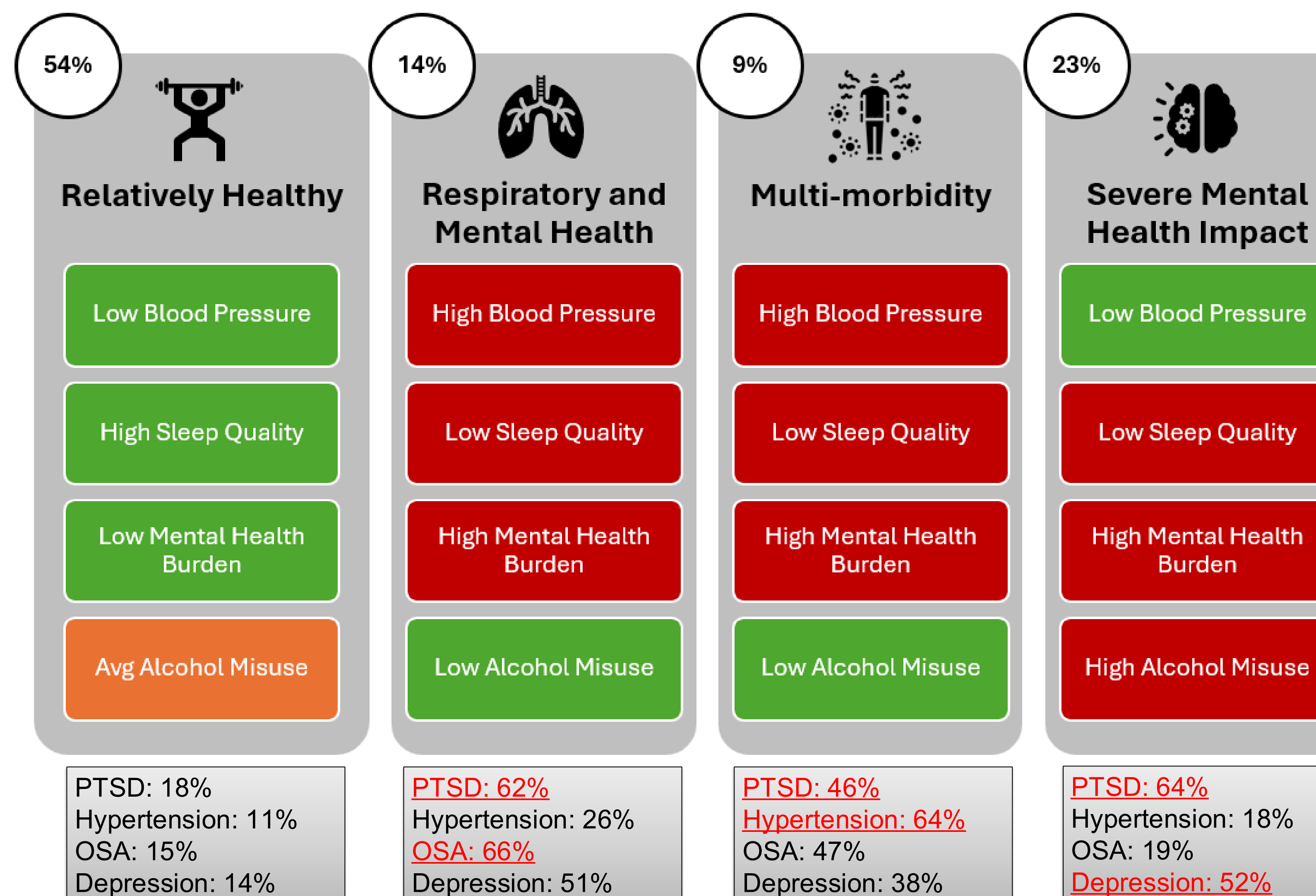


Figure 2. Cluster Descriptions and Characteristics



* Example diagnosis incidence percentages by cluster

