A SMARTPHONE APPLICATION FOR REMOTE WOUND TREATMENT AND DOCUMENTATION COMPLIANCE

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INTRODUCTION AND BACKGROUND

According to the Pressure Ulcer Awareness Program (PUAP), one in four people in any healthcare or homecare facility has a pressure ulcer (bedsore) at any given time. In Canada, the overall prevalence of pressure ulcers was reported to be 26%, for which a 100-bed facility can expect to spend more than $750,000 annually on their treatment. Pressure ulcers are lesions caused by many factors, including unrelieved pressure, friction, humidity, temperature, age, continence, and medication. They can occur on any part of the body, especially portions over bony or cartilaginous areas such as sacrum, elbows, knees, ankles etc. Although easily prevented and completely treatable if found early, pressure ulcers can become chronic and lead to secondary infections and may become fatal – even under the auspices of medical care. Pressure ulcers are one of the leading iatrogenic causes of death reported in developed countries, with patients in long-term care and the elderly being particularly vulnerable. The development of pressure ulcers also directly impacts quality of life, as patients with pressure ulcers face additional stress due to loss of independence and social isolation [1][2][3].

For more than a decade, various national and international organizations have been working to improve outcomes in pressure ulcer prevention and therapy by consistent research, education and the implementation of different policies and procedures [4]. Risk assessment and regular standardized documentation are identified as critical steps in the prevention and treatment of pressure ulcers [5]. The biggest challenges in controlling and treating pressure ulcers are non-compliance to protocol and inconsistency of documentation. Data are often non-specific [6] or incomplete relative to documentation [7].

While standardized paper forms have been created to document wound care, they are often cumbersome and overly lengthy for healthcare workers (HCWs, including MDs and RNs) already taxed for time. Some studies indicate that poor wound documentation may be preventing hospitals from fully ascertaining early assessment and care for at-risk patients, and as such, other alternatives in assessing and documenting wounds should be explored [4][8]. As a result, attention is focused on electronic information systems. After extensive studies, Thede & Murray [9] conclude that electronic charting models ensure better document accessibility, information sharing among hospital units, improved accuracy of documentation and consume less nursing time. Ultimately, electronic documentation can lead to better pressure ulcer assessments, documentation and treatment.

This research proposes that better compliance and higher consistency in documenting wounds and wound care can improve the patient and HCW experiences, enhance care, and potentially lead to better health outcomes.

The research objective was to develop an interactive web-based software application on a cellular device (3G/4G Smartphone) to allow HCWs to electronically document patients' pressure ulcers in order to facilitate a higher level of compliance in wound care and documentation of care. The application would be used by HCWs in hospitals and personal care homes, and by home-based caregivers (homecare provider or family member) caring for a patient within the residence. When used in home-based care by HCWs and informal caregivers (family members), the application could be extended beyond documentation of the wound care to include a transfer of information and treatment instructions between the home-based caregiver and the discharging service, or between HCWs and caregivers in remote communities and discharging services in major centres.

There are currently an unprecedented number of technologies being developed or ported to the

healthcare community, leveraging existing and emerging technologies. However, the range of available applications are not well catalogued. Thus, it is difficult to state the current scope, specificity, and demonstrated value of healthcare apps that are available for iPhone or Android. While many apps are consumer-oriented (self-management of health issues), an increasing proportion are targeting for use by HCWs, focusing on continuous education, remote monitoring, and/or healthcare management. More specifically, access to electronic health records, and monitoring and coaching of chronic health conditions such as diabetes are some more well-vetted applications.

SYSTEM DESIGN

The design plan was to incrementally build a prototype Smartphone application that could be developed and vetted within a healthcare setting in addressing wound care documentation, where each device running the application would be associated with a unique HCW (vs. the device being associated with a unique patient). The current application is a work-in-progress, with a functional prototype on an Android platform. The Android operating system was chosen because of its availability and popularity.

