



Development of Smartphone Application That Aids Stroke Screening and Identifying Nearby Acute Stroke Care Hospitals

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Received: January 24, 2013

Revised: June 8, 2013

Accepted: June 17, 2013

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The authors have no financial conflicts of interest.

Purpose: The benefits of thrombolytic treatment are time-dependent. We developed a smartphone application that aids stroke patient self-screening and hospital selection, and may also decrease hospital arrival time. **Materials and Methods:** The application was developed for iPhone and Android smartphones. Map data for the application were adopted from the open map. For hospital registration, a web page (<http://stroke119.org>) was developed using PHP and MySQL. **Results:** The Stroke 119 application includes a stroke screening tool and real-time information on nearby hospitals that provide thrombolytic treatment. It also provides information on stroke symptoms, thrombolytic treatment, and prescribed actions when stroke is suspected. The stroke screening tool was adopted from the Cincinnati Prehospital Stroke Scale and is displayed in a cartoon format. If the user taps a cartoon image that represents abnormal findings, a pop-up window shows that the user may be having a stroke, informs the user what to do, and directs the user to call emergency services. Information on nearby hospitals is provided in map and list views, incorporating proximity to the user's location using a Global Positioning System (a built-in function of smartphones). Users can search for a hospital according to specialty and treatment levels. We also developed a web page for hospitals to register in the system. Neurology training hospitals and hospitals that provide acute stroke care in Korea were invited to register. Seventy-seven hospitals had completed registration. **Conclusion:** This application may be useful for reducing hospital arrival times for thrombolytic candidates.

Key Words: Thrombolysis, smartphone, emergency delivery service, stroke

INTRODUCTION

The benefits of thrombolytic treatment are time-dependent,¹ and early patient arrival at a hospital that provides thrombolytic treatment is critical. Early recognition of stroke symptoms, rapid screening, accurate information on nearby hospitals that provide acute stroke care, and rapid dispatch can reduce the delay in thrombolytic treatment, which may improve patient outcomes. There have been several efforts to reduce time interval from stroke onset to initiation of the thrombolytic treat-

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ment. Recently, information technologies, such as computerized physician order entry system and mobile, real-time audio-video streaming telemedicine devices,^{2,4} have been successfully implemented in this process that aims at reducing in-hospital or pre-hospital time delay.

Smartphones are becoming widely used for medical purposes.^{5,6} The benefits of smartphones include portability, easy accessibility, and location sensing frameworks that use a Global Positioning System (GPS). We therefore developed and introduce ‘Stroke 119’, a smartphone application that aids rapid stroke screening and may reduce hospital arrival time for stroke patients.

MATERIALS AND METHODS

We developed a smartphone application named “Stroke 119”, which refers to the emergency telephone number in Korea (equivalent to 9-1-1 in the United States). Stroke 119 was developed for multi-platforms, including iPhone™ (<https://itunes.apple.com/kr/app/noejoljung119/id509755048?mt=8>) and Android™ smartphones (<https://play.google.com/store/apps/details?id=com.jnheo.stroke119>), using the iPhone software development toolkit (SDK 3.0, Apple Inc., Cupertino, CA, USA)⁷ and the Android SDK (SDK r20.0.3).⁸ Map data for the application were adopted from the open map (Daum map API v3, Daum Comp., Seoul, Korea).⁹ For hospital registration, a web page (<http://stroke119.org>) was developed using PHP and MySQL.

The Stroke 119 application was developed as a hybrid app, meaning that the map portion of the app was made as a

web application, thus ensuring that all hospital map data are up-to-date and identical across the platforms. Distances between hospitals and the user are calculated on the server-side, making the application faster and more reliable. A distance calculation algorithm was adopted from the Haversine formula.¹⁰

RESULTS

Components of the Stroke 119 application

The Stroke 119 application includes a stroke screening tool and real-time information on nearby hospitals that provide thrombolytic treatment. It also provides information on stroke symptoms, thrombolytic treatment, and prescribed actions when stroke is suspected.

Rapid stroke screening tool

A stroke screening tool was adopted from the Cincinnati Prehospital Stroke Scale (CPSS).¹¹ The CPSS was developed to help emergency medical technicians and paramedics screen stroke patients. The CPSS is a 3-item scale based on a simplification of the National Institutes of Health Stroke Scale. The CPSS evaluates the presence or absence of facial palsy, asymmetric arm weakness, and speech disturbances in suspected stroke patients.^{11,12} In the Stroke 119 application, cartoon figures for facial palsy and arm weakness, and commands to read a sentence to judge speech disturbances, are displayed one-by-one (Fig. 1). If a user taps a cartoon representing abnormal findings, a pop-up window shows that the user may be having a stroke, informs the user

