A Telehealth Framework for Mobile Nursing: Improving Patient Medical Record Management and Staff Communications

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Abstract— **There is an increasing need for health treatments to be delivered in homes rather than in the healthcare institutions due to its convenience. Nepean Outreach Services (NOS) based at the Nepean hospital aims to provide care for patients recently discharged in their home environment. Care provided by NOS is managed using patient medical records (PMRs) and communication amongst various nursing, medical and specialist staff. Current methods of recording PMRs and communication are problematic. Patient data is difficult to access; communication method between staff is limited. This study proposes a new Telehealth framework specifically designed for NOS. Our framework aims to improve PMR management and enhance the quality and consistency of communication between the NOS staff. We exemplify our framework with a custom-built Outreach App for a mobile device (iPad) which was deployed at the NOS clinic for experimental evaluations. The App provides functions to efficiently take PMRs by capturing written and visual data at the patient's home, as well as the ability to share the data via Cloud-based services (HealthVault) and facilitate video-conferencing communications between NOS staff.**

Keywords— **Mobile nursing, Telehealth, mHealth, Telehealth Deployment; Mobile technology.**

I. INTRODUCTION

Nepean Outreach Service (NOS) is a multidisciplinary health service based at Nepean Hospital and operates with surrounding communities. NOS offers infusion, day only and hospital in the home services. Patients receiving care from NOS are treated in their homes by mobile nurses. Patients also infrequently attend Nepean Hospital for further treatment. In addition to providing treatment, nurses also document clinical issues in individual patient medical records (PMRs). Medical and specialist staff at Nepean Hospital periodically reviews these records to adjust treatments and escalate care where necessary.

PMRs used in NOS feature written and visual material. Notes on treatment progress are handwritten. Images are taken using digital cameras. Mobile nurses delivering the Hospital in the home services occasionally communicate with medical and specialist staff while at patients' homes using mobile phones. Information obtained is added to handwritten notes. Data is stored in paper-based files or locally on devices. PMRs are stored at the Nepean Hospital. These methods of developing PMRs can result in limited accessibility of patient information and miscommunication among all staff.

In recent years, Telehealth technologies have introduced methods to improve patient record management in healthcare institutions such as hospitals and clinics. These methods typically provide tools to manage electronic PMRs, including written, visual and verbal data, via a centralised database that facilitates sharing among the staff in an institution [1-2]. There have also been studies specifically designed for use during the visit to patient's home. SmartNursing App for mobile devices [3] focuses on enhancing communication among mobile nurses by employing voice messaging which can be sent from the patient's home to the health clinic. Similarly SyMO software for Tablet PC with a stylus [4] consists of several modules to improve the recording of clinical procedures (notes) at the patients' homes. Although such systems demonstrated improved consistency and overall communication among the staff, these studies only enable the sharing of notes and voice message, which limits its application to services that require e.g., picture of a patient's wound (with annotations) and the need to conduct video consultations. In addition, they do not address limited accessibility of 3G networks in rural areas. This could be a problematic especially when there is a need to share large size data such as pictures.

In this study, we propose a new Telehealth technology framework specifically designed for NOS in order to improve the quality and consistency of communication between the mobile nurses and medical and specialist staff. We developed an Outreach App for a mobile device (iPad) to provide functions to efficiently take notes and pictures of patients at the patient's home, as well as the ability to share the data via both online (Cloud-based services) and offline and facilitate video-conferencing communications.

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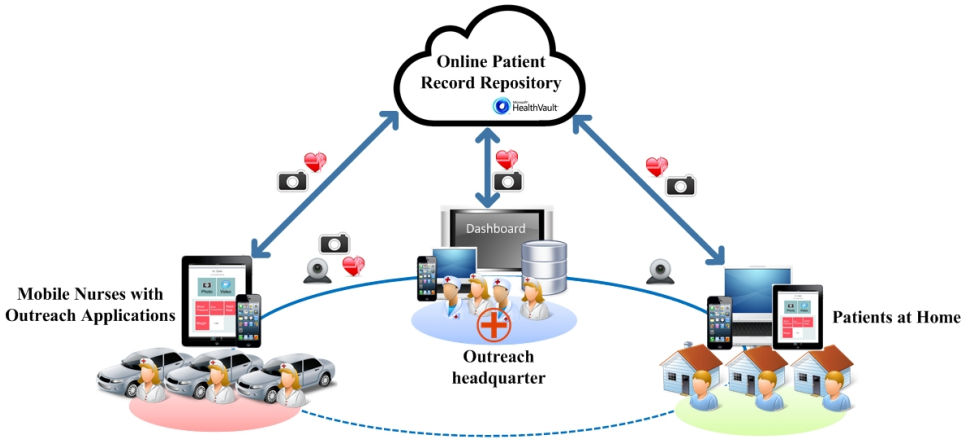

Fig. 1: Telehealth framework for Nepean Outreach Services (NOS).