Figure 3. Suicidal Ideation by Cluster at Baseline

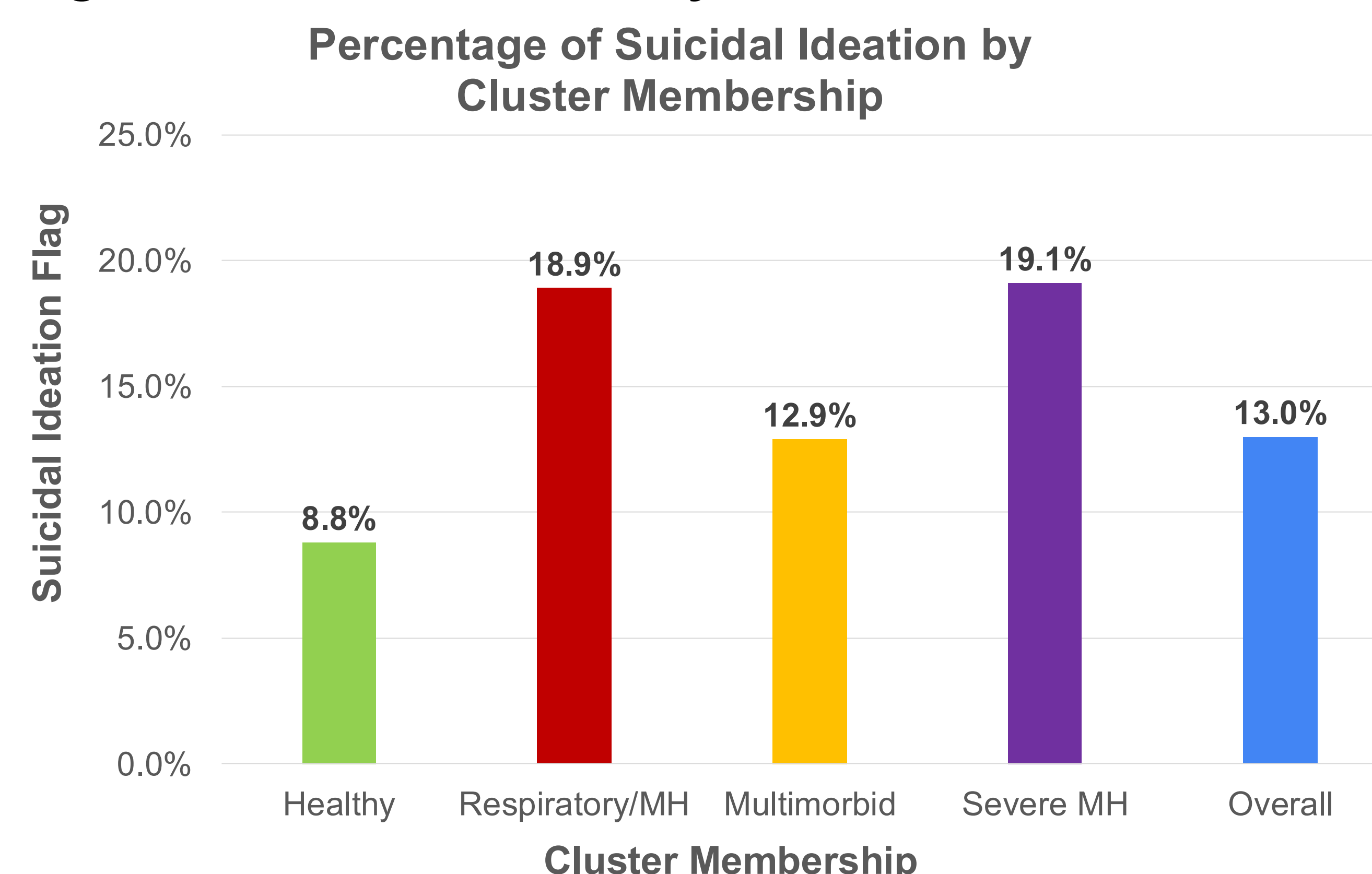
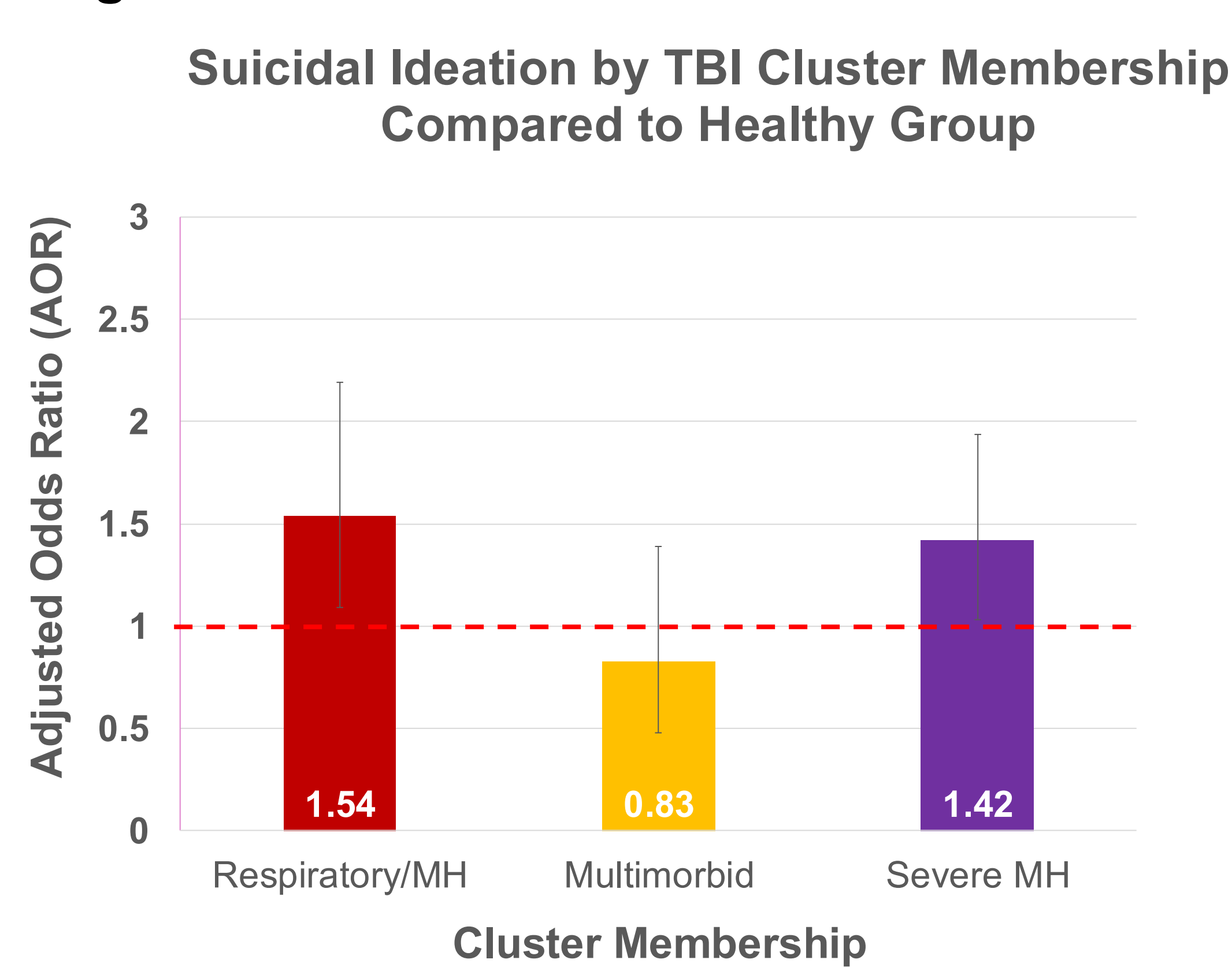


