



# Cluster Analysis of Patients with Traumatic Physical Injuries Seeking Outpatient Behavioral Health Services in a Level-1 Trauma Hospital

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## Abstract

**Introduction:** The use of clustering analysis within healthcare has evidenced promise in grouping complex medical cases, with increasing attention being given in grouping mental health symptoms and outcomes. Limited information is available on clustering for mental health symptoms in patients who have experienced a recent traumatic physical injury. Similarly, it is unknown if different patient subtypes have diverse social risk factors or if treatment response may differ.

**Methodology:** Patients who experienced a physical traumatic injury (N=67) were referred for outpatient behavioral health services through a Level-1 trauma hospital. K-means clustering was used to examine potential groupings based on trauma symptoms, depression scores, adverse childhood experiences, and physical, mental, and general health quality of life.

**Results:** Three clusters emerged based on symptom severity across measures. Behavioral health treatment at 6-weeks resulted in significant decreases in trauma symptoms for the highest  $t(12) = 2.61$ ,  $p = 0.01$ ,  $d = 0.72$  and the mid-range severity groups  $t(7) = 2.12$ ,  $p = 0.03$ ,  $d = 0.75$ . Significant decreases in depression symptoms were noted for the severe symptom group  $t(12) = 3.44$ ,  $p = 0.002$ ,  $d = 0.95$ , but not the mid-range group.

**Conclusion:** Groupings based on symptom severity corresponded with social risk and needs such as food, clothing, housing, medical care, transportation, social activities, witnessing violence, and history of being violent. Patient clusters emerged based on symptom severity. Patients with the highest symptom severity also had the highest social risks and needs. Implications suggest that resources can be allocated to address other needs that may exacerbate symptom presentation.

**Keywords:** Cluster Analysis; Trauma; Posttraumatic Stress Disorder; Depression; Traumatic Physical Injury

## Introduction

The heterogeneity of symptoms in psychiatric disorders has driven inquiry into use of machine learning approaches to detect latent relationships or underlying patterns in patient data. Specifically, cluster analysis is an unsupervised learning approach in which algorithms are used to separate data into latent groups (clusters) based on similarities in characteristics. By examining underlying patient groups, clinicians may use information on clusters to guide clinical decision-making and better be able to personalize patient care.

**Clustering in psychological conditions and response to treatment:** The use of clustering approaches in the field of mental health has largely focused on the ability to detect subtypes in various clinical disorders. A review of the literature found that clusters largely emerged based on symptom severity as opposed to specific symptom features [1]. Similar findings of differences based on symptom severity have been found with panic disorder, posttraumatic stress disorder (PTSD), autism, and schizophrenia, though cluster analysis with borderline personality disorder found clustering based on BPD subtypes as opposed to symptom severity [2-7]. Similar findings were noted in clustering of symptom severity in trauma-exposed soldiers [8].

**Clustering with co-morbid psychological and medical conditions:** Studies in which the clustering of psychological symptoms or disorder occurring in the context of medical conditions have had mixed results. For example, in patients with Parkinson's disease, clusters emerged based

on mood symptoms, resulting in groups experiencing either anxiety or depression only, a group with co-morbid anxiety and depression, and a group with no mood disorder symptoms [9]. In another study classifying patients with major depressive disorder in a hospital setting, subtypes emerged based on sociodemographic characteristics, medical conditions, and medication use [10]. Some of the clusters that emerged surrounded complex psychiatric comorbidity, co-morbid anxiety/depression, and individuals with co-morbid anxiety/depression seeking primary care services. Additional subtypes emerged for patients experiencing major depression that also reported significant pain. Conversely, a study seeking to cluster patients with bipolar disorder using psychological symptom measures, health-related quality of life, and clinical medical measures found clustering based on symptom severity [11]. Based on the presence of comorbid mental health symptoms and physical health measures, the pattern of forming clusters is unclear.

**Traumatic Physical Injuries:** Traumatic physical injuries are injuries that happen suddenly (e.g., car accidents, gun shots, falls, etc.) that require immediate medical attention. The degree of injury dictates pain experienced in the recovery process, potential medical complications, and potential short or long-term individual, familial, occupational, and other impacts. Psychiatric impacts of physical traumatic injuries vary, including psychological distress, depression, anxiety, and trauma symptoms. Psychological distress following motor vehicle crash injuries have been found to last for at least 3 years post event, lasting even as long as 10 years for spinal cord, traumatic brain, or whiplash injuries [12]. Elevated scores for depression and stress have been found in over half of trauma survivors, with 15%-22% of individuals scoring in the extremely severe range [13].

