

Development and validation of an automated delirium risk assessment system (Auto-DelRAS) implemented in the electronic health record system



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ABSTRACT

Background: A key component of the delirium management is prevention and early detection.

Objective: To develop an automated delirium risk assessment system (Auto-DelRAS) that automatically alerts health care providers of an intensive care unit (ICU) patient's delirium risk based only on data collected in an electronic health record (EHR) system, and to evaluate the clinical validity of this system.

Design: Cohort and system development designs were used.

Setting: Medical and surgical ICUs in two university hospitals in Seoul, Korea.

Participants: A total of 3284 patients for the development of Auto-DelRAS, 325 for external validation, 694 for validation after clinical applications.

Methods: The 4211 data items were extracted from the EHR system and delirium was measured using CAM-ICU (Confusion Assessment Method for Intensive Care Unit). The potential predictors were selected and a logistic regression model was established to create a delirium risk scoring algorithm to construct the Auto-DelRAS. The Auto-DelRAS was evaluated at three months and one year after its application to clinical practice to establish the predictive validity of the system.

Results: Eleven predictors were finally included in the logistic regression model. The results of the Auto-DelRAS risk assessment were shown as high/moderate/low risk on a Kardex screen. The predictive validity, analyzed after the clinical application of Auto-DelRAS after one year, showed a sensitivity of 0.88, specificity of 0.72, positive predictive value of 0.53, negative predictive value of 0.94, and a Youden index of 0.59.

Conclusions: A relatively high level of predictive validity was maintained with the Auto-DelRAS system, even one year after it was applied to clinical practice.

What is already known about the topic?

- Patient safety has emerged as a significant issue, especially in critical care settings, due to its serious impact on patient outcomes.
- An automated risk assessment system is one of the most effective solutions for enhancing nursing care quality and patient safety.

What this paper adds

- An automated delirium risk assessment system (Auto-DelRAS) successfully identifies delirium risk using clinical data from electronic health records without the need for nurses' assessment.
- The Auto-DelRAS can facilitate the recognition of intensive care unit patients at high risk for delirium.

1. Introduction

Delirium is a multifactorial, characterized by acute fluctuating change in mental status and disorders of consciousness, and may occur suddenly, especially in intensive care unit (ICU) patients (American Psychiatric Association, 2013). The occurrence of delirium is related to extended ICU stays, is associated with an increase in mortality and medical costs, and may cause chronic damage to cognitive functions (Ely et al., 2004; Girard et al., 2010; Hamdan-Mansour et al., 2010; Inouye et al., 2014; Milbrandt et al., 2004; van den Boogaard et al., 2012a,b). There are several delirium-screening instruments that can be used by critical care nurses for the early detection of delirium. The CAM-ICU instrument is especially well established in terms of validity and reliability (Luetz et al., 2010; van Eijk et al., 2009).

Prevention, early detection, and prompt treatment are key in providing optimal care for patients with delirium, and a reliable systematic

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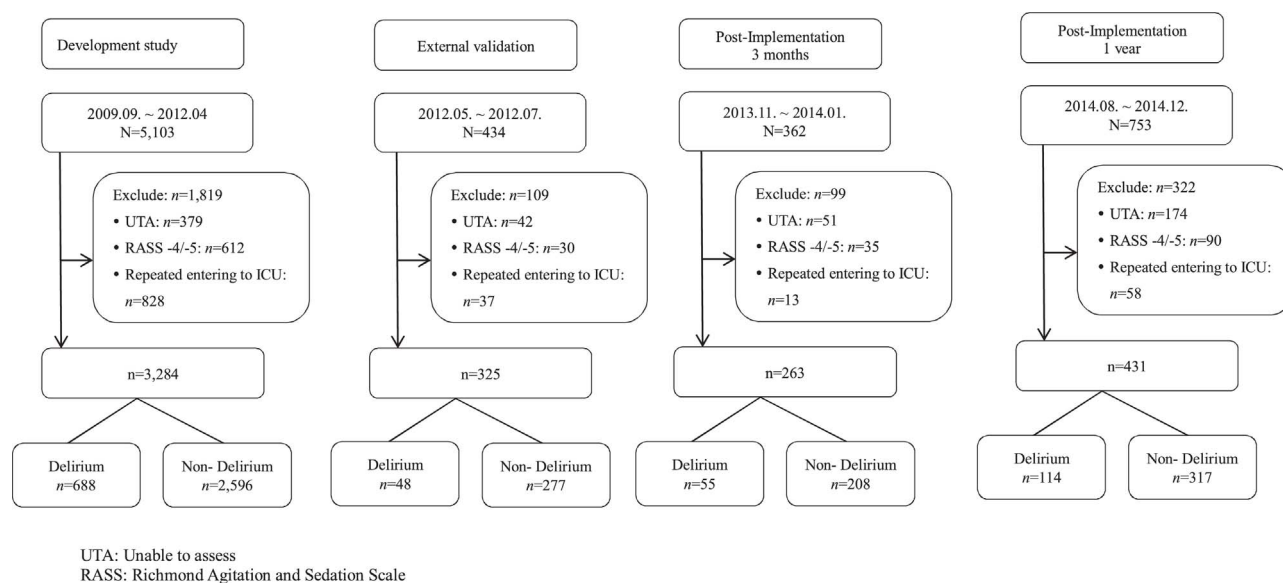


