Enabling Knowledge-driven Care at Scale through CDS Hooks and the FHIR Clinical Reasoning Module

Panel S64

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Kevin Shekleton (Cerner)
James Doyle (Epic)
Bryn Rhodes (HarmonIQ)
Howard R. Strasberg, MD, MS (Wolters Kluwer)
We disclose the following relevant relationship with commercial interests:

- Howard Strasberg is an employee of Wolters Kluwer
- James Doyle is an employee of Epic Systems Corporation
- Kevin Shekleton is an employee of Cerner Corporation
- Bryn Rhodes is an employee of HarmonIQ Health Systems Corporation and has been a consultant on clinical decision support for ONC and CDC* 
- In the past year, Kensaku Kawamoto has been a consultant or sponsored researcher on clinical decision support for ONC*, Hitachi, and McKesson InterQual

*Via ESAC, A+ Government Solutions, Hausam Consulting
## Presenters and Topics

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Need for CDS Interoperability, History, and Challenges

Howard Strasberg, MD, MS

VP of Medical Informatics, Wolters Kluwer Health
Co-Chair, HL7 CDS Work Group
Healthcare Cost

Health expenditure, total (% of GDP)

Source: databank.worldbank.org
Accessed on 10/25/2017
Healthcare Quality

Measure Performance Rate (%)

- Preventive Care and Screening: Screening for Clinical Depression and Follow-Up Plan: 36.35%
- Diabetes: Eye Exam: 47.41%
- Falls: Screening for Fall Risk: 58.17%
- Colorectal Cancer Screening: 59.43%
- Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up Plan: 62.49%
- Preventive Care and Screening: Influenza Immunization: 63.25%
- Breast Cancer Screening: 65.73%
- Preventive Care and Screening: Screening for High Blood Pressure and Follow-Up Documented: 66.57%
- Pneumonia Vaccination Status for Older Adults: 67.13%
- Coronary Artery Disease (CAD): Angiotensin-Converting Enzyme (ACE) Inhibitor or Angiotensin Receptor Blocker (ARB) Therapy -- Diabetes or Left Ventricular Systolic Dysfunction: 80.93%
- Documentation of Current Medications in the Medical Record: 86.00%
- Ischemic Vascular Disease (IVD): Use of Aspirin or Another Antithrombotic: 87.55%
- Preventive Care and Screening: Tobacco Use: Screening and Cessation Intervention: 89.87%
- Heart Failure (HF): Beta-Blocker Therapy for Left Ventricular Systolic Dysfunction (LVSD): 90.70%

Source: data.medicare.gov
Physician Compare 2015
Group Public Reporting
Accessed on 10/25/2017
n=277 organizations
Average score (unweighted)
Mystery Abstract

To determine whether clinical errors can be reduced by prospective computer suggestions about the management of simple clinical events, [author] studied the responses of nine physicians to computer suggestions generated by 390 protocols in a controlled crossover design. These protocols dealt primarily with conditions managed (e.g., elevated blood pressure) or caused (e.g., liver toxicity) by drugs. Physicians responded to 51 per cent of 327 events when given, and 22 per cent of 385 events when not given computer suggestions (P<0.00001).
Arden Syntax

- 1989 informatics retreat
  - Outcome: Arden Syntax for medical logic modules
- 1992 Arden v1: ASTM standard
- 1999 Arden v2: HL7 standard
- Current version 2.10 (2014): HL7 (ANSI)
- Grand vision: sharable CDS artifacts
- “If decision-support systems are to achieve widespread use, knowledge bases must be transferred among institutions, since it is not reasonable to expect each institution to create a substantial knowledge base on its own, from scratch.” (Hripcsak G. Comput Biol Med. 1994;24(5):329)

Arden Homestead, Harriman, NY
Arden Syntax

• Great features (fuzzy logic, XML representation)
• Limited EHR vendor support
• Limited availability of content in this format
• Sharing challenges
  • Curly brace problem – content inside the {} is institution-specific
  • Local governance
  • Local workflows
  • Maintenance
Virtual Medical Record

• Data model for representing clinical information relevant to CDS

**HL7 Virtual Medical Record for Clinical Decision Support (vMR-CDS) Logical Model, Release 2**
January 2014

HL7 DSTU Ballot

Sponsored by:
Clinical Decision Support Work Group
Architecture Board

**HL7 Virtual Medical Record for Clinical Decision Support (vMR-CDS) Logical Model, Release 2**
September 2017

HL7 Normative Ballot
Health eDecisions (2012-2015)

Use Case 1

Use Case 2
Health eDecisions

• Use Case 1 → HL7 Clinical Decision Support Knowledge Artifact Specification (KAS), Release 1.3 (2015)
  • XML representation for event-condition-action rules, order sets, and documentation templates
  • VMR incorporated by reference

  • Combines the HL7 DSS Release 2 standard with the HL7 Virtual Medical Record for Clinical Decision Support (vMR-CDS) information model standard to enable the provision of standards-based, interoperable decision support services.