Screening in patients admitted to the trauma surgery unit found approximately 19% of patients screened had symptoms consistent with posttraumatic stress disorder and 8% with depressive symptoms in the moderately severe or severe range immediately following admission [14]. Symptoms can also be long-lasting, with up to 23% percent of injured patients having symptoms to the level of PTSD even 12 months post-event [15].

While research on clustering of mental health symptoms has largely found separation based on symptom severity, patient clustering has been found to differ when examining these patterns in medical conditions. It is unclear what type of clustering pattern may be noted in cases in which there is a substantial physical injury resulting from a psychologically traumatic event. The purpose of this study is to determine the clustering of patient groups based on trauma symptoms, depression, adverse childhood experiences, and health-related quality of life in survivors who have sustained a traumatic physical injury. Following, the patient groups, if any, will be compared to determine differences in financial needs, witnessing violence, engagement in violence or arrests, and treatment outcomes.

## Research Methodology

The dataset used for this study emerged from a treatment outcome study for adults receiving outpatient behavioral health services through a level-1 trauma hospital due to a traumatic physical injury [14]. The original study was conducted in accordance with the Declaration of Helsinki and was approved by the Louisiana State University Health Sciences Center- New Orleans Institutional Review Board (IRB #9631, original approval date March 15, 2017). All participants completed a written informed consent to participate in data collection.

Following admission to the Trauma Surgery Unit patients were screened for trauma and depression symptoms and referred to the Trauma Recovery Clinic, an outpatient behavioral health clinic specific to patients who obtained physical injuries. Patients had the option for both evidence-based psychotherapy for trauma and pharmacological interventions. Measures were collected at baseline and six weeks into treatment. Data for this study excluded patients with burn injuries as they were placed in a separate, more intensive hospital unit following admission.

## Measures

Posttraumatic Stress Disorder Checklist, Civilian Version (PCL-C) [16]. The PCL-C is a 17-item Likert-type self-report measure assessing symptoms of posttraumatic stress disorder experienced within the last month. An average test-retest reliability has been found to be 0.79 [17]. Internal consistency on the PCL-C had a Cronbach's alpha that averaged at 0.94 across research studies and with an  $\alpha=0.92$  in clinical samples [17]. Scores on the PCL-C can range from 17 to 85. For the purposes of this study, a cutoff score of 35 was used to be consistent with diagnostic validity studies in the research literature indicative of clinically significant PTSD symptoms [17].

Patient Health Questionnaire (PHQ-9) [18]. The PHQ-9 is a 9-item self-report measure for symptoms of depressed mood. Across 98 studies, the pooled internal consistency ( $\alpha=0.85$ ) was found to be excellent [19]. Test-retest reliability in a primary care sample was found to be 0.84 within 48 hours [20].

Medical Outcomes Study Short-Form Health Survey (SF-36) [21]. The SF-36 is a 36-item self-report measure of health-related quality of life. Subscales for this measure include (1) Physical Functioning; (2) Energy Score; (3) Emotion Score; (4) Social Functioning; (5) Pain Score; (6) Role Limitations caused by Physical Health; (7) Role Limitations caused by Emotional Problems; and (8) General Health Score. Internal consistency across subscales have been found to be high, with Cronbach's alphas between 0.71 to 0.93 [22].

Adverse Childhood Experiences (ACES) [23]. The ACES questionnaire was designed as a binary measure of childhood exposure to abuse and household dysfunction. Internal consistency for the 10-item version of the questionnaire ( $\alpha=0.70$ ) was acceptable [24]. Previous research has found that health outcomes and morbidity substantially increased for a person who endorsed four or more adverse childhood experiences [23]. The ACES questionnaire was included in this study as it has been found to predict adult mental health outcomes [25].

The Violence Screening and Assessment of Needs (VIO-SCAN) [26]. The VIO-SCAN is a brief screening measure for the potential of violent behavior through assessing several risk factors. We used this measure to assess for patient self-report of financial strain, housing need, food and clothing insecurity, substance misuse, and history of violence. An additional question was posed on if participants witnessed someone being seriously wounded or killed.

