Immunization Calculation Engine (ICE)

An Open Source Clinical Decision Support System for Integration with Health Information Systems

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Noam H. Arzt, PhD, FHIMSS President HLN Consulting, LLC

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Agenda

- Brief introduction to HLN
- Business Case for ICE
- ICE Architecture & Features
- Who's Using ICE?
- ICE Tools
- Considerations for Moving Forward...
- Where to Learn More



A Few Words about HLN Consulting, LLC

- Provide IT consulting services (not products)
 - Needs assessments, strategic planning, software development
- Serve: Public health agencies, HIEs, and partners
- Academic Heritage: University of Pennsylvania
- Expertise
 - Immunization Information Systems (IIS)
 - Integrated Child Health Systems
 - Master Client Index / Master Patient Index
 - Health Information Exchange, Meaningful Use
- Participate in national orgs. to develop HIT standards
- Membership: AIRA, PHDSC, IHE, HL7, AMIA, APHA, HIMSS, OSEHRA



Business Case for ICE

Consistently Following Clinical Best Practices for Immunizations is Difficult

- New vaccines coming to market
- Large set of complicated rules
 - 36+ immunizations by age 12
- Evolving guidelines from the Advisory
 Committee on Immunization Practices (ACIP)
- Different protocols followed in different clinical settings



Recommended Immunization Schedule from Birth to 18 Years

Figure 1. Recommended immunization schedule for persons aged 0 through 18 years - United States, 2014.

(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are in bold.

| Vaccine | Birth | 1 mo | 2 mos | 4 mos | 6 mos | 9 mos | 12 mos | 15 mos | 18 mos | 19-23 mos | 2-3 yrs | 4-6 yrs | 7-10 yrs | 11-12 yrs | 13 -1 5 yrs | 16-18 yrs |
|--|---------------------|--------------------------|---------------------|----------------------|----------------------|---------|--|----------------------------------|-------------|--------------|---------|----------------------|--------------|--------------------|-----------------------|--------------|
| Hepatitis B ¹ (HepB) | 1 [#] dose | ≺ 2 nd | dose> | | | | 3 rd dose | | > | | | | | | | |
| Rotavirus ² (RV) RV1 (2-dose series); RV5 (3-dose series) | | | 1 [#] dose | 2 nd dose | See footnote 2 | | | | | | | | | | | |
| Diphtheria, tetanus, & acel- lular pertussis ³ (DTaP: <7 yrs) | | | 1¤dose | 2 nd dose | 3 rd dose | | | 4th | dose ·····> | | | 5 th dose | | | | |
| Tetanus, diphtheria, & acel- Iular pertussis⁴ (Tdap: ≥7 yrs) | | | | | | | | | | | | | | (Tdap) | | |
| Haemophilus influenzae type b ^s (Hib) | | | 1 [#] dose | 2 nd dose | See footnote 5 | | ✓3rd or 4 See for | th dose,> otnote 5 | | | | | | | | |
| Pneumococcal conjugate ⁶ (PCV13) | | | 1" dose | 2 nd dose | 3 rd dose | | ≺ ····· 4 th (| dose> | | | | | | | | |
| Pneumococcal polysaccha- ride ^s (PPSV23) | | | | | | | | | | | | | 1 | | | |
| Inactivated poliovirus ⁷ (IPV) (<18 yrs) | | | 1 [#] dose | 2 nd dose | | | ···· 3 rd dose ·· | | > | | | 4 th dose | | | | |
| Influenza ^a (IIV; LAIV) 2 doses for some: See footnote 8 | | | | | | A | nnual vaccin | ation (IIV only | ı) | | | An | nual vaccina | tion (IIV or LA | IV) | |
| Measles, mumps, rubella ⁹ (MMR) | | | | | | | <mark>≺1</mark> *c | lose> | | | | 2 nd dose | | | | |
| Varicella ¹⁰ (VAR) | | | | | | | ≺ 1¤o | lose> | | | | 2 nd dose | | | | |
| Hepatitis A ¹¹ (HepA) | | | | | | | <mark>∢</mark> 2. | dose series, S | ee footnote | 11> | | | | | | |
| Human papillomavirus ¹² (HPV2: females only; HPV4: males and females) | | | | | | | | | | | | | | (3-dose series) | | |
| Meningococcal ¹³ (Hib-Men- CY \geq 6 weeks; MenACWY-D \geq 9 mos; MenACWY-CRM \geq 2 mos) | | | | | i | See foo | tnote 13 | | | | | | | 1ª dose | | Booster |
| Range of recommended ages for catch-up ages for catch-up immunization groups Range of recommended ages encouraged and for certain high-risk recommended ages ages for certain high-risk recommended ages for certain high-risk recommended ages ag | | | | | | d | | | | | | | | | | |

