Concussion and Traumatic Brain Injury in Pediatric Patients

Developer Manual

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Concussion and Traumatic Brain Injury in Pediatric Patients: A CDS App

This web-based app provides clinical decision support for the area of Mild Traumatic Brain Injury (mTBI) in children and adolescents. It provides an extensible CDS framework which can be expanded with new rules as well as a customizable Angular-based user interface.

The app was started in the Fall of 2017 as a semester project for Georgia Tech's Introduction to Health Informatics course and was greatly informed by the input of our mentors (listed below).

Development Team

Semester team name: FHIRStarters

- Jan Marie Andersen (QA, Developer)
- Darryl Buswell (Project Manager)
- Spencer Knight (Developer)
- Lamar Phillips (QA)
- Brian Wells (Developer)

Project Mentors

- Juliet Haarbauer-Krupa (CDC)
- Kelly Sarmiento (CDC)
- Melvin Crum (CDC)
- Jon Bidwell (Georgia Tech)

Source Code Repository

Source code for the project may be found on GitHub at the following link:

https://github.com/CDCgov/GaTech-Fall2017-Krupa-Concussion-FHIRStarters

Thank You

Thank you to Juliet, Kelly, and all others who provided guidance during development. It would not have been possible without them.

Installation

The following instructions will install the app and all dependencies by utilizing Docker. The app currently uses sample data on a standalone FHIR server, but with future work the app will be launchable from within an EHR system using SMART on FHIR. SMART on FHIR is already included in the app code.

1. If you don't already have docker (https://www.docker.com) installed, do so.
2. Clone this repo.
3. In a command window, navigate to the directory GaTech-Fall2017-Krupa-Concussion-FHIRStarters
4. Run `docker-compose up`
5. Wait for everything to build and startup.
6. In a browser, navigate to http://localhost:8083
7. Observe that sample data is automatically pulled from the FHIR server using smart-on-fhir.

Development Environment Setup

1. Download Visual Studio 2017 Installer
2. In the installer, under **Workloads>Web & Cloud**, select **ASP.NET and web development** and **Data storage and processing**. Under **Individual Components**, make sure **.NET Framework 4.6.2** (SDK and targeting) is selected. Install the selected components.
3. Download and install MySQL (scroll down for the installer, no need to login, just say "No thanks"). During installation, choose a custom install and select the **MySQL Server** as well as the **Connector/NET** (and a client if you want one).
4. Download and install MySQL for Visual Studio (choose **Typical** install, again no need to login).
5. Open the MySQL command line client or if you installed a client, open it. Run the follwing commands:
   - `CREATE DATABASE mtbicds .`
   - `CREATE USER 'fhirstarter'@'localhost' IDENTIFIED BY '[insert some password]';`
   - `GRANT ALL PRIVILEGES ON mtbicds.* TO 'fhirstarter'@'localhost' WITH GRANT OPTION;`
   - `CREATE USER 'fhirstarter'@'%' IDENTIFIED BY '[insert some password]';`
   - `GRANT ALL PRIVILEGES ON mtbicds.* TO 'fhirstarter'@'%' WITH GRANT OPTION;`
6. Update the **DefaultConnection** string in the **appSettings.Development.json** file in the fhirStartersApp directory to reflect the username and password you use.
7. Start Visual Studio 2017 and open the **fhirStartersApp.sln** file and wait for dependencies to install.
8. Follow these instructions for connecting to a MySQL database.
9. Attempt to run the server. If you experience an error such as *The command "node node_modules/webpack/bin/webpack.js" exited with code 1*, you may need to install a newer version of NodeJS (e.g. 6.11).

Project Overview

The Problem

Concussion is a well-known type of traumatic brain injury and is also known as mild traumatic brain injury (mTBI). Research suggests that patients with mTBI can present with different symptoms, which makes care and management of children with mTBI challenging. In addition, healthcare providers don't necessarily have the time or training to systematically assess and manage patients with suspected mTBI. The CDC reports that rates of emergency department visits of individuals aged 19 or younger presented with TBI doubled between 2001 and 2012. Therefore, the problem is: how to improve *evidence-based diagnosis* and management of mTBI in these patients?

In general, as described by our mentors, there are two components to improving the diagnosis and management of mTBI:

- Improve the ability of healthcare providers to diagnose mTBI at the time of injury by using evidence-based guidelines, and
- Improve communication between clinicians, families, and schools in order to improve post-injury management

The Solution

Our mentors identified the need for intelligent clinical decision support software to help facilitate these components. This project therefore aims to address the first component by developing a provider interface which provides clinical decision support based on input from the web interface and automatically-obtained information from integration with the provider's EHR via FHIR.

