

Clinical diagnostic phenotypes in hospitalizations due to self-inflicted firearm injury

-- Suicide, Mortality, and Economic Dependency

Feng Li

School of Statistics and Mathematics

Central University of Finance and Economics

<https://feng.li/>

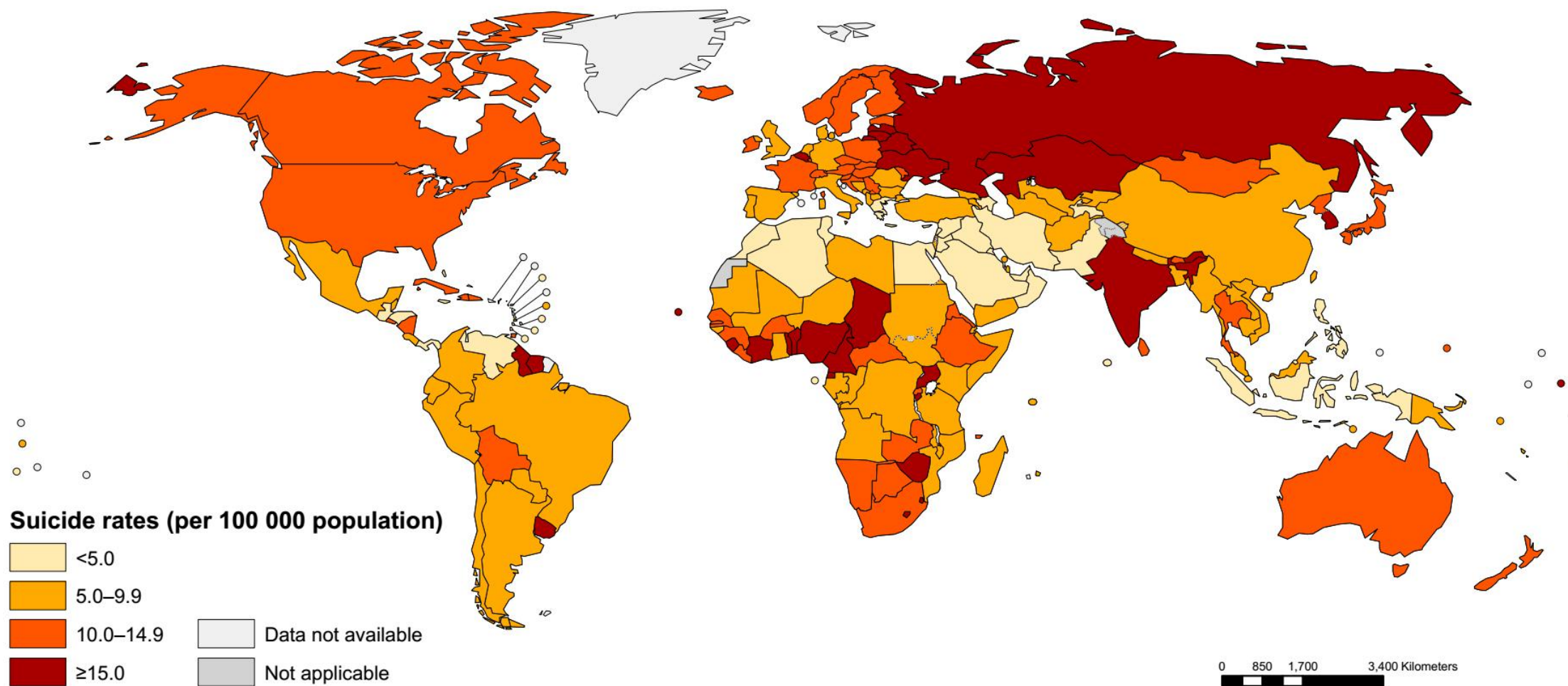
Joint work with

Bindu Kalesan (Boston University Medical Center)

Yi Zuo (Vanderbilt University School of Medicine)

Age-standardized suicide rates (per 100 000 population), both sexes, 2016

Suicide: one person dies every 40 seconds.



Source: World Health Organization (2019): Suicide in the world: Global Health Estimates

Background

- Hospitalized self-inflicted firearm injuries have not been extensively studied, particularly regarding clinical diagnoses at the index admission.
- The objective of this study was to discover the diagnostic phenotypes (DPs) or clusters of hospitalized self-inflicted firearm injuries.
- It is now yet clear to us how machine learning algorithms could be used in assisting clinical diagnoses.

