# **Appendices**

**Appendix 1.** A summary of the development of NLP

In the previous study (Song et al., 2022), the signs/symptoms and problem labels of the Omaha System to identify the corpus of concerning terms used in NLP to detect concerning concepts documented in the nurse notes. The signs/symptoms and problem labels in the Omaha System that were considered as being associated with the risk of hospitalizations or ED visits in HHC were defined as ‘risk factors.’

The risk factors were identified by five experts in HHC and informatics based on the literature, expert's opinion, and/or their clinical experience. The experts were presented with the 335 Omaha System signs and symptoms and asked to indicate: “What signs/symptoms, if documented in the patient records, would cause concern for risk of hospitalizations or ED visits for HHC patients 65 years of age or older?”

The experts scored each sign/symptom on a scale from 1 to 3 (1- usually not concerning; 2- occasionally concerning; 3- usually concerning). The signs/symptoms that received a score of 3 (usually concerning) from the majority of experts (3 or more) were regarded as concerning signs/symptoms potentially associated with hospitalizations or ED visits in HHC. Signs/symptoms that received a score of 2 from the majority of experts were discussed by the study team for further consideration among concerning signs/symptoms. Signs/symptoms that received a score of 1 from the majority of experts (3 or more) were considered as 'not concerning.' The interrater agreement between experts was fair (Fleiss' Kappa = 0.32), and all discrepancies including that the difference between the maximum and the minimum score was 2 were resolved through several consensus group meetings.

Then, our team developed the natural language processing (NLP- an artificial intelligence field in which computers analyze, understand, and extract meaning from human language in a text form) algorithm to extract the risk factors for hospitalizations or ED visits from HHC clinical notes. In summary, based on the Omaha System – a standardized nursing terminology commonly utilized in community health (Martin, 2005) – a subset of 31 Omaha System problems, including "Circulations,” “Respiration,” and "Healthcare supervision,” were identified as risk factors for hospitalizations or ED visits in HHC (**Appendix 2**). Rule-based NLP algorithm were developed via NimbleMiner software (<http://github.com/mtopaz/NimbleMiner>) (Topaz et al., 2019) by analyzing word associations based on generated statistical representations in Word embedding (Word2Vec) (Mikolov et al., 2013), which is a language model that identifies synonyms for relevant words in a text by analyzing word associations based on generated statistical representations (F-score = 0.84). Lastly, the NLP algorithm was applied to identify these risk factors automatically on these 2.3 million HHC clinical notes, and then binary indicators were created for the presence of risk factors within an HHC episode.