Fig. 1. Patients selection flow chart.

delirium risk assessment can improve the early detection and treatment of delirium (Pisani et al., 2009; Sendelbach et al., 2009; Spronk et al., 2009). An assessment that allows the prevention of delirium could reduce the occurrence of delirium, and limit the impact of the disease and the length of the hospital stay. Also, a preventive assessment for delirium could reduce the risk of adverse events associated with the use of unnecessary medications (Boorsma et al., 2011). The delirium assessment of ICU patients who experience a high frequency of delirium is time-sensitive (van den Boogaard et al., 2012a,b, 2014). A delay in the initiation of delirium therapy has been associated with an increase in the risk of death in ICU patients, and early treatment may decrease the rate of progression to multi-organ failure (El Hussein et al., 2014).

The current electronic health records (EHR) system is designed to aid clinical decision making. Utilization of the electronic health records system is increasing, and extensive and varied clinical data are being collected (Levy and Heyes, 2012). Delirium prediction models with proven predictive validity have been developed for general hospital ward patients, elderly ICU patients, and ordinary ICU patients with 0.77–0.87 of AUC (Area Under the receiver operating characteristics (ROC) Curve) (Inouye et al., 1993; Pisani et al., 2007; van den Boogaard et al., 2012a,b, 2014).

However, delirium awareness remains low in the ICU setting and delirium assessment lacks priority in medical and nurses caring for critically ill patients (Hamdan-Mansour et al., 2010; Jung et al., 2013). If risks of delirium were assessed automatically and this assessment could be used to warn nurses of the risk, preventative nursing measures could be implemented in a timelier manner. Therefore, the aim of this study was to develop an automated delirium risk assessment system (Auto-DelRAS) that automatically alerts health care providers of an ICU patient's delirium risk based only on data collected in the electronic health records system, and to evaluate the clinical validity of this system.

2. Materials and methods

2.1. Study design

The Auto-DelRAS was developed from data extracted from the electronic health records and was subsequently implemented into the electronic health records system after development. The research process consisted of the following 4 stages: 1) development of the delirium risk scoring algorithm, 2) external validation of the delirium risk

scoring algorithm, 3) construction of the Auto-DelRAS, and 4) validation of the system after clinical application.

2.2. Setting

The Auto-DelRAS was developed and applied at a 1355-bed university hospital that has utilized an EHR system since October 1, 2008. The study focused on the medical (MICU) and surgical intensive care units (SICU), with a total of 44 beds. The ratio of the day-duty nurses to patients was 1:2.2, and the ratio of evening and night-duty nurses to patients was 1:2.5. The average length of stay was 9.9 days for medical intensive care unit patients and 3.2 days for surgical intensive care unit patients. External validation of the delirium risk scoring algorithm was performed at a 500-bed hospital that was affiliated with the same university.

2.3. Patients

Among study patients, delirium patients were those determined to have delirium, while non-delirium patients were those who did not have delirium during their hospital stay at the same time period. We included patients aged 18 years or older and those who stayed at least one night in the ICU. We excluded the following patients from the study: patients who had severe psychiatric or neurologic diseases, severe visual or auditory impairments that made communication impossible, and patients in deep sedation who did not react to strong stimuli (−4 or −5 scores on the Richmond Agitation and Sedation Scale) (Fig. 1). For the repeated admissions, only the first admission was included.

For each research stage, patients were selected as follows. Patients selected for the development of the risk scoring algorithm were those who were admitted to and discharged from the medical or surgical ICU from September 2009 to April 2012. The total number of patients was 3284 and included 688 (21%) delirium patients and 2596 (79%) non-delirium patients. For the external validation of the risk scoring algorithm, we selected patients who were admitted to and discharged from the medical or surgical ICU in the 500-bed affiliated hospital from May 2012 to July 2012. There were 325 patients, including 48 (15%) delirium patients and 277 (85%) non-delirium patients. To evaluate the predictive validity of the Auto-DelRAS at three months and one year after it was applied in clinical practice, we selected 55 (21%) and 114 (26%) delirium patients and 208 (79%) and 317 (74%) non-delirium

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