This schedule includes recommendations in effect as of January 1, 2014. Any dose not administered at the recommended age should be administered at a subsequent visit, when indicated and feasible. The use of a combination vaccine generally is preferred over separate injections of its equivalent component vaccines. Vaccination provides should consult the relevant Advisory Committee on Immunization Practices (ACIP) statement for detailed recommendations, available online at http://www.cdc.gh/vaccines/hcp/acip-recs/index.html. Clinically significant adverse events that follow vaccination should be reported to the Vaccine Adverse Event Reporting System (VAERS) online (http://www.vaers.hts.gov) or by telephone (800-822-7967).Suspected cases of vaccines/recs/vaccines/r

This schedule is approved by the Advisory Committee on Immunization Practices (http://www.cdc.gov/vaccines/acip), the American Academy of Pediatrics (http://www.aap.org), the American Academy of Family Physicians (http://www.aafp.org), and the American College of Obstetricians and Gynecologists (http://www.acog.org).

NOTE: The above recommendations must be read along with the footnotes of this schedule.

http://www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf



Obstacles to Implementing/Maintaining CDS for Immunizations

- Large, complicated, evolving rule set
- Critical dependence on single programmer?
- Regression testing burden
- Lack of funding in any single organization
- Many competing priorities
- Building CDS for every clinical domain doesn't scale



Goal of the ICE Project

Create an immunization decision support system that:

- Promotes clinical best practices
- Adapts to changing requirements
- Freely Available
- Easily integrates with a wide variety of health information systems
- Easier to configure and maintain
- Is developed and supported collaboratively



Original ICE Collaborators

- New York City Citywide Immunization Registry
- HLN Consulting, LLC
- Alabama Department of Public Health
- OpenCDS Team (Univ of Utah)
- CDC CDSi Project



Rest of Presentation...

- A little more technical
- CDSi too complicated to "go it alone"
- Collaboration community with ICE already in place and ready for more participation!
- Open Source software projects need to be tightly controlled to ensure quality and functionality



ICE Architecture & Features

ICE Software System

ICE Web Service

- Provides immunization forecasting to health information systems through a web service interface
- Pre-configured to support routinely administered vaccine groups, from birth through adulthood

CDS Administration Tool (CAT)

- Web-based tool enables non-technical subject matter experts (SMEs) to manage ICE
- Human readable rules







Easy to Adopt and Integrate With

- Open source (GNU LGPL v3)
- Java-based system runs on a wide variety of sever platforms
- Can be deployed in a variety of ways
- Standards-based Web Service interface
- Public wiki binary releases, source code, implementation guide, immunization rules
- Open Source Challenge: Managing and maintaining a unified code base



Standards-Based

| Attribute of ICE | Conforms to Relevant Technical Standard |
|--------------------------|---|
| Messaging framework | Simple Object Access Protocol (SOAP) |
| Web Service interface | Decision Support Service (DSS) – an HL7 & OMG standard |
| Data model | Virtual Medical Record (vMR) – an HL7 standard |



OpenCDS

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

www.opencds.org



OpenCDS community.



