Get to Green: A FHIR-enabled application for ventilator weaning using Cerner Ignite API

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Learning Objectives

1. Understand how FHIR specifications allow software developers to quickly create apps that connect with Cerner Millennium.

2. Understand how the cloud-based deployment enabled an iterative design process allowing appropriate adjustments to be made based on feedback throughout the build.

3. Understand the challenges that health systems should expect to prepare for when implementing FHIR-based apps.
A Fundamental Problem

Ideas >>> Resources
“I have an idea…”

• What problem does it solve?
• Who wants it?
• Is it a priority?
• Can it be done?
• Approved and “On the list”

• *Wait in line*…
### The Excel Spreadsheet!

<table>
<thead>
<tr>
<th>Time</th>
<th>Parameter</th>
<th>Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>18:35</td>
<td>Hours From MICU Arrival</td>
<td>7.32</td>
<td>PASS</td>
</tr>
<tr>
<td>12/29/15 11:55 AM</td>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/29/15 6:35 PM</td>
<td>Hours From MICU Arrival</td>
<td>7.46</td>
<td>PASS</td>
</tr>
<tr>
<td>01/18/1975</td>
<td>Dob</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Hours From MICU Arrival</td>
<td>7.4</td>
<td>PASS</td>
</tr>
</tbody>
</table>

### SBT Trial Summary

- **First Attempt at SBT Trial**
  - Hours From MICU Arrival: 7.13
  - Result: PASS

- **Second Attempt at SBT Trial**
  - Hours From MICU Arrival: 7.13
  - Result: PASS

- **Third Attempt at SBT Trial**
  - Hours From MICU Arrival: 7.13
  - Result: PASS

- **Fourth Attempt at SBT Trial**
  - Hours From MICU Arrival: 7.13
  - Result: PASS

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*Note: The Excel spreadsheet contains detailed parameters and test results, with time stamps and results indicated in green and red for PASS and FAIL, respectively.*
Ventilator Bundle

1. Head of bed elevated 30 degrees
2. Daily sedative interruption and daily assessment of readiness to extubate
3. Peptic ulcer disease (PUD) prophylaxis
4. Deep vein thrombosis (DVT) prophylaxis
5. Daily oral care with chlorhexidine
Ventilator weaning

- Removing patients from ventilator as soon as safely feasible
- Physician assessment +/- guidelines
- Concern for emergent reintubation and complications

Table 3. Criteria Used in Weaning/Discontinuation Studies to Determine Whether Patients Receiving High Levels of Ventilatory Support Can Be Considered for Discontinuation (ie, Entered Into the Trials)*

| Objective Measurements                                           | Adequate oxygenation (eg, $P_{O_2} \geq 60$ mm Hg on $F_{O_2} \leq 0.4$; PEEP $\leq 5$–$10$ cm H$_2$O; $P_{O_2}/F_{O_2} \geq 150$–$300$)
|                                                               | Stable cardiovascular system (eg, HR $\leq 140$ beats/min; stable blood pressure; no or minimal vasopressors)
|                                                               | Afebrile (eg, temperature $< 38^\circ$C)
|                                                               | No significant respiratory acidosis
|                                                               | Adequate hemoglobin (eg, Hgb $\geq 8$–$10$ g/dL)
|                                                               | Adequate mentation (eg, arousable, GCS $\geq 13$, no continuous sedative infusions)
|                                                               | Stable metabolic status (eg, acceptable electrolytes)
| Subjective Clinical Assessments                                | Resolution of disease acute phase; physician believes discontinuation possible; adequate cough

*Adapted from References 101–103, 107–109, 119, and 120
GET TO GREEN : IMPROVING TEAM COMMUNICATION TO REDUCE VENTILATOR HOURS

AL AMAN
BELA PATEL, MD

MCGOVERN MEDICAL SCHOOL AT UTHEALTH – HOUSTON
Primary drivers for improvement include:

- **Patient Safety**
  Prolonged mechanical ventilation is associated with an increased risk of ventilator related complications and mortality.

- **Cost**
  Extensive ventilator days leads to increased length of stay and subsequently, higher total costs for both the patient and the hospital. The average cost of stay for a typical ICU intubated patient is approximately 2,500 dollars per day.

