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## The Development and Evaluation of Delirium Assessment and Nursing Care Decision-Making Assistant Mobile Application for Intensive Care Unit

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> Abstract. Delirium is a common complication among patients in ICU settings. Although it has been repeatedly confirmed that Confusion Assessment Model for Intensive Care Unit (CAM-ICU), one of the most commonly used ICU delirium assessment tool, is highly accurate in validation studies, it's sensitivity and specificity is relatively low during routine practice among bedside nurses. The aim of this study is to develop a mobile application (app) to detect delirium and to test its reliability and validity both by research nurses and among ICU bedside nurses. The app was programmed with Java and installed on a mobile device with Android system. After completion of reliability and validity testing, the app will be integrated into the existing Hospital Information System in order to automatically retrieve essential information for risk factor identification and formulation of care plan accordingly to prevent or manage ICU delirium.

> **Keywords.** ICU delirium ; mobile application ; Confusion Assessment Model for Intensive Care Unit ; diagnostic test study ; usability evaluation

### 1. Introduction

Delirium is one of the most common complications among ICU patients. The reported incidence for delirium ranged from 30%-83.3% depends on patient population studied <sup>[1-2]</sup>. ICU patients developed delirium will have adverse short and long-term outcomes, such as increased incidence of complications and prolonged ICU and hospital stay, impaired cognitive function, and even increasing mortality <sup>[3]</sup>. Evidences have shown that routine assessment could effectively reduce the risk for developing delirium or early detect the occurrence of delirium therefore reduce the severity/duration of delirium, and reverse the adverse outcomes related to delirium <sup>[4]</sup>. It is recommended by American College of Critical Care Medicine that delirium should be monitored routinely (at least every day, better each shift) using Confusion Assessment Model for Intensive Care Unit (CAM-ICU) for ICU patients <sup>[5]</sup>. Although the sensitivity and specificity of CAM-ICU in detecting delirium is reported repeatedly high (> 90%) in various research papers from different countries, the accuracy in detecting delirium

is relatively low when used in routine practice among bedside nurses (it's sensitivity is only around 50%)<sup>[6-7]</sup>. The reason for such result maybe complicated, lack of adequate training, inaccurate and incomplete interpretation of assessment data or using variable patient baselines when making diagnosis are possible causes for misdiagnosis or missed diagnosis of delirium in ICU settings. To our knowledge, there is no smart app exists.

The purpose of this study are: (1) to develop a standardized and easy to use mobile CAM-ICU delirium detecting app with incorporation of automatic risk factor identification and personalized delirium care planning for bedside nurses; (2) to evaluate its reliability and validity in detecting delirium using diagnostic testing study design; (3) to evaluate its reliability and validity in detecting delirium by ICU bed side nurses during routine practice; and (4) to evaluate its effects on assisting decision making of patient management among bedside nurses and physicians as well as patient's clinical outcomes.

The study is conducted by nursing students and computer science students through collaboration between Capital Medical University and National Yang-Ming University.

#### 2. Methods

The study incudes four stages:

## 2.1. Stage I: Development of the Alpha Version of mobile app and evaluation of its usability.

The Alpha Version of the app was designed with Java and installed on a mobile device. A modified usability evaluation questionnaire based on Technology Acceptance Model (TAM)<sup>[8]</sup>, which includes four domains and 46 items and rated with 5-Likert scale, was used **to test the usability of the developed app**. Convenience sampling was used and ICU nurses from three hospitals were recruited.

## 2.2. Stage II: Revision of the Alpha Version and evaluation of its reliability and validity.

The Alpha Version of the mobile app was refined based on the result of stage I to reprogram the mobile app in terms of its user friendly interface/layout, ease of use, and usefulness to create the Beta Version (Fig 2). Risk factors and nursing intervention options is integrated into the app.