## Statistical analyses

We sought to determine if there were underlying patient groups based on trauma symptoms, depression, adverse childhood experiences, and health-related quality of life. The statistical analyses were conducted using Jamovi 2.6.44 [27]. For this exploratory analysis with continuous data, we used k-means, a centroid-based clustering approach, which aims to partition observations into non-overlapping clusters with the nearest mean. Once clusters were identified from

the sample, the clusters were named by comparing their defining characteristics from the variables included in the analysis. Following, chi-square, paired sample t-tests, and Kruskal-Wallis analysis with pairwise comparisons were conducted to determine differences between the clusters on variables included in the analysis, patient assessment of needs, and treatment progress.

## Results

### Participants

Sixty-seven patients (53.7% female) ranging from 18 to 61 years of age ( $M=37.6$ ,  $SD=11.2$ ) were included in the analysis. Patients were largely Black (49.2%) or White (39.7%) race. Patient injuries varied from blunt force trauma (50.6%) such as car accidents, penetrating traumas (36.4%) such as gun shots, or other trauma types (13.0%). Overall patient scores for posttraumatic stress disorder symptoms were in the clinical range ( $M=56.1$ ) with depression scores ( $M=13$ ) indicative of moderate levels of depression. No significant differences were found for outcome variables based on type of physical trauma injury experienced.

### Clusters

The elbow test for k-means cluster visually resulted in an optimal three cluster solution. This three cluster model provided a good clinical interpretation of group differences based on symptom severity (Figure 1).

**Cluster A- Highest symptoms:** Individuals in Cluster A ( $n=31$ ; 46.3% of participants) exhibited the highest clinical levels of posttraumatic disorder symptoms, moderately severe depression symptoms, and the highest number of adverse childhood experiences. Individuals in this cluster generally reported the worst quality of

life in all domains except for role limiting psychological symptoms, though scores for this subscale were still exceptionally low.

**Cluster B- Midrange symptoms:** Individuals in Cluster B ( $n=25$ ; 37.3% of participants) exhibited clinical levels of posttraumatic stress disorder symptoms, though lower in severity than Cluster A. Individuals in Cluster B were generally reporting moderate depression and reported having adverse childhood experiences, though slightly less than Cluster A. Individuals in this cluster reported midrange health-related quality of life, except for role limiting psychological symptoms, which was the worst of the clusters.

**Cluster C- Lowest symptom severity:** Individuals in Cluster C ( $n=11$ ; 16.4% of participants) exhibited clinical levels of posttraumatic stress disorder symptoms though the lowest in severity across the clusters. Individuals in Cluster C generally were experiencing minimal depression and reported the least amount of adverse childhood experiences. Individuals in this cluster reported the best scores for health-related quality of life.

Cluster descriptives and pairwise comparisons can be found in Table 1. No differences were noted among the clusters in gender and age. There was not a significant difference in numbers of adverse childhood experiences ( $p=0.051$ ), though this may largely be due to inadequate statistical power. Clusters differed from each other on trauma and depression symptom severity. Cluster A (highest symptom severity) had a significantly lower quality of life compared to Cluster B (midrange) and Cluster C (lowest) in physical functioning, energy, emotion, social functioning, pain, role limitation (physical), and general health. Clusters A and B had comparable reports for role limitation (emotional/psychological), which was significantly lower than those in Cluster C. Cluster B also evidenced lower scores in emotion, social functioning, and general health compared to Cluster C (Table 1).

### Differences in social determinants based on cluster type

Figure 2 shows the percentage of individuals within a cluster that endorsed financial challenges for various needs (food, clothing, housing, medical care, transportation, social activities), alcohol misuse, history of violence or criminal arrests, or witnessed violence. Patients in the highest symptom group reported the most financial concerns across all needs and arrests. Additionally, 92% of the highest symptom group endorsed having witnessed someone being wounded or killed compared to the midrange symptom group (52%) and lowest symptom group (36.4%). The midrange group generally had the second highest rates across the social determinants, while the lowest symptom group had relatively few needs and few endorsed violence/arrests. The exception was alcohol misuse. Twenty-seven percent of the lowest symptom group reported being told to cut back on alcohol, more than the highest symptom group (22.3%) and midrange group (16%) (Figure 2).