Data Source

- All data used for our analysis was drawn from the Nationwide Inpatient Sample (NIS) for calendar years 1993-2014, containing data from 20% of in-patient stays from 48 US states.
- The overall cohort included 14072 hospitalizations.
- We identified patients **18 years of age and older** who sustained a self-inflicted firearm injury between 1993-2014 using the International Classification of Diseases (ICD-9-CM) codes for self-inflicted injury by firearms (E9550 - E9554, E9556 and E9559).
- We excluded hospitalizations that did not have information about age and sex as well as ICD-9 codes for self-inflicted firearm injury for this analysis.

Statistical analysis

- We used an unsupervised machine learning approach to determine the diagnostic clusters or phenotypes.
- We used primary and secondary ICD-9-CM 5-digit diagnosis codes of the entire cohort and identified the 25 most frequent, converted into a binary matrix (code and hospitalization) and computed a dissimilarity (distance) matrix by using Jaccard distance.
- Hospitalizations with similar patterns of diagnosis codes will be closer to each other resulting in a relatively low Jaccard distance or low dissimilarity, thus are more likely to be clustered and characterized as a phenotype.
- We determined the optimal number of clusters by constructing three sets of scree plots using the silhouette method.

Cluster-specific distribution of 25 most frequent Diagnosis Codes for self-inflicted firearm injury hospitalizations in diagnostic phenotype 1 (N = 10110)

Rank	ICD-9-CM diagnosis codes	Frequency	Within cluster percentage (%)	Description
1	311	2032	20.10	Depressive disorder, not elsewhere classified
2	4019	1703	16.84	Unspecified essential hypertension
3	2851	1686	16.68	Acute post hemorrhagic anemia
4	3051	1584	15.67	Tobacco use disorder
5	30500	1270	12.56	Alcohol abuse, unspecified
6	5185	1064	10.52	Pulmonary insufficiency following trauma and surgery
7	51881	967	9.56	Acute respiratory failure
8	3485	864	8.55	Cerebral edema
9	85195	843	8.34	Other and unspecified cerebral laceration and contusion, with open intracranial wound, with prolonged [more than 24 hours] loss of consciousness without return to pre-existing conscious level
10	9584	793	7.84	Traumatic shock
11	29620	773	7.65	Major depressive affective disorder, single episode, unspecified
12	8605	672	6.65	Traumatic pneumohemothorax with open wound into thorax
13	8029	662	6.55	Open fracture of other facial bones
14	2768	658	6.51	Hypopotassemia
15	4589	658	6.51	Hypotension, unspecified
16	8025	640	6.33	Open fracture of malar and maxillary bones
17	5180	559	5.53	Pulmonary collapse
18	2762	553	5.47	Acidosis
19	3488	550	5.44	Other conditions of brain
20	25000	507	5.01	Diabetes mellitus without mention of complication, type II or unspecified type, not stated as uncontrolled
21	3009	501	4.96	Unspecified nonpsychotic mental disorder
22	30390	479	4.74	Other and unspecified alcohol dependence, unspecified
23	86131	473	4.68	Contusion of lung with open wound into thorax
24	2859	457	4.52	Anemia, unspecified
25	51851	436	4.31	Acute respiratory failure following trauma and surgery

- The twelve most common diagnoses in DP1 were identical to the overall cohort, including the top five, **major depressive disorder** (27.7%), **hypertension** (16.8%), **acute post hemorrhagic anemia** (16.7%), **tobacco** (15.7%), and **alcohol** use (12.6%) (Table 2).
- The most frequent injuries by diagnostic code were to the **head**.
- The five most common procedures were also similar to the overall cohort with the majority (33.8%) receiving **mechanical ventilation** and **intubation** (23.02%).
- Other frequent procedures included **blood transfusion** as well as procedures to treat **traumatic brain injuries**, and **injuries to the face and skull**.