II. Materials and Methods

A. Mobile Nursing Telehealth Framework

Our proposed Telehealth framework, illustrated in Figure 1, shows the use of NOS mobile nurses to provide Hospital at Home services. Each nurse is equipped with a mobile device installed with our developed 'Outreach' App. This acts as an interface between a nurse and a patient during their consultation at the patient's home. The App can record notes, vital signs and take picture of the patient's wounds. The framework provides a centralised database in the Outreach headquarter (clinics), Nepean Hospital. The database stores all the patient records and synchronises the data between the mobile devices distributed among the mobile nurses. The framework enables the PMRs to be uploaded to a Cloud-based online patient record repository (based on Microsoft HealthVault [5]). By using HealthVault, the uploaded information can be shared between all the NOS staff including clinicians, nurses, and patients.

B. Outreach App

The Outreach App was designed to be efficient and user-friendly specifically for nurses. Apple's iOS platform was chosen for our development due to its large user base and acceptance in the hospital environment [6]. Apple device also feature high quality hardware, such as cameras (1080p). We developed our App to be compatible to both iPad and iPhone devices, with varying user interface to fit the device's screen resolution.

The main menu screen shows multiple tiles that guide the user to sub-menus in Figures 2. A 'tile' style interface introduced by Microsoft was adopted in our App design [7] where the tiles represent buttons for easy user interaction. The 'Patients' button in the top-left corner opens up the patient lists which are used to select the patient and load the PMRs. The 'Patient Notes' button directs users to the note-taking function and a history of previous notes. The 'Camera' button opens up a sub-menu for the camera function, as well as the thumbnail history of pictures stored in the PMRs (sorted by date). A selection of a thumbnail loads a full-size picture. Annotation tool (finger-driven) is added to allow users to directly mark and take notes on the picture. The 'Video call' button opens up pre-installed Skype app, where video conference calls can be made [8]. If necessary, such software can be replaced with other alternatives.

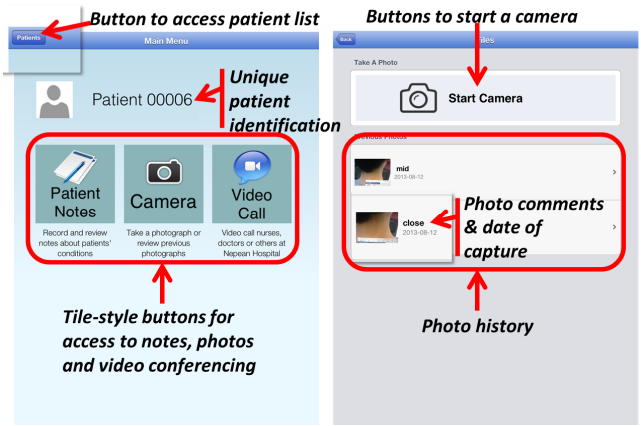

Fig. 2: Main menu (Left) and 'Camera' (Right) sub-menu on an iPad.

Figure 3 (Left) depicts the sub-menu to record blood pressure parameters such as systolic, diastolic and pulse on an iPhone running the Outreach App. Other vital signs, such

as weight or blood pressure, are supported. As shown, this data can be viewed as a graph (Right).

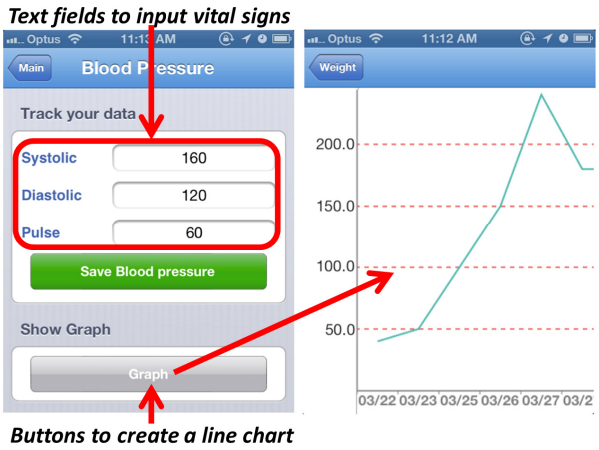

Fig. 3: Blood pressure sub-menu (Left) and Graph view (Right) on an iPhone.

C. Personal Health Record

Our framework integrates Microsoft HealthVault's cloud capabilities for its Cloud-based solution and its rich programming API for software development [9]. To utilise HealthVault, a staff account, such as a nurse can connect their HealthVault account to multiple patient accounts. Once connected, the accounts are synchronised. A key function of our App is the ability to record patient information (notes and pictures) offline and then upload it when the Network is available. This is done by locally storing all the data on the device, and then only uploads to the HealthVault when network is available.