A multi-disciplinary team of physicians, respiratory therapists, nurses, process improvement engineer, and applications analyst were formed to address the length of ventilator hours in MICU by focusing on team communication.
OUR GOAL

The primary goal of this project was to decrease ventilators hours by 20% in 10 months by using a ventilator status communication board. In 2014, average days a patient was on mechanical ventilator was 4.9 days.

Measures of Success:

Primary Measure:

Reduction of ventilator hours per patient.

Secondary Measure:

No increase in percentage of reintubation in extubated patients.
The following ventilation parameters with specified targets were selected for the visual communication board:

1. PEEP
2. FIO2%
3. PH
4. Respiratory Rate
5. Heart Rate
6. Hemoglobin
7. Mean Arterial Pressure
8. Vasopressors
9. RASS
10. Plateau Pressure
11. Tidal Volume
PROCESS IMPROVEMENT INITIATIVES: Get To Green

ICU BED# _______ ETT / TRACH# _______ @ _______

FiO2 ≤ 50%
p/f ratio ≥ 180

PEEP ≤ 5

pH ≥ 7.32

RR 8-35

Pressors ≤ 5
mcg/kg/min
HB ≥ 7 gm/dl
Mean BP ≥ 60 mmHg
HR ≤ 130 bpm

Light or No sedation,
Awakens to voice,
able to initiate inspir.
effort

G E T T O G R E E N

THEN SBT

Male □ Female □

Ht

PBW

Keep Tidal Volume (Vt)
~ 6ml/kg/PBW

= ___________________________mLs

Keep Pplat < 30

= ___________________________ cmH2O

Latest SBT result/date/time

Currently does not meet SBT criteria □
PROCESS IMPROVEMENT INITIATIVES: Get To Green

ICU BED # 17

PEEP ≤ 5
pH ≥ 7.32
RR 8-35

FiO2 ≤ 50%
p/t ratio ≥ 180

Male □ Female □

Ht (inches) 69
PBW (kg) 71

= 453 mls

Target Pplat < 30

Target Tidal Volume (Vt) = 6ml/kg/PBW

Spontaneous Breathing Trial (when all GREEN criteria met)

Date: 4/19
Time: 05:42
Pass □ Fail □

Memorial Hermann
UT Health - Texas Center of Healthcare Quality Innovation at UT Health
RESULT: PRIMARY MEASURE

Average days on mechanical ventilation has decreased from 4.9 days in 2014 to 3.6 days in 2017 (36% improvement), therefore we exceeded our primary measure goal of a 20% decrease in average vent days.
RESULT: PATIENT REINTUBATION FREQUENCY

Average number of reintubations has not increased since the start of the “Get to Green” initiative.
Problems and limitations

- Manual data entry...
- Timeliness of data entry
- Timeliness of analysis
- Timeliness of communication
- Inconsistent usage
Why can’t we have...

• A new flowsheet in Cerner?
  • How will people find it?

• A rule and alert?
  • Difficult
  • High backload of new ambulatory content, refinements, >6 months
  • Maintenance and upgrades

• A new mPage?
  • mPage Developer License
FHIR to the Rescue
Emerging standards make “apps” a reality

- **FHIR** = “Fast Health Interoperability Resources”
  - An API standard for accessing health care data (“Resources”)
  - ReSTful design leverages Internet standards (HTTP, etc.)
  - Created by Health Level 7 International (HL7)
  - Emerging support by most major HIT providers (e.g., Argonaut Project)
  - Meets EHR Certification for MU3

- **SMART** = “Substitutable Medical Applications and Reusable Technology”
  - A SMART App is a Web App
    - HTML5 + JavaScript
    - Typically embedded in EHR
  - EHR Data Access is via FHIR
  - OAuth2 for security and context passing
  - Also supports smart-phone and patient-controlled apps
APIs have transformed many other industries

We believe they can do the same for health care!

• Application Programming Interfaces (APIs):
  • Allow technical solutions to talk to one another in the same language
  • Easily expose services to make them available inside and outside an organization
• Cerner’s open platforms expose standards that make it possible to connect apps or easily transfer discrete data.
APIs enable apps for providers and consumers

Provider-facing apps can be developed that leverage the Millennium Platform using APIs

Government regulation requires more choices for consumer-facing apps via APIs

**Plan to attest for Meaningful Use Stage 3?**
The Ignite API for Millennium addresses *Objective 5, Measure 1*
The HITECH Era and the Path Forward

Vindell Washington, M.D., M.H.C.M., Karen DeSalvo, M.D., M.P.H., Farzad Mostashari, M.D., and David Blumenthal, M.D., M.P.P.