Diagnostic phenotype 2 (N = 3725)

Rank	ICD-9-CM diagnosis codes	Frequency	Within cluster percentage (%)	Description
1	29623	122	3.28	Major depressive affective disorder, single episode, severe, without mention of psychotic behavior
2	3090	109	2.93	Adjustment disorder with depressed mood
3	v3000	101	2.71	Single liveborn, born in hospital, delivered without mention of cesarean section
4	8750	97	2.60	Open wound of chest (wall), without mention of complication
5	85415	95	2.55	Intracranial injury of other and unspecified nature with open intracranial wound, with prolonged [more than 24 hours] loss of consciousness without return to pre-existing conscious level
6	42731	90	2.42	Atrial fibrillation
7	4280	76	2.04	Congestive heart failure, unspecified
8	41401	75	2.01	Coronary atherosclerosis of native coronary artery
9	8631	74	1.99	Injury to stomach, with open wound into cavity
10	4275	71	1.91	Cardiac arrest
11	80075	71	1.91	Open fracture of vault of skull with subarachnoid, subdural, and extradural hemorrhage, with prolonged [more than 24 hours] loss of consciousness, without return to pre-existing conscious level
12	80175	71	1.91	Open fracture of base of skull with subarachnoid, subdural, and extradural hemorrhage, with prolonged [more than 24 hours] loss of consciousness, without return to pre-existing conscious level
13	3004	69	1.85	Dysthymic disorder
14	29630	67	1.80	Major depressive affective disorder, recurrent episode, unspecified
15	30391	67	1.80	Other and unspecified alcohol dependence, continuous
16	496	67	1.80	Chronic airway obstruction, not elsewhere classified
17	8900	67	1.80	Open wound of hip and thigh, without mention of complication
18	8792	66	1.77	Open wound of abdominal wall, anterior, without mention of complication
19	5990	62	1.66	Urinary tract infection, site not specified
20	8621	61	1.64	Injury to diaphragm, with open wound into cavity
21	86330	61	1.64	Injury to small intestine, unspecified site, with open wound into cavity
22	86339	59	1.58	Other injury to small intestine, with open wound into cavity
23	8603	55	1.48	Traumatic hemothorax with open wound into thorax
24	29680	54	1.45	Bipolar disorder, unspecified
25	80165	54	1.45	Open fracture of base of skull with cerebral laceration and contusion, with prolonged [more than 24 hours] loss of consciousness, without return to pre-existing conscious level

Diagnostic phenotype 3 (N = 237)

Rank	ICD-9-CM diagnosis codes	Frequency	Within cluster percentage (%)	Description
1	29633	237	100.00	Major depressive affective disorder, recurrent episode, severe, without mention of psychotic behavior
2	8605	32	13.50	Traumatic pneumohemothorax with open wound into thorax
3	2851	29	12.24	Acute posthemorrhagic anemia
4	3051	21	8.86	Tobacco use disorder
5	86131	17	7.17	Contusion of lung with open wound into thorax
6	4019	16	6.75	Unspecified essential hypertension
7	30390	15	6.33	Other and unspecified alcohol dependence, unspecified
8	8621	15	6.33	Injury to diaphragm, with open wound into cavity
9	8750	15	6.33	Open wound of chest (wall), without mention of complication
10	30981	14	5.91	Posttraumatic stress disorder
11	2449	12	5.06	Unspecified acquired hypothyroidism
12	30000	12	5.06	Anxiety state, unspecified
13	53081	12	5.06	Esophageal reflux
14	5180	11	4.64	Pulmonary collapse
15	5601	11	4.64	Paralytic ileus
16	8601	11	4.64	Traumatic pneumothorax with open wound into thorax
17	86352	11	4.64	Injury to transverse colon, with open wound into cavity
18	2761	10	4.22	Hyposmolality and/or hyponatremia
19	2768	10	4.22	Hypopotassemia
20	30183	10	4.22	Borderline personality disorder
21	30391	<10	<4	Other and unspecified alcohol dependence, continuous
22	8631	<10	<4	Injury to stomach, with open wound into cavity
23	v1541	<10	<4	History of physical abuse
24	30002	<10	<4	Generalized anxiety disorder
25	30300	<10	<4	Acute alcoholic intoxication in alcoholism, unspecified

