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Voice Enabled Framework to Support Post-Surgical Discharge Monitoring

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Abstract:

Unplanned surgical readmissions pose a challenging problem for the American healthcare system. We propose to combine consumer electronic voice recognition technology with the FHIR standard to create a post-surgical discharge monitoring app to identify and alert physicians to a patient's deteriorating status.

Introduction:

Of the nearly 50 Million patients that receive surgical care every year, almost one in five of them will have an unplanned readmission to the hospital[1]. Despite many of these readmissions being preventable, these events cost the American health system over $17 Billion in the Medicare population alone[2]. In addition to these high costs, surgical readmissions have been previously investigated by federal regulators as a potential quality metric for reimbursement[3]. As the healthcare system attempts to realign with these changing reimbursement models that emphasize health outcomes, hospitals have struggled with implementing strategies to reduce these preventable readmissions. Previous work has shown that additional nurse follow-up and monitoring improves surgical outcomes and prevent unplanned readmission in prostatectomy, total joint, and cardiac surgeries[4-6]. While these solutions have shown promising results, the care model requires a specialized nursing staff, limiting the scalability of these care units across multiple service lines. In response to these limitations, health researchers have recently investigated the potential to utilize patient generated data (PGD) to extend care monitoring in the post-surgical care setting[7].

Despite an acute need for PGD to be integrated into the electronic healthcare record (EHR), interoperability and secure authentication methodologies remain an active area of design and research[8]. Specifically, Mandel, et al. highlighted these challenges in the development of the pivotal SMART on FHIR (Fast Healthcare Interoperability Resource) framework which brought standardized authentication methods to FHIR specifications[9]. However, to date there has been scant utilization of these resources to bridge the digital divide between patient home care and the EHR.

Despite comprising only 13% of the overall population, an estimated third of the aggregate national health care spending is concentrated among the elderly. It is therefore imperative for patient-focused devices that enable PGD EHR integration to consider that a significant proportion of users may not be as technologically adept to newer technologies. Previously, detailed user interviews have highlighted the potential benefits of using voice-enabled frameworks to interface with this population. Given the goal of reducing unplanned surgical readmission, we propose a voice enabled framework to monitor these patients in the post-discharge setting using consumer internet connected smart home devices. Using the FHIR based standards, we aim to provide EHR connectivity to structured patient interviews performed by the smart home device, prompting clinician in potential medical crises.

METHODS:

Colorectal surgery was identified by the collaborating surgical residents as a primary clinical use case given the high degree of post-surgical intervention for this patient population. User screening questions and potential question responses were developed. These were then compiled into a dialogue tree, which was used to inform the application state machine design. Additional clinical applications could be added with unique dialogue trees to reflect the heterogeneity of surgical complications.

We considered all major consumer-grade home voice-command assistive device platforms including Apple Siri, Google Home, Microsoft Cortana, and Amazon Alexa. Given the strong market share and wide range of developer tools necessary for rapid prototyping, the Amazon Alexa (and associated Voice Skills application framework) was chosen[10]. This framework provides developer specified intents (invocation programming triggers) and utterances (mapping to user dialogue), which are mapped together in the server application. Incoming intents trigger the Amazon Voice Service server to send a JSON

POST request to the application server. Using the flask-ask extension for the flask python microframework (https://github.com/johnwheeler/flask-ask), these intents are mapped to state dependent functionality, providing context aware and seemingly 'intelligent' communication abilities.

FHIR was chosen given its conformance to modern REST-like messaging standards and providing HTTP verb functionality such as 'GET' and 'POST'. With an appropriately authorized oauth token, secure and interoperable transmission of patient information to the application server is enabled.

Results:

The proposed schematic is displays the technical and interactive details using this framework (Supplemental materials). (Step 1) When a patient is being discharged, the surgeon would select a relevant surgical indication that would specify the type of questions the framework would ask. (Step 2) Upon the patient's activation of the Amazon Alexa app, he would be prompted to login through their patient portal credentials. This would create a session level oauth token allowing the patient server to request their medical information from a FHIR enabled server. Using the Encounter FHIR resource specifying the patient's surgery from an appropriate 'GET' request search, surgery-specific screening questions are then mapped to the current session

(Step 3) The application then confirms that this application is okay to proceed, and asks birth date information to further verify the identity of the patient. Failure to appropriately authorized would result in quitting of the application and deauthorization of the token. After each question is answered, it is similarly saved to the application until the final question is answered. The patient is then asked to confirm any abnormalities that were found during the screening session before alerting the clinician. (Step 4) The screening application then structures all recorded answers as a FHIR's 'QuestionnaireResponse' resource, and 'POSTS' these data to the hospital's FHIR enabled server. (Step 5) Once these data are integrated into the hospital's EHR, the attending surgeon's email would receive a starred alert message contained structured results of the patient interaction, prompting the doctor to follow up with a clinical care team to further investigate the patient.

Source Code for the alpha prototype is available from https://github.com/KBlansit/Alexa-Discharge-Monitering/tree/master. The video describing the patient interaction is located at https://youtu.be/05MgJHWA-ns.

Conclusions:

Developing new modalities to extend care monitoring to the home is a current and active area of research. In this project, we elected to utilize a consumer home assistant device. While using this platform permitted the focus of development on the underlying server application logic, it limited the scope and capabilities of the project to curated interactions, which may not fully cover the landscape of potential medical needs from patients. Since this platform uses both consumer technology and interoperable health web standards, there is high potential for scalability of this framework to reduce unplanned surgical readmissions. Future efforts should seek to formally evaluate the potential of this framework to aid in reducing unplanned surgical admissions and increase patient recovery self-efficacy. Partnership with a surgical department to pilot these efforts would be necessary to aid in the study coordination. Further considerations must be given the integration into each medical site's EHR as robust APIs from vendors do not come standardized.

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