• Harmonize standards used in Clinical Decision Support (CDS) and Clinical Quality Measurement (CQM)

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<th>Data Model</th>
<th>Expression Language</th>
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<td>CDS</td>
<td>Virtual Medical Record (VMR)</td>
<td>Knowledge Artifact Specification (KAS)</td>
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<tr>
<td>CQM</td>
<td>Quality Data Model (QDM)</td>
<td>Health Quality Measure Format (HQMF)</td>
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<tr>
<td>Harmonized</td>
<td>Quality Improvement and Clinical Knowledge (QUICK)</td>
<td>Clinical Quality Language (CQL)</td>
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</table>
• FHIR Clinical Reasoning module
  • Express a CDS artifact using a PlanDefinition resource in combination with a Library containing Clinical Quality Language (CQL) logic
  • Invoke CDS services using a combination of ServiceDefinition, $evaluate and GuidanceResponse

• CDS hooks – new, simpler alternative for CDS services
  • CDS hooks is replacing the ServiceDefinition approach for user-facing external CDS use case

Source: http://cds-hooks.org/
CDS Content Provider Questions

• How can we provide CDS content in a standard format for implementation at a local site independent of the EHR?
  • Even now, in 2017, people ask for English descriptions of the logic, which they will then implement in their local system.

• How can we provide CDS services in an EHR-independent manner?
  • Is CDS hooks the answer?
  • If so, when will the major EHR vendors support it?
  • What level of support will be available (i.e. display information versus accept structured suggestions/orders)?
CDS Standards Unification Effort and FHIR Clinical Reasoning

Bryn Rhodes
CTO, HarmonIQ Health Systems Corporation
Project Lead, FHIR Clinical Reasoning
CDS Standards Unification

• Latest generation of CDS specifications:
  • FHIR Clinical Reasoning
  • CDS Hooks

• Mutual decision to unify

• Approach:
  • FHIR Clinical Reasoning for knowledge artifact sharing
  • CDS Hooks for sharing CDS as a service
FHIR Clinical Reasoning Module

• Set of FHIR Resources and implementation guidance designed to support key use cases in clinical quality measurement and decision support

• Artifacts that define the structure of content including
  • order sets
  • documentation templates
  • event-condition-action rules
  • protocols

• Libraries that describe the behavior using logic in Clinical Quality Language (CQL)
Clinical Reasoning Topics

• Expression Logic
  • How to use expression languages like FHIRPath and CQL in FHIR

• Definitional Resources
  • ActivityDefinition – The definition counterpart of the request resources

• Representing Knowledge Artifacts
  • PlanDefinition – Resource to capture generalized workflow
  • Hierarchical series of actions
  • Each action is either a group or a leaf
  • Leaves are defined using ActivityDefinition
Opioid Management Recommendation #5

1.2.1 Recommendation #5

When opioids are started, providers should prescribe the lowest effective dosage. Providers should use caution when prescribing opioids at any dosage, should carefully reassess evidence of individual benefits and risks when considering increasing dosage to ≥50 morphine milligram equivalents (MME)/day, and should avoid increasing dosage to ≥90 MME/day or carefully justify a decision to titrate dosage to >90 MME/day (recommendation category: A, evidence type: 3).

- Patient is being prescribed opioids for chronic pain
- Patient does not appear to be at end of life
- If MME >= 50 and < 90, provide a recommendation to taper
- If MME >= 90, provide a recommendation to taper now
Recommendation #5 Workflow

1. **Medication Prescribe**
2. **Opioid with primary care abuse potential?**
3. **Malignant/pancreatic cancer?**
4. **On liquid form opioid other than codeine?**
5. **>= 80 days in past 90 days covered?**

- **Calculate MME for prescription + active opioids**
- **MME >= 50?**
- **MME >= 90?**
- **Overdose risk – taper now**
- **Overdose risk – consider tapering**

