Immunization Calculation Engine (ICE)

an Open-Source Immunization Forecaster for Integration with EHR Systems

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Mike Suralik, MCS, Senior Project Manager, HLN Consulting, LLC
Daryl Chertcoff, Senior Project Manager, HLN Consulting, LLC
Noam Arzt, Ph.D., President, HLN Consulting, LLC
Kensaku Kawamoto, M.D, Ph.D., University of Utah
Clinical Decision Support for Immunizations (aka Immunization Forecasting)

**EXAMPLES**

Evaluations (of immunization history)

- The Polio shot that was administered to the patient on June 1, 2013 was **invalid**.
- The Td shot that was administered to the patient on March 15, 2014 was **valid**.

Recommendations

- The patient’s next Meningococcal vaccine is **due on September 18, 2014**.
- The patient has **completed** their MMR immunizations.
ICE Project

- Collaboration of immunization and IT experts from public and private sector

GOAL: An open-source immunization decision support system that:

- Promotes clinical best practices
- Easily integrates with other health information systems
- May be maintained and adapted by non-technical subject matter experts
OpenCDS

- Collaborative project, led by Dr. Kensaku Kawamoto at University of Utah
- Software platform and toolkit for developers implementing CDS services
- Open source
- Standards-based
- Web Service interface

www.opencds.org
ICE Software System

- **ICE Web Service**
  - Provides immunization forecasting to clinical systems through a web service interface
  - Pre-configured to support routinely administered vaccine groups, from infant to adult

- **CDS Administration Tool (CAT)**
  - Web-based tool enables non-technical subject matter experts (SMEs) to manage ICE
  - Human readable rules
Sample ICE Deployment

Provider

Immunization Registry

EHR-S

School Health System

Subject Matter Experts

ICE Web Service

OpenCDS

ICE Software System

CDS Admin Tool (CAT)
- Code System Editor
- Vaccine Editor
- Series Editor
- Rule Editor
- Test Editor

HL7/OMG CDSS Web Service Interface

SOAP

SOAP

SOAP
Easy to Adopt and Integrate With

- Open-source (GNU LGPL v3)
- Java-based system runs on a wide variety of server platforms
- Can be deployed in a variety of ways
- Standards-based Web Service interface
- Public wiki – binary release, source code, implementation guide, immunization rules
Software Architecture

- ICE/OpenCDS
  - Servlet Container (Java EE 6 or 7 compliant)
  - J Boss Drools (rule engine/database)
  - HL7 CDSS (web service interface)
  - HL7 vMR (data model)

- CAT
  - Application Server (Java EE 6 compliant)
  - JavaServer Faces (GUI)
  - Enterprise JavaBeans (business logic)
  - JDBC compliant database
Production Use of ICE by an EHR System

- eClinicalWorks (eCW) v10 uses ICE to deliver evaluations and recommendations
- Deployed at the end of 2013
- Integrated by eCW developers, with minimal support from ICE team
- No modifications to the default configuration
- ICE is hosted by eCW at central location
Beginning of Efforts to Integrate ICE with VistA

- ICE and CAT accepted into the VA Technical Reference Model (TRM)
- Authorization to use ICE/CAT on VA hardware platforms and to interface with other VA applications
- Working prototype of VistA integrated w/ ICE
- OSEHRA Immunization Workgroup
- Collaboration between VA, open-source community, and IHS
“ICE Client” - Free Tool to Try ICE

- Enables users to try ICE with patient data
- Runs on smart phones, tablets, browsers
- Shows vMR (input and output)
- Browser-based app:
- Android app for mobile devices:
  - Goto [https://play.google.com](https://play.google.com)
  - Then search on “OpenCDS”
- iOS app for iPhones/iPads: Coming Soon...
**ICE Client**

**Patient Info**

- **Name:** John Smith
- **DOB:** 20140801
- **Gender:** M
- **Evaluation Date:** 20140904
- **Age @Evaluation:** 0y 1m 3d

**Patient Output Grid**

<table>
<thead>
<tr>
<th>Vaccine Group</th>
<th>Recommendations</th>
<th>Evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td>HepB</td>
<td>Date: 20141001</td>
<td>Date: 20140802</td>
</tr>
<tr>
<td></td>
<td>Status: FUTURE_RECOMMENDED</td>
<td>Age: 0y 0m 1d</td>
</tr>
<tr>
<td></td>
<td>Message: DUE_IN_FUTURE</td>
<td>Valid: true</td>
</tr>
<tr>
<td></td>
<td>Vaccine Group: HepB</td>
<td>Vaccine: Hep B, adolescent/high risk infant (42)</td>
</tr>
</tbody>
</table>
CDS Administration Tool (CAT)
Code System Editor

Code System Details

ID: e0bc41f880dc19d217656508b6cf9908
OID: 2.16.840.1.113883.12.292
Name: CVX

Codes ( # of Results: 101 )

<table>
<thead>
<tr>
<th>Code</th>
<th>Display Name</th>
<th>Delete</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>Hep B, adolescent/high risk infant</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Hep B, adult</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Hep B, dialysis</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Hib (HbOC)</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Hib (PRP-D)</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Hib (PRP-OMP)</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Hib (PRP-T)</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Hib NOS</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Hib-Hep B</td>
<td></td>
</tr>
<tr>
<td>137</td>
<td>HPV NOS</td>
<td></td>
</tr>
</tbody>
</table>

(4 of 11)
Rule Editor - Example: Varicella Rule for Patients Born before 01/01/1980

When

1. The Patient information $PatientInformation$ must be known to complete writing this rule
   a. The Patient's birthdate is $ < 01/01/1980$
2. There is a Series $TargetSeries$ that needs Forecasting
   a. The Series belongs to the Vaccine Group $Varicella (600)$
   b. The Series Completion Status is $Not Complete$

Then

1. Create a Recommendation as $Recommendation$ with Status $Conditional (CONDITIONAL)$ for the Series $TargetSeries$
2. Set the Conditional Recommendation Reason for $Recommendation$ to $High Risk (HIGH_RISK)$
3. Include the Recommendation $Recommendation$ for Consideration in the final Forecast of the Series $TargetSeries$
## Suite Test Results for: HepB Tests

Expand rows to see detailed information

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Duration (ms)</th>
<th>Eval. Passed?</th>
<th>Rec. Passed?</th>
<th>Passed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>Minimum interval minus one day (23 days) between Dose 1 and Dose 2.</td>
<td>97</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>73</td>
<td>Minimum interval (24 days) between Dose 1 and Dose 2.</td>
<td>115.39</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>74</td>
<td>Minimum interval plus one day (25 days) between Dose 1 and Dose 2.</td>
<td>93.18</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Differences

Recommendation Date Due date values do not match: **ICE=10/01/2011; EXPECTED=10/10/2011**

<table>
<thead>
<tr>
<th>ID</th>
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<th>Duration (ms)</th>
<th>Eval. Passed?</th>
<th>Rec. Passed?</th>
<th>Passed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>Minimum interval minus one day (51 days) between Dose 2 and Dose 3.</td>
<td>96.92</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Options for Learning More …

- ICE wiki (cdsframework.org)
- HLN’s ICE webpage (www.hln.com/ice)
- Try the ICE Client from your mobile device or browser
- Integrate and test against free HLN-hosted instance of ICE
- Install ICE yourself (binary or source)
- See a CAT software demonstration
Contact Us for More Information

Mike Suralik
856-751-1094
suralik@hln.com

URL: www.hln.com/ice
Email: ice@hln.com