D. Centralised Database Server in NOS

In our framework, a centralised PC server at Nepean Hospital manages all PMRs and synchronise all data between the mobile devices. From the Outreach App, the data can be transferred to the server via a USB or network (Wi-Fi or 3G) connections. PMRs recorded using our app include three types of data: 'Note', 'Picture' and 'Patient Record'. Each is represented via an XML format; thus making it easier to parse the data for database management [10]. The created XML data type has several 'Nodes' that represents the sub-elements of the data. The date and time attached with the XML file are used to sort the records. The XML file contains additional nodes such as latitude and longitude (GPS coordinates) to identify where the picture was taken. A sample XML is shown in Figure 4.

E. Security

Patient data transmitted from the Outreach App to the HealthVault are encrypted with secure sockets layer (SSL). SSL is a cryptographic communication protocol that can prevent third parties from viewing information [16]. To reduce the risk of patient information theft, the App holds only the PMRs for a single day's round (visits). Once the round is complete, the nurse returns to the Nepean Hospital and synchronises all the PMRs to a centralised PC server and the data is then removed from the device.

Further protection is provided by requiring users to input passwords to access PMRs and HealthVault accounts. If more than 3 invalid attempts are made, the device automatically becomes inaccessible. In addition, if misplaced, the device can be easily located using GPS capability. In such cases, the data can be erased remotely [11].

```
<picture>
    <type-id>bd0403c5-4ae2-4b0e-a8db-1888678e4528</type-id>
    <eff-date>2013-08-08T10:41:12.237Z</eff-date>
    <patient-name>Patient 00003</patient-name>
    <latitude>-33.889052</latitude>
    <longitude>151.190834</longitude>
    <data-xml>
        <file>
        <name>Patient 000030808201310-41-10.jpeg</name>
        <size>304357</size>
        <content-type>image/jpeg</content-type>
        </file>
        <common>
        <note>The comment can be added with the image.</note>
        </common>
    </data-xml>
</picture>
```

Fig. 4: A sample XML format for a picture.

III. Results and Discussion

A. Framework Evaluation Setting

The proposed framework was evaluated for its ability to perform the functions stated in its design (Section II). Two typical mobile nursing scenarios, simulating the routine of NOS nurses, were conducted. The Outreach App was used to record PMRs through note-taking and taking pictures of wounds. Two iPads (iPad2 and iPad3) were used in the evaluation. The iPads were synchronised to a PC server running HealthVault as the cloud services. The iPads were connected using Wi-Fi at the Nepean Hospital and 3G network outside the hospital. In total, 50 pictures and 50 notes were acquired for each iPad. For the Wi-Fi, we measured average of 21.25 Mbps for download and 16.42 Mbps for upload, respectively; and with the 3G network, average uploading and downloading speeds of 4.83 and 1.15 Mbps, respectively. Results of measuring the time to upload the pictures and notes to the HealthVault are shown in Table 1. With Wi-Fi network, two data types consisting of 100 'pictures' (1024×1024 resolution) and 100 'notes' (50 characters) were uploaded within a few minutes. In our scenario,

only a short note was considered; however, our note function supports larger character counts (no limit). As for the 3G, the total time to upload pictures took longer as expected, but still within a reasonable rate of 11.1 seconds per image. With notes being very small, there were minor differences (2.1 seconds) between Wi-Fi and 3G times. In this experiment, we considered 'patient record' data type to be the same as the note data type, since it only contains textual patient information not exceeding 50 characters.

Table 1: The average time spent for uploading pictures and notes.

Task	Network	Total Time	Total Size
Upload 100 pictures	Wi-Fi	3 min 16 sec	220 MB
Upload 100 notes	Wi-Fi	12.6 sec	8KB
Upload 100 pictures	3G	18 min 30 sec	220 MB
Upload 100 notes	3G	14.7 sec	8KB

The computational performance of the Outreach App was also measured using an iPad3. During picture taking and sharing, the peak RAM usage was ~15.0% of available 1G. The peak CPU was 47.6%, occurred during image uploading. Similar performances were recorded when the test was repeated with an iPad2. This result indicates that our framework is able to instantly share data shortly after acquisition using cloud storage.

IV. CONCLUSIONS AND FUTURE WORK

In this study, we proposed a new Telehealth framework specifically designed for the NOS at the Nepean Hospital, Australia. Our experimental results demonstrate that our framework was capable of capturing several data types and maintain consistency among the different NOS staff. Using our App, the NOS staff can record and review PMRs offline and when it is necessary, they communicate remotely without noticeable time delay with HealthVault. Future work will include larger scale evaluation of our framework with NOS mobile nurses to get usability feedback.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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