More than a decade ago, the National Academy of Medicine outlined the serious consequences of a paper-based health system: redundant tests; increased costs; uncoordinated and fragmented care; medical decisions made with incomplete data, leading to adverse events; and potential clinical innovations left undiscovered, hidden in patient files. To help address these concerns, Congress passed the Health Information Technology for Economic and Clinical Health (HITECH) Act, part of the American Recovery and Reinvestment Act, to shepherd the health care sector into the digital age. The HITECH Act statutorily authorized the ONC and called for establishing the Health IT Certification Program to set health IT standards and implementation specifications. It also provided substantial resources to offset the cost of adopting and using electronic health records (EHRs) for eligible hospitals and providers, support population health management with data, and develop a national infrastructure for health information exchange. Today, almost all U.S. hospitals and health systems are in the process of adopting and implementing electronic health records.

The HITECH Era in Retrospect

John D. Halamka, M.D., and Micky Tripathi, Ph.D.

A t a high level, the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 accomplished something miraculous: the vast majority of U.S. hospitals and physicians are now active users of electronic health record (EHR) systems. No other sector of the U.S. economy of similar size (one sixth of the gross domestic product) and complexity (more than 5,000 hospitals and more than 500,000 physicians) has undergone such rapid computerization.

Along the way, however, we lost the hearts and minds of clinicians. We overwhelmed them with confusing layers of regulations. We tried to drive cultural change by expecting health care systems to follow regulations and guidelines. Soon physicians were expected to provide high-quality and empathetic care in a 12-minute visit while weaning themselves from paper-based workflows, entering the numerous structured data elements required for meaningful use, rolling out new HIPAA privacy notices, implementing security protections for new electronic data, learning and incorporating new ICD-10 billing codes, and convincing their patients to use patient portals and secure e-mail, all while avoiding safety and malpractice issues. Instead of being a gift horse that reduced clinician burden, the EHR became an expensive Trojan horse loaded with an array of new regulatory requirements.

Application programming interfaces & FHIR
The HITECH Era and the Path Forward
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More than a decade ago, the National Academy of Medicine outlined the serious consequences of a paper-based health system: redundant tests; increased costs; uncoordinated and fragmented care; medical decision-making based on anecdote rather than evidence.

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In 2009, the American Recovery and Reinvestment Act (HHRERA) Act, part of the American Recovery and Reinvestment Act of 2009, provided a large-scale stimulus program to support the adoption of electronic health records (EHRs) and promotion of meaningful use—technology solutions that were designed to improve care and reduce costs. HHRERA provided $848 billion to the healthcare sector of the U.S. economy of similar size (one sixth of the gross domestic product) and complexity (more than 5000 hospitals and more than 500,000 physicians) has undergone such rapid computerization.

Along the way, however, we lost the hearts and minds of clinicians—a purpose for which, as a technology investment program, it was not adequate.

This approach led to complex requirements that stressed processes more than outcomes, telling providers not only what they should do with their EHRs but also how they should use them.

...
Enabling innovation among clients and developers

- Developer Site: code.cerner.com
- Free and open documentation of available API Resource endpoints
- Starter app and tutorials
- Sandbox on actual Cerner EHR back-end for patient and provider-facing apps (over 1,200 registered apps)
- Active Google Group (300+ members, 200 posts per month). Cerner Engineers are highest contributors.
Breakfast with the CIO

- Developed internal FHIR server and developed prototype ~ 10 days
- Demonstrated application prototype cycle can be fast
- Prototype is “simple”, “desired”, has great champion…
- CONTRACT!
Advantages of custom FHIR development

• Development by external team
• Infrastructure investment based on FHIR as an accepted standard
• Far less application interdependence; smaller team
• Springboard for future development
• Low(er) cost, low(er) risk

• Ability to support a strong clinical leader with history of proven quality improvement success
  • An innovative, determined physician leader with a good balance of patience, persistence and perseverance
Arrangement

• 1/3 Memorial Hermann
• 1/3 McGovern Medical School
• 1/3 School of Biomedical Informatics

• Intellectual property held by University of Texas System

• Sticking point: Indemnification for research prototype
Design issues

• Parameter settings
• Team Workflows & Decision making
  • Phase 1—data displays
  • Phase 2—with notifications