- **Stop**

**Decision Paths:**
- **Will reduce dosage**
- **Risk considered and outweighed; snooze 3 mos.**
- **Acute pain; snooze 1 mo.**
- **N/A – see comment; snooze 3 mos.**

**Legend:**
- EHR Triggering Event
- Calculation Logic
- User Interaction
Recommendation #5 Logic

```java
// MME - Milligram Morphine Equivalents as a list of tuples:
// List<Tuple { rxNormCode: Code, isDraft: Boolean, isPRN: Boolean, prescription: String, dailyDose: String, conversionFactor: Decimal, mme: System.Quantity, dosesPerDay: Decimal }}>

// function CalculateMMEs(medications: list<Tuple { rxNormCode: Code, doseQuantity: System.Quantity, dosesPerDay: Decimal }}):

define MME:
  Prescriptions P
  let mme: SingletonFrom(CMTKLogic.CalculateMMEs({ { rxNormCode: P.rxNormCode, doseQuantity: P.dose, dosesPerDay: P.dosesPerDay } }))
  return {
    rxNormCode: P.rxNormCode,
    isDraft: P.isDraft,
    isPRN: P.isPRN,
    prescription: P.prescription,
    dailyDose: mme.dailyDoseDescription,
    conversionFactor: mme.conversionFactor,
    mme: mme.mme
  }

  sort by if isDraft then 0 else 1, rxNormCode.code
```
Recommendation #5 Logic (cont)

```java
// TotalMME - Sum of all MME for currently and about-to-be prescribed opioid medications

define TotalMME: System.Quantity { value: Sum(MME.M return M.mme.value), unit: 'mg/d' }

define IsMME50OrMore: TotalMME >= 50 'mg/d'

define Results:
  IsMME50OrMore M
  return {
    mmeOver50: M,
    title: 'High risk for opioid overdose - ' + case when TotalMME.value >= 90
      then 'taper now'
      else 'consider tapering'
    end

    else 'MME is within the recommended range.',
    description:
      if M
        then 'Total morphine milligram equivalent (MME) is ' + ToString(TotalMME) + '. Taper to less than 50.'
      else 'Total morphine milligram equivalent (MME) is ' + ToString(TotalMME) + '. This falls within the accepted range.'
  }
```
Recommendation #5 PlanDefinition

```
<triggerDefinition>
  <type value="named-event"/>
  <eventName value="medication-prescribe"/>
</triggerDefinition>

<condition>
  <kind value="applicability"/>
  <description value="Is total MME >= 50?"/>
  <language value="text/cql"/>
  <expression value="IsMME50OrMore"/>
</condition>
```
Recommendation #5 Mechanics

Clinical Reasoning Implementation

EHR medication-prescribe

CDS Hooks Request with Patient Data

CDS Hooks API

CDS Hooks Response

PlanDefinition

CQL Libraries

Sapply operation

CarePlan with RequestGroup
CDS Hooks and Cerner Perspective

Kevin Shekleton
VP and Distinguished Engineer, Cerner Corporation
Project Lead, CDS Hooks
The problem with SMART apps

Bilirubin Chart
Newborns < 120 hours old
Bilirubin results that are either:
Not documented
Outside of the accepted range

The user needs to know the app is available
The user needs to know the app is relevant
The user has to find the app and launch it
A vendor agnostic remote decision support specification

- Moving into HL7
- Open source (Apache)
- Preparing 1.0 release
CDS Service

A service that is:

invoked by the EHR via a **hook**, 
evaluates **its own logic** using FHIR data, 
returns decision support via **cards**
Example Hooks

**patient-view**
When a patient’s chart is opened

**medication-prescribe**
When a medication is selected for prescription

**order-review**
Viewing pending orders for signing
CDS Services

1. EHR triggers a **CDS hook** and invokes a remote service

2. **CDS Service** executes its own rules, leveraging FHIR data as needed

3. Returns **CDS cards** (rendered and displayed by EHR)

---

**EHR Med Order**

Rx

Toprol XL

50 mg daily

---

- **Information card**
  - $200 per month (patient pays $30)

- **Suggestion card**
  - Try HCTZ as first-line
  - [Switch to HCTZ](#)

- **Smart app link card**
  - Managing hypertension?
  - [Launch JNC 8 Rx Pro](#)
Common Card Examples

Medication Information

ADRA2A (C/C): The genotype of this patient suggests a reduced response to certain ADHD medications.

Source: RxCheck

Information Only
Textual information for the provider
Common Card Examples

Medication Alert for lisinopril 5 mg tablet

This medication is not recommended for Black or African American patients.