Requirements Gathering

The interface needed to be designed such that it would maximize user compliance and value of the data for caregivers. Also, to reduce any potential confusion by users, simplicity of the user interface needed to be maximized, and potentially varied between an institutional healthcare version and a lay (plain-language) homecare version. Toward these ends, the number of visual elements on each screen needed to be minimized in order to reduce clutter and show only important and relevant information. Also, the number of steps required to complete common tasks needed to be minimized to reduce time spent, and intuitive guidance leads the user only to the areas of the form applicable for the given patient.

In addition to replicating the paper-based reporting forms, the application needed a way to: determine the location of each wound, assess the severity of each wound, allow users to record new wound locations, allow users to update old wound assessments, allow users to describe wound treatments administered, allow users to view the history of each wound, and provide users with treatment recommendations based on the history of a wound. These requirements would be implemented through the conversion of the paper-based forms currently used at Riverview Health Centre to electronic-based forms. Additional functionality was determined for implementation, including visual patient charts, possible utilization of a device's built-in camera, adding new patient profiles from the application itself, and providing security via a user login screen. The application also provides additional intelligence through pre-set programmable alerts or alarms for conditions including, but not limited to, wounds present longer than set durations, wounds that have been deteriorating for longer than a pre-set duration or a pre-set rate, and anomalies in data entry. Additional considerations included the device's role in infection control, integration potential with electronic medical records, the electronic file as a legal document, and the interface with a facility's IT infrastructure.

At Riverview Health Centre, a long-term care centre in Winnipeg, Canada, HCWs caring for patients' pressure ulcers use a paper-based form called the Pressure Ulcer Scale for Healing (PUSH) Tool, developed by NPUAP [www.npuap.org]. The PUSH Tool was created as a quick and reliable tool for HCWs to monitor the progression or regression of a pressure ulcer over time. The PUSH Tool requires HCWs to fill in four fields: the location of the wound, the surface area of the wound, the amount of exudate from the wound, and the tissue type of the wound. Each field, except for the wound location, uses Likert-type scale values which are associated with a number. For a HCW to determine the severity of a wound, each number is added together and the result represents the wound's score (out of 17). Every week, each PUSH form needs to be updated until each wound has completely healed. The initial goal of the project was to integrate the PUSH form into an electronic version. However, in order to implement all requirements, new forms needed to be introduced. These forms include treatment plan forms, additional wound information forms, and new patient forms (when adding a new patient to the database).

Application Functionality

Data entry should minimize opportunities for free-lance comments, in order to minimize the

variation in how a wound is described between HCWs. Thus, images representing the front and back sides of a human body allow users to slide their fingers on the screen and pinpoint the location of the wound (Figure 1). For consistency, the same technique is followed when users select a wound to view its history, or update a wound in a new PUSH form. For each initial assessment, the body part can be selected from the screen, and the wound location entered in more detail. Subsequent assessments omit this step.

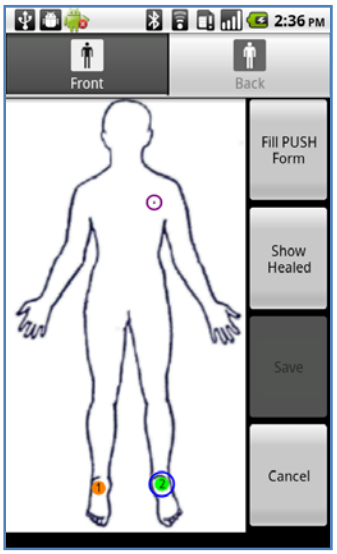

Figure 1. The device's touchscreen

Since the prototype application uses a small-sized touchscreen, the need to type using the onscreen keyboard should be minimized. Simple widgets such as checkboxes and spinners were used for increased simplicity and consistency.