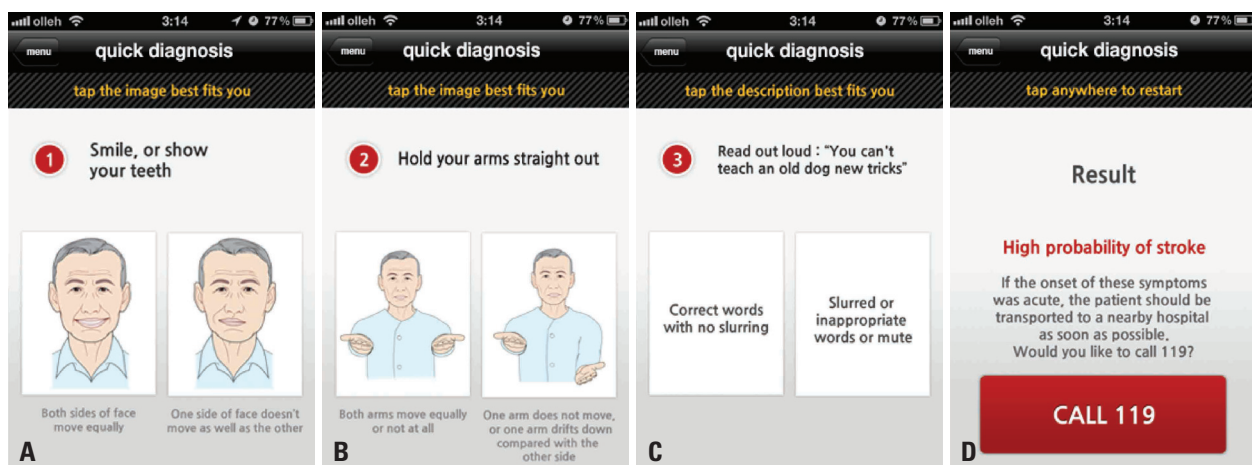


Fig. 1. Stroke screening tool. Cartoon figures for facial palsy (A), arm weakness (B), and a command for reading a sentence to judge speech disturbances (C) are displayed one-by-one. A user can select a cartoon image by tapping the screen. When the user taps a cartoon image representing abnormal responses, a pop-up window shows that the user may be having a stroke, informs the user to go to a hospital immediately, and asks if the user wants to call 1-1-9 (emergency phone number) (D). If the user taps the “Yes” icon, the application connects to 1-1-9 immediately. These screen shots are translated into English.

to go to a hospital immediately, and directs him/her to call emergency services.

Finding nearby hospitals

Information on nearby hospitals is provided using GPS, which is a built-in function of the iPhones and most of the Android smartphones. The application displays the nearest hospitals in a map view and a list view. In the map view, both the nearest hospitals and the user's location are shown on the map. In the list view, the nearest hospitals are given based on proximity to the user. The user also can view hospitals according to the level of specialty and treatment by using the option menu (Fig. 2).

Registration of hospitals

Requested information at the time of hospital registration included: 1) availability of specialties such as neurology, neurosurgery, and emergency department, 2) availability of specific treatments including IV thrombolysis, intra-arterial thrombolysis, and brain surgery, 3) presence of a stroke unit, and 4) the hospital's address, emergency telephone number, and hours of operation (Fig. 2). Upon receiving a hospital's submission to register via the web page, an administrator reviewed the information provided and approved the site.

Neurology training hospitals and hospitals that provide acute stroke care in Korea were invited to register their hospital information on the website. Seventy-seven hospitals

had completed registration at the time of submission of this manuscript and were approved. The hospitals are located all over the country.

DISCUSSION

The Stroke 119 application may be useful for effective thrombolytic treatment in several ways. Simple screening tools have been developed for rapid and easy diagnosis of stroke. Although these screening tools are reliable,^{11,13} their widespread use is limited because the user needs to have the screening protocol on hand. Previously, these tools were tested on emergency delivery service personnel. With our application, the screening tool is on hand as long as the user has a smartphone; the Stroke 119 application therefore can be used in the general population.

Although smartphones are increasingly used for medical purposes, almost all applications were ones that provide medical information on hand using their portability. However, their usefulness can be expanded by using built-in functions of the smartphones such as the GPS and gyrometer. Use of the GPS is a notable feature of the Stroke 119 application, which enables the application to determine a user's location and search for nearby hospitals. This allows stroke victims, witnesses, and emergency delivery service personnel to find nearby hospitals that provide thrombolytic

