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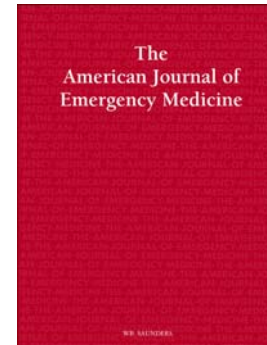
Artificial Neural Networks: Predicting Head CT Findings in Elderly Patients  
Presenting With Minor Head Injury After a Fall

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# Artificial Neural Networks: Predicting Head CT Findings in Elderly Patients Presenting With Minor Head Injury After a Fall

## Abstract

**Objectives:** To construct an artificial neural network (ANN) model that can predict the presence of acute CT findings with *both* high sensitivity and high specificity when applied to the population of patients  $\geq$  age 65 years who have incurred minor head injury after a fall.

**Methods:** An ANN was created in the Python programming language using a population of 514 patients  $\geq$  age 65 years presenting to the ED with minor head injury after a fall. The patient dataset was divided into three parts: 60% for “training”, 20% for “cross validation”, and 20% for “testing”. Sensitivity, specificity, positive and negative predictive values, and accuracy were determined by comparing the model’s predictions to the actual correct answers for each patient.

**Results:** On the “cross validation” data, the model attained a sensitivity (“recall”) of 100.00%, specificity of 78.95%, PPV (“precision”) of 78.95%, NPV of 100.00%, and accuracy of 88.24% in detecting the presence of positive head CTs. On the “test” data, the model attained a sensitivity of 97.78%, specificity of 89.47%, PPV of 88.00%, NPV of 98.08%, and accuracy of 93.14% in detecting the presence of positive head CTs.

**Conclusions:** ANNs show great potential for predicting CT findings in the population of patients  $\geq$  65 years of age presenting with minor head injury after a fall. As a good first step, the ANN showed comparable sensitivity, predictive values, and accuracy, with a much higher specificity than the existing decision rules in clinical usage for predicting head CTs with acute intracranial findings.

**Keywords:** Neural Network Models; Elderly; Head Injury, Minor; Falls

## 1. Introduction

Current evidence suggests that patients  $\geq$  65 years old presenting to the emergency department (ED) with minor head injury after a fall should receive a head CT scan. However, only a small percentage of these patients are actually found to have acute findings associated with the scan. Therefore, predictors for this class of patients that are *both* sensitive and specific would be desirable.

In 2004, injuries resulted in 31 million ED visits, representing 32% of all visits to the ED for any reason [1, 2]. Elderly patients are at the highest risk for both fatal and nonfatal injuries, with mortality and hospitalization rates for injuries reported to increase dramatically [1, 2]. Falls are the most common mechanism of injury for older patients visiting the ED, and are the most common cause of injury-related death [1, 2]. Due to the generally increased incidence of injury, specifically closed head injury, head CT is frequently ordered [3]. However, CT scans are costly and are recognized to carry a radiation risk [4, 5]; specifically, head CTs obtained because of a fall account

for the expenditure of millions of dollars annually in the United States [6].

In 2001, a study was published to determine predictors of positive CT findings for patients of all ages with minor head injury, resulting in a highly sensitive decision rule known as the Canadian CT Head Rule (CCHR) [6]. Notably, an age  $\geq$  65 was a sensitive predictor of positive CT findings, but this age group was not further stratified.

Several other widely noted evidence-based decision rules for the general population [6, 7, 8] also indicate that age above 60 or 65 years places the patient at high risk for an abnormal head CT after mild head injury. These various decision rules have been compared to determine if one or another more readily identifies the patient who will benefit from head CT [9, 10, 11, 12, 13, 14, 15], but none specifically addresses the population of patients over age 65 who potentially have an intracranial injury, particularly after a fall or other relatively minor mechanism. Currently, no definitive evidence exists regarding how to evaluate elderly patients after a fall, although a promising paper recently has been published using the non-age related New Orleans Criteria [16], predicting 100% of the abnormal head CT scans in an elderly population in a retrospective fashion.

A recent retrospective study [17] of 2149 elderly patients older than 65 years presenting to the ED with minor head injury found that 2.18% (47) of these patients had

Abbreviations - ANN: Artificial Neural Network

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