82% of providers selected this recommendation.

Switch to amiloride 5 mg-hydrochlorothiazide 50 mg tablet

Source: RxCheck

Suggestions

Proposed actions encoded as FHIR resources
Common Card Examples

ASCVD Risk Alert
12% 10-year risk
69% lifetime risk

Source: Demo CDS Service
ASCVD Risk Calculator

App Links
Proposed SMART app that should be used
Cards can contain any combination of information, suggestions, and links

**Medication Alert**

*Source: RxCheck*

**lisinopril 5 mg tablet**

- This medication is not recommended for Black or African American patients.

*82% of providers selected this recommendation.*

- Switch to amiloride 5 mg-hydrochlorothiazide 50 mg tablet

**Medication Review**
CDS Hooks Sandbox

Patient View

Daniel X. Adams
ID: SMART-1288992 Birthdate: 1925-12-23

Now seeing: Daniel Adams
Source: CDS Service Tutorial
Learn more about CDS Hooks

Hello Daniel!
Source: Patient greeting service

Bilirubin Chart
Source: HSPC Bilirubin Risk Chart App
Demonstration app designed to help clinician treat newborn hyperbilirubinemia appropriately.
HSPC Bilirubin Risk Chart App

CDS Service Exchange
Select a Service:
http://hooks.fhir.me:8082/cds-services/patient-hello-world

Request
Response

```json
{
  "cards": [
    {
      "summary": "Hello Daniel!",
      "source": {
        "label": "Patient greeting service"
      },
      "indicator": "info",
      "suggestions": [],
      "links": []
    }
  ],
  "decisions": []
}
```
References

Specification & documentation
http://cds-hooks.org

Demo sandbox
http://sandbox.cds-hooks.org

Source code
https://github.com/cds-hooks
Today > Decision Support in Cerner

Local rule engine/GUI

Robust set of events

CDS can be rendered as native dialogs and HTML (allows for remote CDS logic and content)
Argonaut Initiative and Epic Perspective

James Doyle

Senior Software Engineer and CDS Lead

Epic Systems Corporation
The Argonauts!
Decision Support in Epic

Build

Import

Outsource

Hybrid

© Strasberg, Rhodes, Shekleton, Doyle, Kawamoto 2017
Importing CDS Content

Medication warnings
Inline dose warnings
Formulary-based alternatives
Diagnosis groupers
BestPractice Advisories
BestPractice Advisory Web Service

Introduced April 2014 in Epic 2014

1. Show BestPractice Advisory?
2. Display Content
3. Orders to Remove
4. Orders to Place
5. External Link
BestPractice Advisory Web Service

```xml
<CDSAdvisory>
  <ShowAlert>true</ShowAlert>
  <DisplayText>[HTML-enabled content]</DisplayText>
  <FollowUp>
    <RemoveUnsignedOrder>
      <OrderNumber>1</OrderNumber>
      <Checked>true</Checked>
    </RemoveUnsignedOrder>
    [Repeat as necessary]
    <Order>
      <Title>MR, head, no iv contrast</Title>
      <Key>MRHEAD-NOCON</Key>
      ... [Specify other order details]
    </Order>
    [Repeat as necessary]
  </FollowUp>
</CDSAdvisory>
```
Challenge: Epic-specific standard

“If you want to go fast, go alone. If you want to go far, go together.”

Epic is working on CDS Hooks support as part of the Argonaut Project
Health Care System Perspective

Kensaku Kawamoto, MD, PhD, MHS
Associate CMIO, University of Utah
Co-Chair, HL7 CDS Work Group
Foundational Issue: Difficulty Sharing

- **Vision**: sharing executable CDS is as easy and plug-and-play as exchanging emails across different email systems (Hotmail, Gmail, Outlook, etc.)

- **Historical reality**: sharing executable CDS is hard, expensive, and rarely happens in operational contexts

- **Consequences**:
  - Each health care institution mostly builds and manages CDS assets on its own
  - CDS only available for a small sliver of areas where CDS could help patients and providers
  - Existing CDS is suboptimal and leads to alert fatigue
  - Ultimately, worse patient outcomes and higher costs
What Do We Need as Health Care Systems?