Software Architecture

ICE/OpenCDS

- Servlet Container (Java EE 6 or 7 compliant)
- JBoss Drools (rule engine/database)
- HL7 Decision Support Service "DSS" (web service interface)
- HL7 Virtual Medical Record "vMR" (data model)
- CAT
 - Application Server (Java EE 6 compliant)
 - JavaServer Faces (GUI)
 - Enterprise JavaBeans (business logic)
 - JDBC compliant database



Pre-Configured with Default Immunization Schedule

- Childhood, adolescent, and adult schedules for 14 vaccine groups
- Pre-configured by SME Workgroup
- Follows ACIP guidelines
- Informed by CDC's CDSi project



Pre-Configured Vaccine Groups

- 1. HepB
- 2. Rotavirus
- 3. DTP (in progress)
- 4. Hib
- 5. PCV Pneumococcal Conjugate
- 6. Polio
- 7. MMR

- 8. Varicella
- 9. HepA
- 10. Meningococcal
- 11. PPSV Pneumococcal Polysaccharide
- 12. HPV
- 13. Influenza
- 14. H1N1



ICE Wiki: Default Immunization Schedule

| <u>Glossary</u> | The Glossary contains terms and concepts that may require additional clarification in order to understand the default ICE rules. Standard immunization evaluation and forecasting terms and concepts, e.g., vaccine, series, recommended interval, etc., are not listed in the Glossary. |
|---|--|
| General Rules | This page contains general rules that apply to all vaccine groups. If there is an exception, a reference will be provided to the vaccine group that does not follow the general rule. |
| Vaccine Group Rules | Evaluation and forecasting rules specific to a vaccine group are documented on the following pages: DTP (not yet implemented, in progress) H1N1 Hep A Hep B Hib HPV Influenza Meningococcal MMR Pneumococcal Conjugate Pheumococcal Polysaccharide Polio Rotavirus Varicella |
| Evaluation and Recommendation Codes | The evaluation codes and corresponding reasons as well as the recommendation codes and corresponding reasons listed in the tables on this page are utilized in the vaccine series rules. |

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ICE Wiki: Default Immunization Schedule (continued)

Immunization Series: Hep B Newborn Series

The Hep B Newborn series is complete after 3 doses.

Vaccine Dose Parameters - Minimum and Routine Ages

| Dose | Series Name | Absolute Minimum Age | Minimum Age | Routine Age | Valid CVX Code(s) per Dose for this Series | Invalid CVX Code(s) per Dose for this Series |
|------|---------------|-------------------------|-------------|-----------------------|--|--|
| 1 | Hep B Newborn | 0 days | 0 days | 0 days | 08, 42, 45, 43, 44, 51, 110, 104 | N/A |
| 2 | Hep B Newborn | 24 days | 28 days | 2 months ¹ | 08, 42, 45, 43, 44, 51, 110, 104 | N/A |
| 3 | Hep B Newborn | 164 days | 168 days | 6 months | 08, 42, 45, 43, 44, 51, 110, 104 | N/A |

Vaccine Dose Parameters - Minimum and Recommended Intervals

| Doses | Series Name | Absolute Minimum Interval | Minimum Interval | Recommended Interval |
|-------------|---------------|---------------------------|------------------|----------------------|
| Dose 1 to 2 | Hep B Newborn | 24 days | 28 days | N/A ² |
| Dose 2 to 3 | Hep B Newborn | 52 days | 56 days | 56 days |

Series Special Rules

There are no special rules for this series.

Notes

- The routine age for dose 2 in the table above (2 months)¹ differs from the CDC CDSi routine age of 1 month. The ICE Workgroup recommends 2 months as the routine recommended age for the following reasons:
 - Two months is a routine age for preventive care visits and the recommended age for several other vaccine groups.
 - . If combination Hep B vaccines are used, these are not licensed before 6 weeks of age.
 - For a routine recommendation for a healthy child, it is not necessary to squeeze dose 2 in before 2 months of age.

Who's Using ICE?