Each user has the ability to graphically view all pressure ulcers on a patient (Figure 2). Each patient is represented by two pictures: the front and back outlines of a human body. Colored circles represent a pressure ulcer. The resulting score of a PUSH assessment indicates the severity of a wound, with each wound color representing the a degree of severity. This color-coding allows users to quickly see which pressure ulcers need the most attention. Each circle contains a number which represents the wound ID. Healed wounds can be hidden or shown, as well as updated again since it is common for patients to have reoccurring pressure ulcers in the same location. Users can also read, as text, general patient information (first and last name, date of birth, etc.), the number of pressure ulcers present and healed, and the locations of each wound.

Given the series of PUSH scores, a HCW can determine if a wound is healing or deteriorating. This motivated the feature of graphically showing a patient's PUSH scores for each pressure ulcer over time on a chart (Figure 3).

To allow HCWs to determine treatment plans, the previous treatments need to be reviewed. To facilitate this, a separate form specifically for treatments needed to be included. To maximize user compliance, all additional forms are presented as optional, and would only be exposed if the user chooses them. The application includes a notification feature, reminding HCWs of all patients that are due for a wound reassessment.

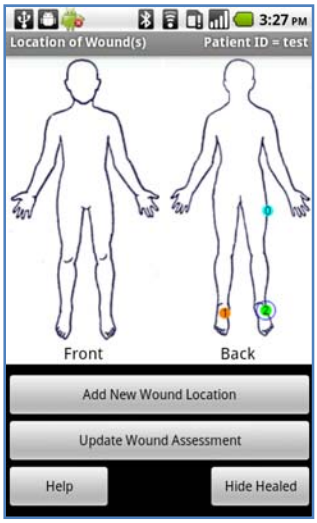

Figure 2. Overall wound locations

Figure 3. Graphical representations of history

The application may use the Smartphone's built-in digital camera (if present) to further document a wound for each assessment. This feature would require strict protocols establishing

how a photo is taken (lighting, angle, distance from the wound). A server-side administrative preference could be implemented to accept or reject photos sent from clients.

Privacy of personal health information and medical records are critical priorities. Each user will be assigned a user ID and password for secure login, which will connect to a server to confirm access rights. All data will be stored server-side. All user IDs and passwords will only be granted from an administrative standpoint, run by a separate server-side application. All messages sent from either client or server will be encrypted, then decrypted upon the arrival.

Network Architecture & Design

A centralized server will hold patient and HCW records and data. Encrypted messages will be passed back and forth from server to client over a network, allowing for the information exchange. Depending on the location of each client, any device running the wound care application is able to communicate with a server via a Wi-Fi or 3G/4G internet connection. HCWs would most likely have access to a Wi-Fi connection at their facility, while home-care givers and remote caregivers may rely on cellular services. The overall network architecture of the system is not predefined in terms of the location of the server. In a healthcare setting, the location of the server would most likely be in the same institution. However, it is also possible for the server to be located externally. If the server was to be shared among numerous institutions, additional privacy measures need to be considered to prevent access to or viewing of records from different facilities. Having one centralized server would allow for privileged, server-side applications to data-mine for anomalies with a larger data set. The backend database can then be fused with the existing and evolving hospital patient records system. Being IP-centric overall, all public internet security protocols would be integrated.

Application and Device Extensions

The wound care application framework was designed to facilitate extensions to other platforms (iPhone, BlackBerry, device-agnostic HTML5) and other wounds (e.g. surgical wounds). Additionally, extensions can include the reporting of other medical conditions (for example, monitoring of blood pressure, body weight, blood sugar, depression screening, dementia screening.

SUMMARY AND FUTURE WORK

The current work is preliminary in status. To date, the work-in-progress has been directed toward the development of a prototype application on the Android platform, which serves as a proof-of-concept of the viability of the technology for one particular patient care application. Besides extensions to other platforms, the evaluation of the application's performance, efficacy, ease of use, and patient and HCW satisfaction are pending.

The application builds a framework for a range of potential follow-on projects that could include further development and evaluations in clinical trials. The research has considerable practical significance: documentation of wound care, and caregiver and patient experiences are expected to improve through this work, potentially facilitating mitigation of pressure ulcer development and progression. The work advances the area of healthcare applications and the increasing prevalence of e-health in nursing practice.

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