- Standards, and vendor support for those standards, that allow us to seamlessly share both CDS services and CDS knowledge artifacts
- Fast execution speed
- Robust security
- Ability to meet the needs of our patients and providers
  - Our providers do not want to hear: “Sorry, that makes complete sense but we can’t do that because the standard/our vendor doesn’t support that yet”
  - The 80/20 rule doesn’t work when your needs fall in the 20%
- True semantic interoperability
  - FHIR profiles based on detailed clinical models (e.g., from CIMI)
- Higher quality, lower cost CDS through economies of scale
University of Utah Health Strategy

- Interoperable Apps and Services (IAPPS) initiative
  - Goal: enhance patient care and provider experience via interoperable extensions to EHR
  - Multi-stakeholder initiative co-chaired by CIO and CMIO

- FHIR Clinical Reasoning CDS knowledge artifacts
  - Desired for order sets, doc. templates; also rules (for native execution speed and security)
  - Use to power CDS Hooks where appropriate; explore use for population health management
  - Encouraging and awaiting EHR vendor support

- CDS Hooks
  - Main approach for external CDS
  - Use OpenCDS – open-source, standards-based CDS service (www.opencds.org)
  - Develop and share CDS Hooks adapter prior to native Epic support
  - Use locally hosted services and potentially remotely hosted services with prefetch/data push
University of Utah Health Strategy

- **SMART on FHIR**
  - Use CDS Hooks to suggest SMART on FHIR apps
  - Use CDS Hooks to drive complex CDS processing within SMART on FHIR apps

- **FHIR**
  - Use EHR vendor-supported FHIR APIs whenever possible
  - Where not supported, develop FHIR APIs in coordination with EHR vendor
  - Plan to use CIMI detailed clinical models
  - Still identifying best way to ensure interoperability of FHIR APIs across EHR vendors
CDS Hooks Integration Architecture

- EHR
- BPA Web Services
- FHIR Wrapper
- CDS Hooks Adapter
- CDS Service (OpenCDS)

Connections:
- CCDA
- Guidance
- FHIR + OAuth 2.0 Access Token
- Guidance Card
- OAuth 2.0 Token
- FHIR
CDS Hooks Example: Opioid CDS Service

• Goal: provide point-of-care support for CDC prescribing guideline on opioid use for chronic pain

• Supported by CDC with ONC involvement

• Partners: Yale, Houston Methodist, ESAC

• Extensive use of National Library of Medicine’s RxNav knowledge base

• Knowledge encoded as FHIR Clinical Reasoning module

• Preparing for operational use at University of Utah Health
Maximum morphine equivalent daily dose (MEDD) is **545 mg/day** (PRN meds assumed to be taken at maximum allowed frequency). Taper to < 50.

<table>
<thead>
<tr>
<th>Opioid Rx</th>
<th>Max MEDD</th>
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</thead>
<tbody>
<tr>
<td><strong>[ New ] Oxycodone Hydrochloride 5 MG Oral Tablet</strong></td>
<td></td>
</tr>
<tr>
<td>Sig: 5 mg Oral Every 4 hours as needed</td>
<td></td>
</tr>
<tr>
<td>Daily dose: Oxycodone Oral Tablet 5 mg = 30 mg, Morphine equivalence: 1.5x.</td>
<td>45 mg</td>
</tr>
<tr>
<td><strong>72 HR Fentanyl 0.1 MG/HR Transdermal System</strong></td>
<td></td>
</tr>
<tr>
<td>Sig: Apply 1 patch to the skin Every 72 hours.</td>
<td></td>
</tr>
<tr>
<td>Prescriber: Michael Flynn, MD. Rx date: 2017-09-19.</td>
<td></td>
</tr>
<tr>
<td>Dispense: 30 patches. Refills: 0. Expected supply duration: through 2017-12-17.</td>
<td></td>
</tr>
<tr>
<td>Daily dose: Fentanyl patch: 1 * 0.1 mg/hr = 0.1 mg/hr. Morphine equivalence: 2400x.</td>
<td>240 mg</td>
</tr>
<tr>
<td><strong>Buprenorphine 2 MG Sublingual Tablet</strong></td>
<td></td>
</tr>
<tr>
<td>Sig: Place 2 mg under the tongue 2 times a day.</td>
<td></td>
</tr>
<tr>
<td>Prescriber: HISTORICAL, MEDS.</td>
<td></td>
</tr>
<tr>
<td>Daily dose: Buprenorphine Sublingual Tablet 2 mg = 4 mg, Morphine equivalence: 30x.</td>
<td>120 mg</td>
</tr>
<tr>
<td><strong>Methadone Hydrochloride 10 MG Oral Tablet</strong></td>
<td></td>
</tr>
<tr>
<td>Sig: Take 0.5 tablets by mouth Every 6 hours as needed for pain for up to 180 days.</td>
<td></td>
</tr>
<tr>
<td>Prescriber: Michael Flynn, MD. Rx date: 2017-09-19.</td>
<td></td>
</tr>
<tr>
<td>Dispense: 360 tablets. Refills: 0. Expected supply duration: through 2017-12-30.</td>
<td></td>
</tr>
<tr>
<td>Daily dose: Methadone Oral Tablet 4 mg = 20 mg, Morphine equivalence: 4x.</td>
<td>80 mg</td>
</tr>
<tr>
<td><strong>Oxycodone Hydrochloride 5 MG Oral Capsule</strong></td>
<td></td>
</tr>
<tr>
<td>Sig: Take 2 capsules by mouth Every 6 hours as needed.</td>
<td></td>
</tr>
<tr>
<td>Prescriber: Michael Flynn, MD. Rx date: 2017-09-19.</td>
<td></td>
</tr>
<tr>
<td>Daily dose: Oxycodone Oral Capsule 4 mg = 40 mg, Morphine equivalence: 1.5x.</td>
<td>50 mg</td>
</tr>
</tbody>
</table>