### Treatment outcomes by cluster

Overall, there was a significant decrease in trauma scores  $t_{(24)}=3.33$ ,  $p=0.001$ ,  $d=0.67$  and depression  $t_{(24)}=2.23$ ,  $p=0.018$ ,  $d=0.446$  for all participants 6 weeks into treatment. Significant improvements for the highest severity cluster (A) at 6 weeks of treatment were noted for trauma symptoms  $t_{(12)}=2.61$ ,  $p=0.011$ ,  $d=0.724$  and depression  $t_{(12)}=3.44$ ,  $p=0.002$ ,  $d=0.955$ . The midrange cluster (B) showed significant improvements for trauma symptoms  $t_{(7)}=2.12$ ,  $p=0.036$ ,  $d=0.748$ , but not for depression. Cluster C with the lowest symptoms did not evidence a significant decrease in trauma symptoms by six

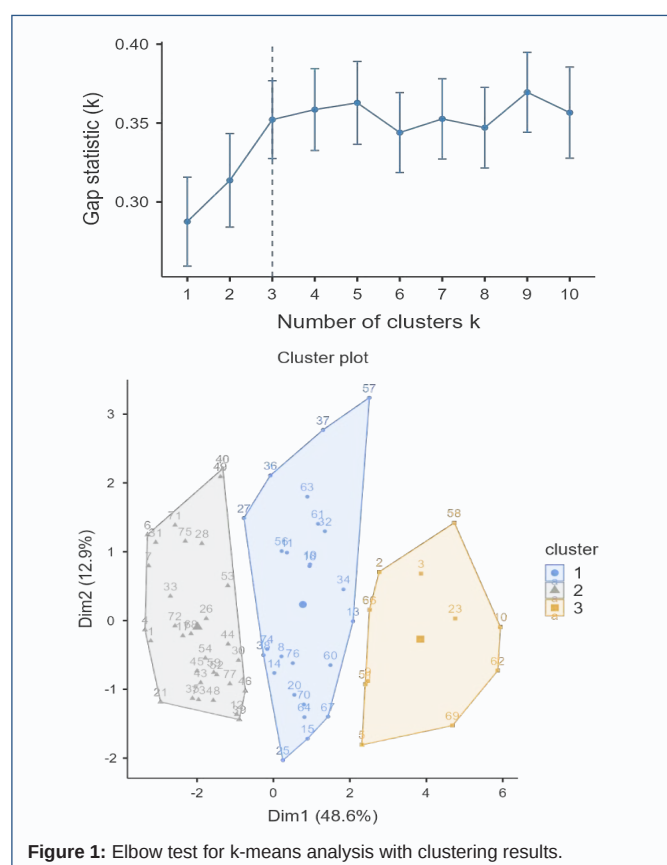
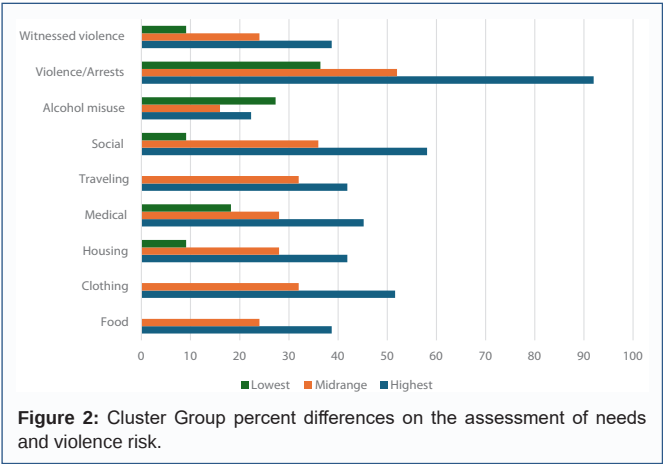


Figure 1: Elbow test for k-means analysis with clustering results.