Production Use of ICE by EHR & PHR Systems

- 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
- Other EHR system vendors considering ICE as well
- Caredox (PHR) using ICE in school/parent module



Uses of ICE within Public Health

- Denver Public Health testing use of ICE for analytics and up-to-date calculations
- NYC Citywide Immunization Registry being modified to use ICE in 2015
- Several other state IIS strongly considering ICE as algorithm replacements



Beginning of Efforts to Integrate ICE with VistA

- Working prototype of VistA integrated w/ICE
- OSEHRA Immunization Workgroup
- Collaboration between Veteran's Aministration (VA), open-source community, and Indian Health Services (IHS)
- ICE and CAT accepted into the VA Technical Reference Model (TRM)
- Authorized for use on VA hardware platforms and for integration with other VA applications
- OpenCDS being deployed by eHMP generally





Clinical Decision Support Administration Tool (CAT)

- Graphical user interface
- Non-technical SMEs may configure ICE
- Create, edit, delete...
 - Vocabulary and code sets
 - Schedule parameters
 - Rules
 - Test cases
- Can expand to other clinical domains



Code System Editor

| ID: | e0bc41f880dc19d217656508b6cf9908 | | |
|------------------------|------------------------------------|--------------------|----------|
| OID: | 2.16.840.1.113883.12.292 | | |
| Name: | CVX | | |
| Codes (# of Results: 3 | 01) | Search all fields: | B New |
| Code | 🗘 Display Name | | Delete |
| 42 | Hep B, adolescent/high risk infant | | â |
| 43 | Hep B, adult | | ô |
| 44 | Hep B, dialysis | | Ō |
| 47 | Hib (HbOC) | | Ť |
| 46 | Hib (PRP-D) | | ŵ |
| 49 | Hib (PRP-OMP) | | T |
| 48 | Hib (PRP-T) | | Ô |
| 17 | Hib NOS | | Ö |
| 51 | Нір-Нер В | | T |
| 137 | HPV NOS | | Ô |
| 10 🗸 😝 🤜 | 4 of 11) 🔛 🗾 | | |
| | | | |



Vaccine Editor

| ccine Editor | | | | | | |
|--------------------------------|----------------------------------|--------------|---------|--|--|--|
| accine Details | | | | | | |
| ID: | 6883576bd868da1d907142ade9f7b923 | | | | | |
| Vaccine: | Hib-Hep B (51) | | | | | |
| Trade Name: | COMVAX | | | | | |
| Custom Display Name: | Hib-Hep B (COMVAX) | | | | | |
| Manufacturer Code: | Choose one | | | | | |
| Valid Min Age: | | | | | | |
| Valid May Age: | | | | | | |
| Liconsod Min Age: | | | | | | |
| Licensed Min Age. | | | | | | |
| Licensed Max Age: | | | | | | |
| Licensed Min Date: | | | | | | |
| Licensed Max Date: | | | | | | |
| Active?: | ✓ | | | | | |
| Live Vaccine?: | 0 | | | | | |
| Disease List: | Hepatitis B, Hib | | | | | |
| | | | | | | |
| Vaccine Component List (# of | Results: 2) | | 🕒 New | | | |
| Vaccine Component | | Vaccine Code | Options | | | |
| Hib (PRP-OMP) | | 49 | Î | | | |
| Hep B, adolescent or pediatric | | 08 | ā | | | |