Figure 4. Risk of Suicidal Ideation



Summary

- Clusters identified were similar to phenotypes found in prior studies:
 - “Healthy”
 - “Mental Health Burden”
 - “Multimorbidity”
- Clinical implications and utility:
 - Enhance detection of comorbidity patterns common after mild TBI
 - Facilitates identifying risk for adverse outcome like suicide-related behavior (e.g., SI)
 - Facilitates patient-centered care by revealing likely comorbidity patterns and enabling strategic care provision

What's new?

- Cluster membership predicted SI despite not being a variable included in the initial algorithm to identify clusters.
- Mental Health conditions were common among all but the ‘Relatively Healthy’ group; subtypes varied in comorbidity presentation
 - Severe MH burden (e.g., PTSD, Depression)
 - Multimorbidity (e.g., Hypertension, Diabetes)
 - Respiratory & MH (e.g., OSA)

Limitations

- Self-report data
- Specificity to the leveraged, clinically rich, dataset

Future Research

- Applying this model to identify mild TBI clusters may improve healthcare providers' capacity to detect and intervene on suicide risk at an early stage.
- Further research should seek to validate risk prediction with longitudinal data.
 - Tracking outcomes compared to predicted risk models.
 - Conducting the same algorithm with longitudinal data to track changes in cluster identification and membership

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