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Analysis of multi-dimensional contemporaneous EHR data to refine delirium assessments

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ABSTRACT

Delirium is a potentially lethal condition of altered mental status, attention, and level of consciousness with an acute onset and fluctuating course. Its causes are multi-factorial, and its pathophysiology is not well understood; therefore clinical focus has been on prevention strategies and early detection. One patient evaluation technique in routine use is the Confusion Assessment Method (CAM): a relatively simple test resulting in 'positive', 'negative' or 'unable-to-assess' (UTA) ratings. Hartford Hospital nursing staff use the CAM regularly on all non-critical care units, and a high frequency of UTA was observed after reviewing several years of records. In addition, patients with UTA ratings displayed poor outcomes such as in-hospital mortality, longer lengths of stay, and discharge to acute and long term care facilities. We sought to better understand the use of UTA, especially outside of critical care environments, in order to improve delirium detection throughout the hospital. An unsupervised clustering approach was used with additional, concurrent assessment data available in the EHR to categorize patient visits with UTA CAMs. The results yielded insights into the most common situations in which the UTA rating was used (e.g. impaired verbal communication, dementia), suggesting potentially inappropriate ratings that could be refined with further evaluation and remedied with updated clinical training. Analysis of the patient clusters also suggested that unrecognized delirium may contribute to the poor outcomes associated with the use of UTA. This method of using temporally related high dimensional EHR data to illuminate a dynamic medical condition could have wider applicability.

1. Introduction

The adoption of electronic health record (EHR) systems has ushered in a new era in healthcare by providing a structured method of collection, storage, and review of patient information. In addition to monitoring a patient's condition and treatments in real time, EHR systems facilitate the retrospective analysis of medical records at both the individual and population levels. However, the research opportunities presented by this digital trove are accompanied by challenges associated with the nature of the data. Medical records are voluminous, with a large variety of data types that may be stored independently. Data may be highly structured or completely unstructured; data may be missing or inconsistently available; and data quality and veracity may be difficult to ascertain. A critical feature of clinical documentation is the capture of the temporal sequence of events in a hospital visit, allowing for the identification of relationships between measures and outcomes that may be causal in nature. While many clinical variables are quantitative (e.g. vital signs, laboratory test results), there are more subjective assessments (e.g. cognition, mood, pain) that are also an integral part of the record. In the case of qualitative measures, the temporal component of the EHR data can be used to better understand those characteristics of a patient's condition or to evaluate the quality and consistency of the clinical assessments.

Delirium is an acute confusional state characterized by disturbances in attention, cognition, and level of consciousness. Unlike dementia, delirium has a rapid onset, transient and fluctuating course, and represents a departure from an individual's baseline function. The incidence of delirium arising during hospitalization ranges from 10–18% in general medicine wards, up to 60% in frail elderly patients, and 60–80% in the ICU [1]. Delirium is a serious, life-threatening complication of hospital stays, and multiple studies have found that it is associated with poor outcomes (e.g. length of stay, in-hospital mortality, discharge disposition, and readmission), even after adjusting for additional factors such as

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age and severity of illness [2–6]. It has been estimated that the healthcare costs attributable to delirium in the US are as much as $152 billion per year [7].

There are a variety of predisposing and precipitating risk factors for delirium, but the full etiology of the syndrome is still poorly understood. Given the significant impact of delirium on patient outcomes, much emphasis has been placed on early detection and prevention strategies [8, 9]. Bedside testing methods have been developed, such as the Confusion Assessment Method[1] (CAM), to allow for the rapid and routine screening of patients for changes in mental status [10]. Tools like CAM can be used to identify patients for whom further evaluation is warranted to determine the underlying causes of and appropriate interventions for their delirium. In late 2012, Hartford Hospital began implementing thrice daily assessments of patients using CAM in non-critical care areas and CAM-ICU in critical care areas [11, 12].

In order for a patient to score 'positive' on the CAM, there must be acute onset and fluctuating course of symptoms, signs of inattention, and either/both disorganized thinking or altered level of consciousness. If those criteria are not met, the CAM is 'negative'; whereas if the assessment cannot be made with confidence, the patient is 'unable-to-assess' (UTA). Appropriate use of the UTA categorization is reserved for instances in which the patient is comatose or has a significant impediment preventing communication. Initial reviews of Hartford Hospital's CAM database revealed a relatively high frequency of the use of UTA by nursing staff. In addition, outcomes for patients who were unable to be assessed on CAM were nearly as poor as for those who had met the criteria for delirium. This would be expected if all UTA patients were critically ill, but such a determination can only be made by a comprehensive review of the medical records. To address this question, we used additional structured assessments in the EHR system that were concurrent with the CAM. UTA patients were clustered based on term co-occurrences, and outcomes of the patient clusters were compared. This approach helped elucidate common reasons for the use of UTA and defined which patient conditions contributed most to the poor outcomes observed in the group as a whole.