Demographic characteristics of firearm injury hospitalizations

<i>n</i>	Total 14,072	Diagnostic cluster 1 10,110	Diagnostic cluster 2 3,725	Diagnostic cluster 3 237
Demographic				
Age, Mean (SD)	41.89 (19.76)	43.33 (19.13)	37.96 (21.15)	42.39 (14.37)
Age Group				
0 – 15	462 (3.3%)	170 (1.7%)	290 (7.8%)	<10 (-)
16 – 45	8,136 (57.8%)	5,720 (56.6%)	2,271 (61.0%)	145 (61.2%)
46 +	5,474 (38.9%)	4,220 (41.7%)	1,164 (31.2%)	90 (40.0%)
Race				
White	3,352 (23.8%)	2,497 (24.7%)	805 (21.6%)	50 (21.1%)
Black	5,352 (38.0%)	3,991 (39.5%)	1,262 (33.9%)	99 (41.8%)
Hispanic	1,900 (13.5%)	1,462 (14.5%)	398 (10.7%)	40 (16.9%)
Other	542 (3.9%)	421 (4.2%)	115 (3.1%)	<10 (-)
Unknown	2,926 (20.8%)	1,739 (17.2%)	1,145 (30.7%)	42 (17.7%)
Sex				
Male	12,446 (88.4%)	8,969 (88.7%)	3,275 (87.9%)	202 (85.2%)
Female	1,626 (11.6%)	1,141 (11.3%)	450 (12.1%)	35 (14.8%)
Insurance				
Private/Medicare	7,516 (53.4%)	5,471 (54.1%)	1,911 (51.3%)	134 (56.5%)
Self-pay	2,858 (20.3%)	2,075 (20.5%)	739 (19.8%)	44 (18.6%)
Medicaid/No charge/Other	3,585 (25.5%)	2,477 (24.5%)	1,052 (28.2%)	56 (23.6%)
Unknown	113 (0.8%)	87 (0.9%)	23 (0.6%)	<10 (-)
Neighborhood income quartiles				
≤ \$24,999	5,820 (41.4%)	4,275 (42.3%)	1,446 (38.8%)	99 (41.8%)
\$25,000-\$34,999	3,827 (27.2%)	2,630 (26.0%)	1,134 (30.4%)	63 (26.6%)
\$35,000-\$44,999	2,265 (16.1%)	1,631 (16.1%)	599 (16.1%)	35 (14.8%)
≥ \$45,000	1,282 (9.1%)	915 (9.1%)	349 (9.4%)	18 (7.6%)
Unknown	878 (6.2%)	659 (6.5%)	197 (5.3%)	22 (9.3%)
Hospital Location				
Rural	762 (5.4%)	513 (5.1%)	241 (6.5%)	<10 (-)
Urban	13,212 (93.9%)	9,520 (94.2%)	3,464 (93.0%)	228 (96.2%)
Unknown	98 (0.7%)	77 (0.8%)	20 (0.5%)	<10 (-)

- The majority of patients were **young adults** (age 16-45), **male**, black, had either private or Medicare health insurance, and live **in low-income** neighborhoods.
- The hospitals to which they were admitted were mostly large, urban, and teaching institutions, primarily in the southern region of the country.
- **One-third** of the cohort died during hospitalization.

Discussions

- Our study provides evidence that unsupervised machine learning algorithms can be used to classify traumatic injuries separated by mechanism and intent.
- These phenotypes can be used to develop injury specific predictive models. This may additionally allow clinicians to tailor treatment, target resources towards specific diagnostic phenotypes.
- This study facilitates future research in an effort to improve suicide prevention and prevent further morbidity and mortality.
- Our findings suggest that the affected rural populations are very diverse and there are collective environmental risk factors, including the primary economies, that play an important role in firearm suicide rates.
- Hence, focusing on actions related to firearms alone without considering the built environment may not achieve the desired result.

References

- Clinical diagnostic phenotypes in hospitalizations due to self-inflicted firearm injury, *Journal of Affective Disorders* 278(1):172-180. (with Megan G Janeway, et al.2021)
- Intersections between firearm suicide, drug mortality and economic dependency in rural America, *Journal of Surgical Research*. 256, pp 96-102. (with Bindu Kalesan et al. 2020)
- Changes in patterns of mortality rates and years of life lost due to firearms in the United States, 1999 to 2016: A joinpoint analysis. *PLoS One*, 14(11). (with Bailey et al. 2019)

Thank you!