**Total** 545 mg

**CDC opioid recommendation #5**

**MME conversion table**

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High risk for opioid overdose - taper now.

Maximum morphine equivalent daily dose (MEDD) is 365 mg/day (PRN meds assumed to be taken at maximum allowed frequency). Taper to < 50.

**Active Opioid Rx**

- **Oxycodone Hydrochloride 5 MG Oral Capsule**
  - Sig: 5 mg Oral Every 4 hours as needed
  - Daily dose: Oxycodone Oral Capsule 6/5 mg = 30 mg. Morphine equivalence: 1.5x.
  - Max MEDD: 45 mg

- **72 HR Fentanyl 0.1 MG/HR Transdermal System**
  - Sig: 1 patch q3d
  - Prescriber: Michael Flynn, MD (Internal Medicine/Pediatrics).
  - Daily dose: Fentanyl patch 1.0 mg/hr = 0.1 mg/hr. Morphine equivalence: 2400x.
  - Max MEDD: 240 mg

- **Buprenorphine 2 MG Sublingual Tablet**
  - Sig: Place 1 tablet under the tongue Every 6 hours as needed.
  - Prescriber: Michael Flynn, MD (Internal Medicine/Pediatrics).
  - Daily dose: Buprenorphine Sublingual Tablet 1/2 tablet 2 mg = 2 mg. Morphine equivalence: 30x.
  - Max MEDD: 60 mg

- **Methadone Hydrochloride 10 MG Oral Tablet**
  - Sig: Take 0.5 tablets by mouth Every 6 hours as needed for pain.
  - Prescriber: Michael Flynn, MD (Internal Medicine/Pediatrics).
  - Daily dose: Methadone Oral Tablet 1/2 tablet 0.5 tablet 10 mg = 5 mg. Morphine equivalence: 4x.
  - Max MEDD: 20 mg

Total: 365 mg

- **CDC opioid recommendation #5**
- **MME conversion table**

Source: CDC
CDS Hooks in Bilirubin SMART on FHIR App

• Goal: improve neonatal bilirubin management and prevent neurotoxicity
• Started with a basic bilirubin graphing app developed by Intermountain Healthcare on Cerner platform
• Iteratively enhanced based on user requests
• Estimated to save >300 hrs of MD time/yr
• Originally supported by FHIR Clinical Reasoning *evaluate* interface
• Being transitioned to use CDS Hooks interface
• Awarded HHS Provider User Experience App Challenge Awards ([link](#))
Lessons Learned & Next Steps

• EHR vendor engagement is truly a game-changer

• Current state = excellent starting point, more needs to be done. E.g.:
  • Cross-EHR support for comprehensive, truly interoperable FHIR services (e.g., standardized medication route codes; support for encounters, procedures, and imaging results)
  • Cross-EHR support for additional hooks (e.g., invocation from SMART on FHIR app, Epic Health Maintenance module)

• Hands-on, collaborative learning on how to scale CDS resources across institutions and EHR platforms
  • Plan to share CDS Hooks services described in this presentation as free, open-source software
Discussion and Q&A

• What areas of clinical medicine do you think can benefit most from interoperable CDS?

• What recommendations do you have for standards development and implementation in this area?

• What gaps do you see in the current interoperability frameworks offered by EHR systems?

• What can be done to facilitate order mapping from external CDS systems to local order catalogs?
## Thank You!

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