Notable Features

- Extensible CDS rule structure
  - Several CDS rules have been implemented
  - Rule framework makes implementing new rules plug-and-play
- Responsive front-end design
  - Data retrieved from the EHR using SMART on FHIR are highlighted for the physician
- Compiles to Docker image for easy deployment
  - docker-compose file creates containers for the web application, a MySQL database for persisting application state, and FHIR server to simulate an EHR system

Architecture

High-Level

- Server-side: ASP.NET (C#)
  - Clinical decision support logic
- Client-side: Angular, SMART on FHIR Javascript library
  - User interface: data collection and results display
- Database: MySQL
  - Securely stores patient data guiding decision logic

CDS Logic

The CDS logic processing is handled on the server. In the server-side code, the `DataCollectionController` class provides methods which handle API requests from the client. The client app POSTs patient and observation data to the server which is sent by this object to the `ClinicalDecisionSupportService`. This service runs the CDS rules (classes implementing `IRule`), collects their results, and sends them to the client as `DecisionSupportResult` objects.

The data fields (observations) are listed below, under CDS Values. These represent all data collected by the web app and consumed by the server-side CDS rules.

Web-Based Client

The Angular-based client application consists of two main Angular components, representing the two client views: the `DataCollectionComponent` and the `ResultsComponent`. The former is displayed by default. Both components operate in one Angular module. Data is shared between these components using the singleton `AppService` which also tracks which data fields the CDS logic has identified as needed. In addition, several models mirror data structures used on the server.

The client application also includes the SMART on FHIR JavaScript library which is capable of querying data on a FHIR server such as an EHR. This provides the potential to pull some data needed by the CDS logic into the interface automatically.

CDS Values

Table of Data Values

The following table lists data values needed by the CDS logic and their (potential) sources.

Symbol	Type	Source	Notes
Age	Number	FHIR	Age (years)
GlasgowComaScale	Number	FHIR	Glasgow Coma Scale
SignsOfAlteredMentalStatus	Trilean	Interface?	Altered mental status
SignsOfPalpableSkullFracture	Trilean	Interface?	Palpable skull fracture
LossOfConsciousness	Trilean	FHIR	Loss of consciousness
LossOfConsciousnessTime	Number	FHIR	Loss of consciousness (seconds)
OptScalpHematoma	Trilean	FHIR	Occipital/parietal/temporal scalp hematoma
SevereMechanismOfInjury	Trilean	Interface?	Severe mechanism of injury
AbnormalBehaviorPerParentalAssessment	Trilean	Interface	Acting normally, according to parents
SignsOfBasilarSkullFracture	Trilean	FHIR?	Basilar skull fracture
Vomiting	Trilean	FHIR?	Vomiting
AnyHeadaches	Trilean	FHIR	Any headaches
SevereHeadache	Trilean	FHIR?	Severe headache
WorseningSymptoms	Trilean	Interface	Worsening symptoms
ConcussionHistory	Trilean	FHIR	History of concussion(s)
CtImagingTaken	Trilean	FHIR	Cranial CT image taken?
CtImagingResultsAbnormal	Trilean	FHIR?	Cranial CT image results are abnormal?
LightNoiseSensitivity	Trilean	FHIR?	Sensitivity to light/noise
MinorBluntHeadTraumaContusions	Trilean	FHIR	Cerebal contusions from minor blunt head trauma
MinorBluntHeadTraumaContusionsSmallAndIsolated	Trilean	FHIR?	If contusions, small and isolated?
IncludeSchoolRecommendations	Boolean	Interface	Include school recommendations in results?
RestRecommended	Boolean	Interface	Rest recommended?
RestRecommendedDays	Number	Interface	Days of rest recommended
SignsOfOtherSkullFracture	Trilean	FHIR?	Other skull fracture
OtherScalpHematoma	Trilean	FHIR	Other scalp hematoma
ChronicDiseases	Trilean	FHIR	Chronic diseases (asthma, diabetes, etc)

SevereSymptoms	Trilean	FHIR	Severe symptoms
PersistentMentalStatusChanges	Trilean	FHIR?	Persistent mental status changes
CerebralContusionsSuspected	Trilean	FHIR?	Cerebral contusions
MriTaken	Trilean	FHIR	MRI taken
MriResultsAbnormal	Trilean	FHIR	MRI results abnormal