**Appendix 2.** Identified risk factors for hospitalization or ED Visits in HHC within Omaha System problem

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| --- | --- |
| Problem Classification Scheme  (The Omaha System problems) | Signs/Symptoms of Actual |
| Income | uninsured medical expenses |
| difficulty buying necessities |
| Sanitation | inadequate food storage/disposal |
| inadequate water supply |
| infectious/contaminating agents |
| Residence | inadequate heating/cooling |
| inadequate/obstructed exits/entries |
| unsafe storage or dangerous objects/substances |
| unsafe mats/throw rugs |
| inadequate safety devices |
| unsafe appliances/equipment |
| exposed wiring |
| structural barriers |
| homeless |
| Neighborhood/workplace safety | uncontrolled/dangerous/infected animals |
| physical hazards |
| Communication with community resources | transportation barrier |
| limited access to care/services/goods |
| unable to use/has inadequate communication devices/equipment |
| Social contact | limited social contact |
| Interpersonal relationship | inappropriate suspicion/manipulation/compulsion/aggression |
| physically/emotionally abusive to partner |
| Mental health | sadness/hopeless/decreased self-esteem |
| apprehension/undefined fear |
| narrowed to scattered attention/focus |
| irritable/agitated/aggressive |
| purposeless/compulsive activity |
| somatic complaints/fatigue |
| delusions |
| hallucinations/illusions |
| expresses suicidal/homicidal thoughts |
| attempts suicide/homicide |
| self-mutilation |
| mood swings |
| flash-backs |
| Sexuality | sexual acting out/provocative behaviors/harassment |
| sexual perpetration/assault |
| Neglect | lacks adequate physical care |
| inappropriately left alone |
| lacks necessary supervision |
| inadequate/delayed medical care |
| Abuse | harsh/excessive discipline |
| welts/bruises/burns/other injuries |
| questionable explanation of injury |
| attacked verbally |
| fearful/hypervigilant behavior |
| violent environment |
| consistent negative messages |
| assaulted sexually |
| Hearing | absent/abnormal response to sound |
| Speech and language | absent/abnormal ability to speak/vocalize |
| absent/abnormal ability to understand |
| Oral health | Sore/swollen/bleeding gums |
| Cognition | disoriented to time/place/person |
| impulsiveness |
| repetitious language/behavior |
| wanders |
| Pain | expresses discomfort/pain |
| elevated pulse/respirations/blood pressure |
| compensated movement/guarding |
| restless behavior |
| facial grimaces |
| pallor/perspiration |
| Consciousness | lethargic |
| stuporous |
| unresponsive |
| comatose |
| Skin | lesion/pressure ulcer |
| delayed incisional healing |
| rash |
| inflammation |
| pruritus |
| drainage |
| bruising |
| Neuro-Musculo-Skeletal function | decreased sensation |
| decreased balance |
| gait/ambulation disturbance |
| difficulty transferring |
| fractures |
| tremors/seizures |
| difficulty with thermoregulation |
| Respiration | abnormal breath patterns |
| unable to breathe independently |
| unable to cough/expectorate independently |
| cyanosis |
| abnormal sputum |
| noisy respirations |
| abnormal breath sounds |
| abnormal respiratory laboratory results |
| Circulation | edema |
| cramping/pain of extremities |
| decreased pulses |
| discoloration of skin/cyanosis |
| temperature change in affected area |
| syncopal episodes (fainting)/dizziness |
| abnormal blood pressure reading |
| pulse deficit |
| irregular heart rate |
| excessively rapid heart rate |
| excessively slow heart rate |
| anginal pain |
| abnormal heart sounds/murmurs |
| abnormal clotting |
| abnormal cardiac laboratory results |
| Digestion-hydration | nausea/vomiting |
| difficulty/inability to chew/swallow/digest |
| anorexia |
| ascites |
| jaundice/liver enlargement |
| decreased skin turgor |
| electrolyte imbalance |
| Bowel function | decreased bowel sounds |
| blood in stools |
| abnormal color |
| cramping/abdominal discomfort |
| incontinent of stool |
| Genito-urinary function | urgency/frequency |
| burning/painful urination |
| difficulty initiating urination |
| difficulty emptying bladder |
| abnormal amount |
| hematuria/abnormal color |
| abnormal urinary laboratory result |
| Communicable/infectious condition | infestation |
| infection |
| fever |
| biological hazards |
| positive screening/culture/laboratory result |
| inadequate supplies/equipment/policies to prevent transmission |
| does not follow infection control regimen |
| inadequate immunity |
| Nutrition | underweight (adult BMI 18.5 or less) |
| lacks established standards for daily caloric/fluid intake |
| exceeds established standards for daily caloric/ fluid intake |
| unexplained/progressive weight loss |
| unable to obtain/prepare food |
| hypoglycemia |
| hyperglycemia |
| Sleep and rest patterns | sleep apnea |
| Personal care | difficulty with toileting activities |
| foul body odor |
| Substance use | abuses over-the-counter/prescription medication |
| abuses alcohol |
| difficulty performing normal routines |
| reflex disturbances |
| Health care supervision | fails to obtain routine/preventive health care |
| fails to seek care for symptoms requiring evaluation/treatment |
| fails to return as requested to health care provider |
| inability to coordinate multiple appointments/treatment plans |
| inconsistent source of health care |
| inadequate source of health care |
| inadequate treatment plan |
| Medication regimen | does not follow recommended dosage/schedule |
| evidence of side effects/adverse reactions |
| inadequate system for taking medication |
| improper storage of medication |
| fails to obtain refills appropriately |
| fails to obtain immunizations |
| inadequate medication regimen |
| unable to take medications without help |

**References**

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