Vaccine Series Editor

| eries Details | | | | | | | | | |
|--|-------------------------------------|---------------------------|---------------------------|----------------------------------|-----------------------|-----------------------------------|-------------|----------------|---------|
| | ID: 47 | aaadbc2554c28 | of97b17753ecc7 | da3 | | | | | |
| | Name: M | MR Series | | | | | | | |
| Vaco | ine Group: M | MR | | * | | | | | |
| | Notes: | | | | | | | | |
| Business Scope | Version List | (# of Results: 1 |) | | | | | | 🕒 New |
| Business Scope | | | Version | | | | | Optio | ns |
| CE - org.nyc.cir | | | Default ICE Sc | hedule - 1.0.0 | | | | Ũ | |
| Dose List - bold | vaccine code | s are preferred | l (# of Results: : | 2) | | | | | 🗅 New |
| Deservice in the second | Abs Min Ag | e Min Age | Max Age | Earliest Rec | Age 1 | Latest Rec Age | CVX Code | e(s) | Delete |
| Dose Number | 361d | 1y | | 1y | | | 05, 04, 03, | 94, 07, 06, 38 | Û |
| Dose Number | | 389d | | 4у | | | 05, 04, 03, | 94, 07, 06, 38 | Û |
| Dose Number | 389d | 11 | | | | | | - | 🗅 New |
| Dose Interval I | 389d ist - new seri | es doses won'i | be selectable | until changes ar | e applied | | | | |
| Dose Number 2 Dose Interval I From Dose # | 389d ist - new seri To Dose # | es doses won'i Abs Min | be selectable Interval | until changes ar Min Interval | e applied Earliest | (# of Results: 1) Rec Interval | Latest Re | ec Interval | Options |

Rule Editor - Example: Varicella Rule for Patients Born before 01/01/1980

| Rule Editor | |
|--|----------------------------------|
| Rule Summary Rule Details Advanced | |
| When + | |
| 1. The Patient information SPatientInformation must be known to complete writing this rule | |
| a The Patient's birthdate is < 01/01/1980 | |
| 2. There is a Series STargetSeries1 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 SRecommendation with Status Conditional (CONDITIONAL) | for the Series \$TargetSeries1 - |
| 2. Set the Conditional Recommendation Reason for \$Recommendation1 🔽 to High Risk (HIGH_RISK 🔻 | |
| 3. Include the Recommendation \$Recommendation1 🚽 for Consideration in the final Forecast of the Series \$TargetSeries | 1 - |



Test Editor (Test Case View)

Test Reference View:

Show Date Calculator

Test #: 125

Name: Minimum interval minus one day (51 days) between Dose 2 and Dose 3.

Test Execution Date: 10/21/2011

Patient DOB: 04/01/2011

Age @ Execution Date: 6 months 20 days (203 days)

| Administered Immunization Components | | | | | | | |
|--------------------------------------|-------------------------------|-------------------------------|------------|--------------------------------|------------|------------------------|--|
| ID | Admin Vaccine Code | Comp Vaccine Code | Admin Date | Age @ Admin Date | Evaluation | Reason(s) | |
| 263 | HepB peds < 20yrs (CVX 08) | HepB peds < 20yrs (CVX 08) | 04/29/2011 | 28 days (28 days) | VALID | | |
| 264 | HepB peds < 20yrs (CVX 08) | HepB peds < 20yrs (CVX 08) | 07/23/2011 | 3 months 22 days (113 days) | VALID | | |
| 265 | HepB peds < 20yrs (CVX 08) | HepB peds < 20yrs (CVX 08) | 09/12/2011 | 5 months 11 days (164 days) | INVALID | Below Minimum Interval | |

| Shot Component Intervals | | | | | |
|---|-----------------------------|--|--|--|--|
| Interval Between | Interval | | | | |
| Shot 1 (Group HepB/CVX 08) and Shot 2 (Group HepB/CVX 08) | 2 months 24 days (85 days) | | | | |
| Shot 1 (Group HepB/CVX 08) and Shot 3 (Group HepB/CVX 08) | 4 months 14 days (136 days) | | | | |
| Shot 2 (Group HepB/CVX 08) and Shot 3 (Group HepB/CVX 08) | 1 months 20 days (51 days) | | | | |

| Proof of Immunity/Documented Disease | | | | | | | |
|--------------------------------------|---------------|----------------|-----------------|--|--|--|--|
| Antigen | Immunity Date | Age @ Imm Date | Immunity Reason | | | | |
| No records found. | | | | | | | |

| Recommendations | | | | | | | |
|---------------------------|------------|-------------------------------|-----------------------|---------------|--|--|--|
| Recommended Vaccine/Group | Date Due | Age @ Rec Date | Recommendation | Reason | | | |
| НерВ | 11/07/2011 | 7 months 6 days (220 days) | Future Recommendation | Due in Future | | | |