• Clinical mappings!!
it looks to me like the best **SNOMED** code for the client event code 91539847 (Extubation Event) would be **SNOMED** code 271280005 (Endotracheal extubation).
Start time of spontaneous breathing trial (?)
# Get to Green - An App to monitor patients’ readiness for weaning from mechanical ventilation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Latest Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP Positive End-Expiratory Pressure</td>
<td>18 cm H₂O</td>
<td>Green if value &lt;= 5, Last Modified 09-Oct-2017 04:45:00 PM</td>
</tr>
<tr>
<td>FiO₂ Fraction of Inspired Oxygen</td>
<td>80 percentage (%)</td>
<td>Green if value &lt;= 50, Last Modified 09-Oct-2017 04:45:00 PM</td>
</tr>
<tr>
<td>pH Arterial pH</td>
<td>7.48 (no unit)</td>
<td>Green if value &gt; 7.32, Last Modified 09-Oct-2017 07:16:00 AM, over 4 hours</td>
</tr>
<tr>
<td>RR Respiratory Rate</td>
<td>34 breaths/min</td>
<td>Green if value between 8-35, Last Modified 09-Oct-2017 05:00:00 PM</td>
</tr>
<tr>
<td>HR Heart Rate</td>
<td>97 beats/min</td>
<td>Green if value &lt;= 130, Last Modified 09-Oct-2017 05:00:00 PM</td>
</tr>
<tr>
<td>Hgb Blood Hemoglobin</td>
<td>8.9 g/dl</td>
<td>Green if value &gt;= 7, Last Modified 09-Oct-2017 06:11:00 AM, over 4 hours</td>
</tr>
<tr>
<td>MAP Mean Arterial Pressure</td>
<td>122 mm Hg</td>
<td>Green if value &gt;= 65, Last Modified 09-Oct-2017 05:00:00 PM</td>
</tr>
<tr>
<td>NorEpi Dose of Norepinephrine</td>
<td>NA mcg/min</td>
<td>Green if value &lt;= 5, Last Modified NA</td>
</tr>
</tbody>
</table>
Implementation Challenges and Considerations
Build a Project Team

- Clinical Representative
- Cerner Data Expert
- Application Builder
When Scoping the Project

• Timeline
  • Allocation of Time for Cerner to Complete Testing and Validation in Sandbox Server
  • Allocation of Time for Mapping Data Elements

• Identifying Data Elements
  • Compile a list for Concept Mapping
  • Review list of Cerner Mapped Data
  • Include clinical event code for those without SNOMED or LOINC

• Consider App growth and determine best location
  • Existing Internal Website vs. Net New
  • Future Applications to be developed
  • User Authentication
Technical Challenges

• Cerner Sandbox vs. Memorial Hermann Domain
Technical Challenges

• Know your Firewall Settings

• Troubleshooting and Logging
  • Create a logging method
    • What to log?
    • Where to keep log files?
    • How long to keep log files?
Where are we now?

- Monitor and address Issues as they arise
- Defining Long Term Support Model
  - Application Display Issues
  - Data Issues
  - Change requests
- Building Our FHIR Application team
  - Manage FHIR Apps
  - Assist in Testing and Implementation
- Looking at other areas of FHIR Growth!
Future
HealtheIntent Platform

Data | Connect
Aggregate and normalize

Data | Transform
Establish and evolve longitudinal record

Knowledge | Action
Deliver insights within workflow

Community care management
Person engagement
Registries and scorecards
Analytics
For a person and populations
HealtheIntent and SMART

SMART-capable *HealtheIntent* applications

- *HealtheRegistries* and *HealtheRecord*

SMART-specific applications

- Built on top of HealtheIntent APIs
  - HealtheInsights

HealtheCare

- Built on *Millennium®* and HealtheIntent
- *Millennium* extensibility via SMART
Future: HealtheIntent API

• Case of failure to see a specific lab result

• CDS Hooks with labs in HealtheIntent

• Partnership with a University development corporation

• Pursuing SBIR/STTR
CDS Services

EHR Med Order

Rx
Toprol XL
50 mg daily

EHR triggers a CDS hook and invokes a remote service

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

1

2

3

EHR FHIR Server

Returns CDS cards (rendered and displayed by EHR)

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

HealtheIntent API
Questions?
TOMORROW, TODAY.

Cerner Health Conference 2017