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Objectives

1) Gain experience in developing platform agnostic, fully operational and clinically relevant web applications for effective pharmacist led patient care. 2) Create a decision-support tool using open source software to facilitate evidence-based management therapy of warfarin in clinical settings where it is available for everyone to use at anytime

Introduction

Healthcare is continuously growing and modern technologies provide opportunities for the creation of effective tools to manage multiple diseases. Mobile devices such as smartphones enable easy access to a variety of websites remotely and make data and information readily available for use. Additionally, mobile devices can offer healthcare providers with fast and easy access to essential medical information to support patient care[1]. The profession of pharmacy is fast changing from one primarily focussed on dispensing medicinal goods to one intensely focused on the delivery of patient care[2-3]. This has led pharmacists to be involved in a diverse clinical service such as patient's education, Medication Therapy Management (MTM) and medications dose adjustment. Implementing such services often place additional stress on the daily routine of pharmacists[3]. Therefore, there is a high need to find efficient ways to support healthcare related clinical services. Studies have clearly demonstrated that mobile device apps help healthcare professionals to have sufficient time to deliver patient care of the highest quality and also reduce medication error rate[4]. One of the widely used anticoagulant medications is warfarin. Warfarin has been available on the market as effective therapy in management of thrombotic disorders. However, warfarin is frequently associated with medications errors which may lead to serious adverse events[4]. As such, it is considered a high-risk medication. Current level of technology has the capacity to provide an application that facilitates healthcare professionals duties as well as to reduce medication related errors[4]. The purpose of this paper is to demonstrate this fact via a fully functional warfarin dosing web application to help support healthcare professionals in clinical settings.

Methods

Open-source programming language R in conjunction with RStudio version 1.2.5033 were used to develop and implement our warfarin dosing platform. Shiny packages for R with other packages were used to create our platform as a web-based app and Shinyapps.io for hosting the shiny app in the cloud and make it public. We based our calculations and functions of our platform on the UW health warfarin management- adult-ambulatory clinical practice guidelines.[5-6]

```
library(shiny)
ui <- fluidPage()

server <- function(input, output) {}

shinyApp(ui = ui, server = server)
```

Figure 1: Structure of a Shiny App. Shiny is an R package that can build interactive web applications (apps) directly from R. Shiny apps are contained in a single script called app.R. The script app.R lives in a directory and the app can be run with runApp. app. R has three important components: 1) a user interface object, 2) a server function and 3) a call to the shinyApp function. The user interface (ui) object regulate the layout and appearance of the app. The server function has the instructions that a computer needs to create the app. Finally, the shinyApp function makes Shiny app objects from an explicit UI/server pair.

Figure 2: Publishing a shiny app to the public with shinyapps.io: Shinyapps.io is a self-service platform that makes it easy for users to share their shiny applications on the web to the public in just short time. The service runs in the cloud on shared servers that are operated by RStudio. Each application in the Shinyapps.io is independent and operates on either data that is uploaded with the application, or data that the code pulls from third-party data stores, such as databases or web services.

Results

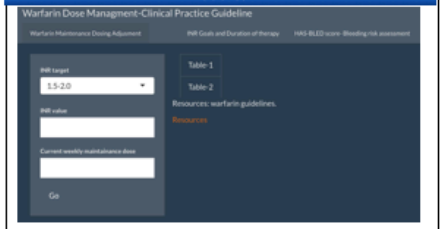

Figure 3: The appearance of the online warfarin dosing platform and the tools inside it .The app's page contains the title of the app, three tools users can use:1) Calculating the warfarin maintenance dose,2) Selecting INR goals and duration of therapy,3) Assessment of Bleeding risk. Additionally, the app has a hyperlink to direct the users to the resource used in this app.

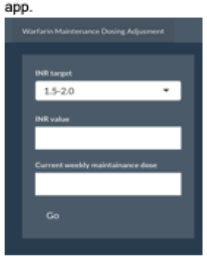

Figure 4:The inputs required to calculate a patient maintenance dose. On the side bar, there is a drop down menu, where the user can select their INR target from three different option:1-(INR target of 1.5-2.0),3-(INR target of 2.0-3.0), or 3-(INR target of 2.5-3.5). The side bar contains also two numeric input, the first is INR value. This is basically any patients INR after measuring it. The second is the "current weekly maintenance dose" . After the users input all of the required values,the user can press the "Go" button and the app will immediately display the results.

Table 1 –The table result to display the warfarin maintenance dose. After the user input the required values, the script does some calculations and then display the results as a table. The table display two outputs, the first is the new daily dose of a patient in mg. The second output is the "action needed". The action needed inform the users of what has to be done when the patients required to skip a couple of doses in case of high INR, or to give extra doses to the patient in case of low INR values. Furthermore, the app gives other dosing options for the users.

Table 2: Determining the INR target recommended for patients. On the second page of the app, there is a feature for users helps to choose the INR target recommended based on patient conditions. There is a drop down menu contains different type of antithrombotic indications.

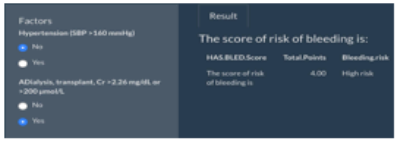

Table 3: Assessing the risk of bleeding for patients with Atrial Fibrillation. On the third page of the app, there is a feature for users helps to calculate the bleeding risk using HAS-BLED score. The users can answer "Yes" or "No" on multiple risk factors to stratify patients risk into low, moderate or high.

Conclusions

Our warfarin dosing platform demonstrates the feasibility of creating a free-tool for healthcare professionals to facilitate their daily practice and potential for reducing medication related errors. Additionally, we demonstrate that pharmacists can take advantage of open-sources resources available to develop any health related application suitable to their needs.

Future Directions

The skills gained in the implementation of this full stack web application development will be further improved upon to develop additional clinical support tools for pharmacists. Further implementations will also incorporate fully or partially trained machine learning models. Our ultimate goal is to allow pharmacists to utilize data driven decision making strategies to implement fast and effective patient care.

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