**Table 1:** Patient Characteristics by Cluster.

| Characteristic                        | Cluster A (n=31)          | Cluster B (n=25)          | Cluster C (n=11)          | p-value |
|---------------------------------------|---------------------------|---------------------------|---------------------------|---------|
| % Female                              | 61.3%                     | 54.5%                     | 44.0%                     | 0.434   |
| Age (SD)                              | 40.0 (10.7)               | 36.2 (10.4)               | 35.8 (13.7)               | 0.377   |
| PCL-C                                 | 66.9 (8.47) <sup>bc</sup> | 51.2 (12.1) <sup>ac</sup> | 36.5 (10.3) <sup>ab</sup> | <.001   |
| PHQ-9                                 | 17.8 (4.14) <sup>bc</sup> | 10.9 (3.33) <sup>ac</sup> | 4.00 (4.82) <sup>ab</sup> | <.001   |
| ACES                                  | 4.77 (3.20)               | 3.04 (2.52)               | 2.55 (2.30)               | 0.051   |
| <b>Quality of Life: SF-36</b>         |                           |                           |                           |         |
| Physical Functioning                  | 26.3 (19.7) <sup>bc</sup> | 59.6 (24.7) <sup>a</sup>  | 77.3 (16.6) <sup>a</sup>  | <.001   |
| Energy                                | 22.4 (15.6) <sup>bc</sup> | 39.2 (18.1) <sup>a</sup>  | 57.3 (20.8) <sup>a</sup>  | <.001   |
| Emotion                               | 32.9 (16.4) <sup>bc</sup> | 51.7 (17.8) <sup>ac</sup> | 75.3 (15.8) <sup>ab</sup> | <.001   |
| Social Functioning                    | 16.9 (14.6) <sup>bc</sup> | 44.5 (19.5) <sup>ac</sup> | 75.0 (20.2) <sup>ab</sup> | <.001   |
| Pain                                  | 16.2 (18.6) <sup>bc</sup> | 45.9 (31.3) <sup>a</sup>  | 58.4 (28.3) <sup>a</sup>  | <.001   |
| Role Limitations – Physical Health    | 3.23 (10.7) <sup>bc</sup> | 23.0 (33.8) <sup>a</sup>  | 54.5 (40.0) <sup>a</sup>  | <.001   |
| Role Limitations – Emotional Problems | 12.8 (23.7) <sup>c</sup>  | 10.6 (22.8) <sup>c</sup>  | 90.7 (15.9) <sup>ab</sup> | <.001   |
| General Health Score                  | 43.2 (16.1) <sup>bc</sup> | 62.2 (15.8) <sup>ac</sup> | 75.9 (13.2) <sup>ab</sup> | <.001   |

Pairwise comparisons for latent groups: a. Cluster A, b. Cluster B, c. Cluster C indicating significant differences.



weeks. No analyses were conducted for the lowest severity group on depression as they exhibited minimal symptoms pre-treatment. No significant differences were found in attrition before six weeks of treatment among the severity groups.

Conclusion

The purpose of this study was to determine if there were underlying clusters of patients pursuing outpatient behavioral health treatment following a traumatic physical injury. The findings suggested three groups that differed based on symptom severity for trauma, depression, adverse childhood experiences, and health-related quality of life. All three clusters evidenced trauma scores in the clinical range, though varied in severity. Clusters with highest and midrange symptoms evidenced clinically significant levels of depression.

Findings of a three-cluster model based on symptom severity have been noted in other studies of mental health symptoms, particularly PTSD and depression [8] [28]. The current study extends the literature on clusters based on mental health symptom severity but specifically adds to the research on these clusters emerging in a patient population experiencing traumatic physical injuries. The cluster with the most severe symptoms and poorest health-related

quality of life also evidenced the most financial needs in terms of food, clothing, housing, transportation, medical care, and social activities. Additionally, they were more likely to witness violence, engage in violence, and be arrested. Clinical implications of this study highlight the importance of having special services to address patient life needs and trauma history, particularly in a group who has experienced a recent traumatic event. Given that patients with the highest severity of psychological distress also are more likely to have adverse childhood experiences and witnessed previous violence, this underscores the need for clinicians and other medical professionals tending these patients be well-acquainted with trauma-informed care.

While current research has used cluster analysis to observe treatment results for physical illnesses, limited studies have examined post-intervention outcomes for mental health conditions. Lara-Huallipe and colleagues [29] found higher rates of post-treatment relapse for patients with the most severe gambling disorder severity and psychopathological functioning. This study contributes to a limited field examining patient clusters as it relates to treatment outcomes.

Use of cluster analysis in psychological functioning in a sample of patients having a physical injury is limited. Future studies should seek to use this technique in a larger sample with additional demographic or sociodemographic variables that may impact the formation of clusters (e.g., child victims). Additionally, it may be important to examine these clusters within specific injury subtypes, such as victims of burn injuries. While this study specifically excluded victims with burn injuries, examining this group within the context of all physical injuries or as a specific subset would be necessary given unique recovery needs for this group.

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