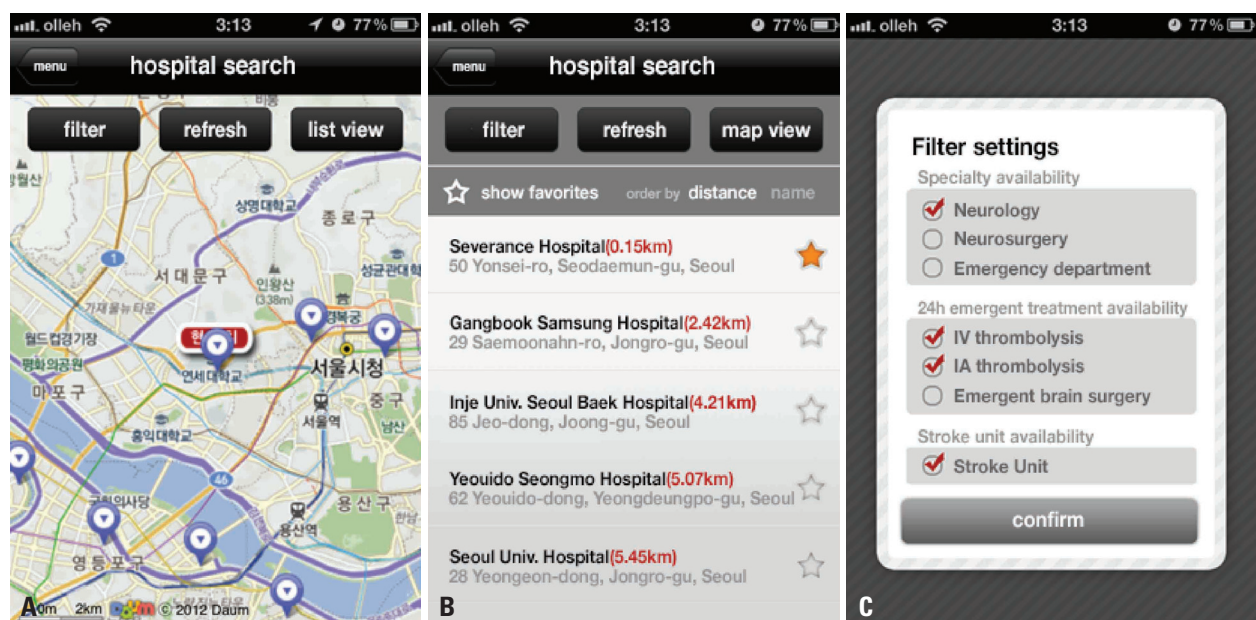


Fig. 2. Finding nearby hospitals. The Stroke 119 application provides information on nearby hospitals in a map view (A) and a list view (B). In the map view, both the user's location and nearest hospitals are displayed on the map (A). In the list view, the nearest hospitals are shown with the closest hospitals at the top of the list (B). By using option menu, the user can select hospitals according to their specialty, available treatments, and the presence of a stroke unit (C). These screen shots are shown translated into English.

treatment in real time. Stroke patients, who lack information on an appropriate stroke care hospitals, may visit hospitals far from their location or hospitals that are not ready to provide the thrombolytic treatment, which may delay the thrombolytic treatment, as it was demonstrated in previous studies in that referral from other hospital was associated with delayed arrival to an appropriate acute care hospital.^{14,15} Therefore, the Stroke 119 application may facilitate finding hospitals that provide thrombolysis, thus shortening hospital arrival times.

While this application might be useful for the general population, the primary target of this application would be stroke patients or their families, who are admitted to the hospital or visited outpatient clinic, as well as paramedics of the emergency delivery services. Stroke patients and/or their families can easily download it while they were being admitted and when stroke nurses or physicians provide stroke education at discharge for them, or the patient visits to the outpatient clinic.

The usefulness of this application may depend on the accuracy of information provided by the registered hospitals. We primarily invited neurology training hospitals and hospitals that provide acute stroke care for registration because they are accessible within one or two hours in most areas of Korea, and play major roles in acute stroke care.^{16,17} In countries with a certification system for primary stroke centers or stroke units, those certified hospitals also could be included in registration. Early arrival at a hospital and identification of the nearby hospitals that provide an appropriate care are critical in other medical conditions such as acute myocardial infarction and trauma as well as acute stroke. The concept, which uses a rapid screening tool and the GPS for helping stroke victims find nearby hospitals, can be applicable also in those emergent conditions.

This study has limitations. This application has been developed based on hypothesis that the use of application may reduce the time intervals from stroke onset to hospital arrival of a stroke victim, and the frequency of referrals from other hospitals that do not provide thrombolytic treatment. Although this hypothesis was based on solid evidence that the Cincinnati Prehospital Stroke Scale is valid, and that referral from another hospital is a significant factor of delayed presentation, we could not provide data on the effectiveness of this application. Therefore, it is inconclusive that this application can improve patient outcome in real practice.

In conclusion, we developed a smartphone application that provides rapid self-screening for stroke, identifies nearby

hospitals that provide thrombolytic treatment, and facilitates calling emergency services. This application may reduce hospital arrival times and delays of thrombolytic treatment.

ACKNOWLEDGEMENTS

This study was supported by a grant from the Korea Health 21 R&D Project, Ministry of Health & Welfare, Republic of Korea (HI10C2020).

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