2. Materials and methods

2.1. EHR data

This retrospective, observational study was carried out at Hartford Hospital, which is an 800-bed teaching hospital in Hartford, Connecticut. The Hartford Hospital Institutional Review Board (Assurance #FWA000000601) approved the study and certified that it met the criteria for a waiver of the requirement to obtain informed consent. During the timeframe in which patient records were analyzed, Hartford Hospital used Sunrise Clinical Manager (SCM) (Allscripts, Chicago, IL) as the primary EHR system. For the analyses described here, patient records with recorded CAMs were identified from September 1, 2012 to June 17, 2015. The SCM provides fields in the nursing notes section for cognitive, neurological, and perceptual assessments, typically done once per eight hour nursing shift. A patient's state can either be identified as 'within defined limits' or exceptions can be recorded for level of consciousness, orientation, mood/behavior, speech, and motor response. The database provides a controlled vocabulary of 140 terms, as well as allowing free text entries. Assessments using only controlled vocabulary that were contemporaneous with a UTA CAM were identified by matching on the date and time recorded for each in the database query. Patient assessments in the ICU, PACU, or palliative care units, as well as those for patients with Richmond Agitation Sedation Scale (RASS) scores of −4 and −5 were excluded from the term frequency analysis (as shown in Fig. 2) to focus on non-obvious cases and those where the standard CAM was employed.

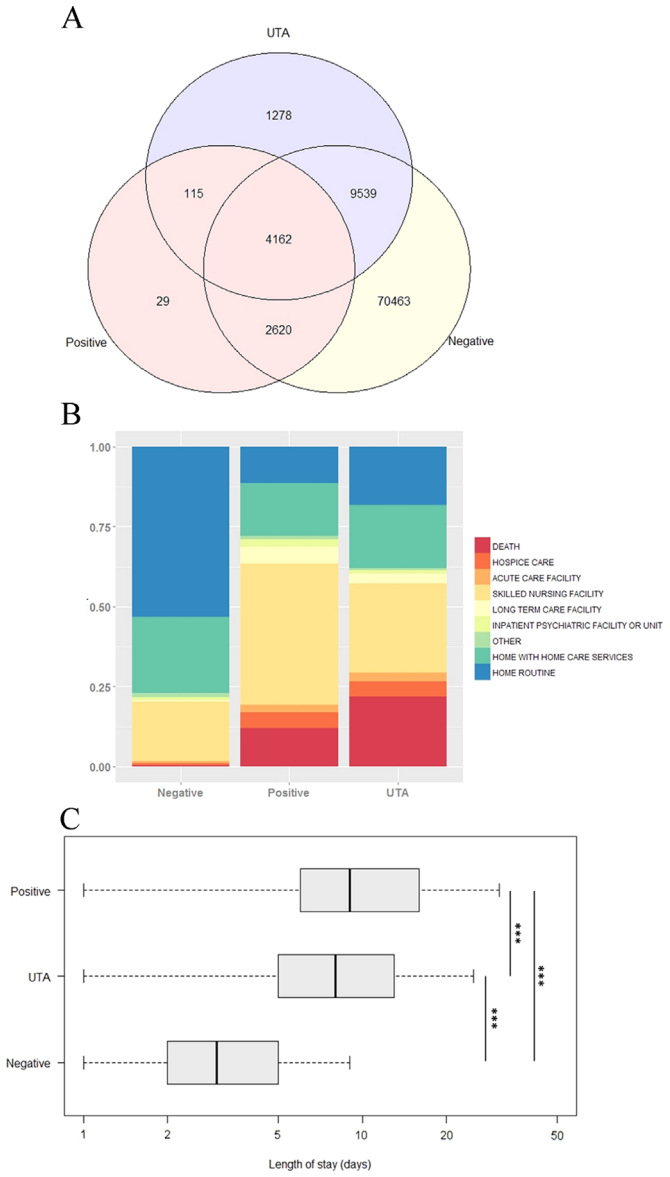

Fig. 1. Patient visits characterized by CAM and their outcomes A. Venn diagram depicting the numbers of patient visits with combinations of CAM results. Each circle represents all visits with at least one positive, negative, or UTA CAM. The coloring denotes the three non-overlapping CAM groups defined by their general pattern of assessments. The 'Positive' group (pink) consists of patient visits in which there was at least one positive CAM; the 'Negative' group (yellow) consists of patient visits in which the CAM was always negative; and the 'UTA' group (blue) consists of visits in which there was at least one UTA CAM, but no positives. B. Frequencies of discharge dispositions of the patients within the CAM groups defined in 1A, ordered from best (home routine) to worst (death). The different frequencies of in-hospital mortality, discharge to skilled nursing facilities, and home routine were most prominent. C. Distributions of the length of stay (LOS) for patients within the defined CAM groups. The box and whiskers plot displays the interquartile range (IQR) as the box, median as the bisecting line, and the minimum and maximum values as the whiskers. LOS is plotted on a log scale as it displays a log-normal distribution. The means of log(LOS) for all three groups differed significantly (***$p < 0.001$).

[1] Confusion Assessment Method. © 1988, 2003, Hospital Elder Life Program. All rights reserved. Not to be reproduced without permission. Instructions for correct usage available at: http://www.hospitalelderlifeprogram.org