We followed the GB17859-1999 "Classification Criteria for Security Protection of Computer Information System" codes and the GB/T 18336-2001 "Information Technology Security Evaluation Criteria" codes on confidentiality and safety. Both of them are national standards in china and are equivalent to the principles of US Trusted Computer System Evaluation Criteria (TCSEC) and ISO/IEC 15408 respectively. Data transmission was secured with SSL protocol.

Its reliability and validity is evaluated using diagnostic test study design and the diagnosis of delirium from a psychiatrist using Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) is used as the gold standard. Each patient in four ICUs of Chaoyang hospital is assessed with the mobile app and the CAM-ICU

paper version by two nurse investigators, and by the psychiatrist separately but within 2 hours. Both the two nurse investigators and the psychiatrist are blinded to each other's assessment results.

# 2.3. Stage III: Evaluation of its reliability and validity in detecting delirium by ICU bed side nurses during routine practice

The validated CAM-ICU app is installed into ICU nurse's PDA they used in their daily practice, and incorporated into the Hospital Information System in our affiliated hospitals. Sensitivity and specificity will be determined through a diagnostic test study design and using DSM-IV as the gold standard. Nurses from four ICUs in our affiliated hospital will use the app to assess their patients between 9 am and 11 am in their routine practice. The psychiatrist who are blinded to the results of bedside nurses' assessment will also assess these patients during this time frame to ensure that the patients are in the same condition.

2.4. Stage IV: Effects of the mobile app on nurses' and physician's actions and patient's clinical outcomes

A concurrent controlled clinical trial study will be conducted during stage III. Our another affiliated hospital will be used as control. ICU nurses in the intervention hospital will use the mobile app routinely to detect delirium among admitted patients, and ICU nurses in the control hospital will conduct neurological assessment in their daily practice. Data on nurses' actions and physicians' actions in terms of delirium prevention and management, incidence of delirium, short term hospital outcomes, and ICU and in-hospital cost will be collected prospectively.

### 3. Results

# 3.1. Stage I: Development of the Alpha Version mobile app and evaluation of its usability.

The screenshots of the app (Version Alpha) are shown in Figure 1. The app was programmed to automatically retrieve baseline data for comparison and provide the result on whether or not the patient has delirium. One hundred and two nurses from ICU settings of three hospitals completed the questionnaire after using both mobile and regular paper CAM-ICU tools. The mean score of the four domains are: perceived usefulness: 4.09-4.22, perceived ease of use: 4.07-4.33, attitudes towards usage: 3.90-4.16, behavior intention to use: 3.97-4.24.

### 3.2. Stage II: Revision of the mobile app and evaluation of its reliability and validity.

Refining the interfaces was conducted through Axsure to prototype the mobile app layout and customize the functional components (Version Beta, Figure 2) base on the result of stage I. The final layout of the mobile app was completed through Java programing (Final Version, Figure 3), and is finalized after multiple testing until the research investigator and try-use nurses were satisfied with its layout and function. **The**  **technical architecture of the mobile app is shown in Figure 4.** The reliability and validity of the final version are currently under investigation. By now, there are 45 patients has been enrolled in this study.





Figure 1. Screenshots of the mobile app (Version Alpha)





Figure 3. Final version and the flow chart of the mobile app



Figure 4. The technical architecture of the mobile app

*3.3. Stage III: Evaluation of its reliability and validity in detecting delirium by ICU bed side nurses during routine practice* 

This will be ready for NI2016 (June 2016)

3.4. Stage IV: Effects of the mobile app on nurses' and physician's actions and patient's clinical outcomes

This will be partially ready for NI2016 (June 2016)

### 4. Discussion

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The mobile CAM-ICU app we developed has interfaces that are user friendly and easy to use. The evaluation study indicated that its accuracy was identical to it's regular paper form but was easier to use compared with the regular paper form. The full discussion will be completed after having all the results.

### 5. Maturity at presentation

At the time of presentation, we will be able to present the result of Stage II and Stage III. We will showcase a complete delirium assessment process, decision-making assistance with delirium risk factor identification and individualized preventive and management interventions at presentation.

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