Test Editor (Test Results View)



Suite Details Suite Test Results

Suite Test Results for: HepB Tests

| | ID 🔺 | Name 🗘 | Duration (ms) | Eval. Passed? | Rec. Passed? | Passed? 🗘 |
|------|----------|--|-------------------|---------------|--------------|-----------|
| D | 72 | Minimum interval minus one day (23 days) between Dose 1 and Dose 2. | 97 | 4 | ~ | ~ |
| D | 73 | Minimum interval (24 days) between Dose 1 and Dose 2. | 115.39 | ~ | ~ | - |
| 9 | 74 | Minimum interval plus one day (25 days) between Dose 1 and Dose 2. | 93.18 | ~ | 0 | 0 |
| Dif | ferences | | | | | |
| ecor | nmendati | on Date Due date values do not match: ICE=10/01/2011; I | EXPECTED=10/10/20 | 11 | | |
| D | 75 | Minimum interval minus one day (51 days) between Dose 2 and Dose 3. | 96.92 | ~ | ~ | - |

"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:
 - Goto <u>http://cds.hln.com/iceweb/</u>
- Android app for mobile devices:
 - Goto <u>https://play.google.com</u>
 - Then search on "OpenCDS"
- iOS app foriPhones/iPads:
 - Goto https://itunes.apple.com/us/app/ice-opencdsclient/id911983938





Patient Info

Name: John Smith

DOB: 20140801

 $\textbf{Gender:} \ \mathsf{M}$

Evaluation Date: 20140904

Age @Evaluation: 0y 1m 3d

Patient Output Grid

| Vaccine Group | Recommendations | Evaluations | |
|---------------|---|---|--|
| НерВ | Date: 20141001 Status: FUTURE_RECOMMENDED Message: DUE_IN_FUTURE Vaccine Group: HepB | Date: 20140802 Age: 0y 0m 1d Valid: true Vaccine: Hep B, adolescent/high risk infant (42) | |



Considerations for Moving Forward...

Considerations for Moving Forward...

Hosting ICE

- Who hosts the server?
- Who administers the server?
- Maintenance of schedule (rules and tests)
 - Who specifies/documents the rules?
 - Who creates the tests?
 - Who configures the rules?
 - Merging schedules from different sources?
- Enhancements to software
 - Support for contraindications?



...Possible Answers

- Utilize whatever the original ICE collaborators release
- User organization acts independently
- User organizations collaborate
 - Do themselves and split the work
 - Hire contractor and split the cost
 - Continue the work of the original collaborators and cooperatively develop and support the software
- Hire contractor to train the user organization



HLN can provide...

Technical Support

- Web conference/phone/email support to IT staff
- Creation of additional technical documentation
- Assistance integrating ICE with your organization's clinical information systems
- Enhancements to the ICE software to support the custom needs of an organization
- User Support for CAT Administrators
 - Web conference/phone/email support to users of CAT
 - Creation of user documentation for CAT
 - Training for subject matter experts who will utilize CAT
- Configuration Services for an IZ schedule
- Hosting Services for an instance of the ICE service



Learn More About ICE Through...

- HLN's ICE Webpage (<u>www.hln.com/ice</u>)
- ICE Wiki (<u>cdsframework.org</u>)
- ICE Client
- Software Demonstrations
- Executable software distribution
- HLN-hosted test instance
- Source code



The Message

- CDSi too complicated to "go it alone"
- Collaboration community with ICE already in place and ready for more participation!
- Open Source software projects need to be tightly controlled to ensure quality and functionality



Contact Information

Noam H. Arzt President, HLN Consulting, LLC 858-538-2220 (Voice) 858-538-2209 (FAX) arzt@hln.com http://www.hln.com/noam/

