ELECTRONIC ADAPTIVE CLINICAL PATHWAYS

Group 5
Ashish Dave, Stephen Ruffenach, Natalie Schwartz, Philip White, Stephanie Wong
What are clinical pathways?

**Background:**
- Introduced in the 1990’s in the USA and UK
- Widely accepted tools in the practice of medicine
- Structured, multidisciplinary plans of care
- Detailed guidance the management of a particular disease state within a given time period
- Instructive, not prescriptive
- Current paper based and electronic clinical pathways are not adaptive
Benefits and Barriers of Current Pathways

**Benefits:**
- Enables the integration of standards of care, evidence-based guidelines with clinical decisions
- Improves multidisciplinary communication and teamwork
- Reduces provider variability in disease management and resource utilization and improves patient outcomes
- Supports risk management, clinical auditing, and quality of care processes

**Barriers and Problems:**
- Not able to predict unusual or unpredictable presentations of disease
- Do not respond well to unexpected changes in patient’s condition
- Static algorithms that require manual entry and feedback of clinical data to the provider
- Poorly managed and maintained across multiple care settings
- Clinicians must choose the appropriate clinical pathway upfront
- Physicians argue that they depersonalize patient care, they are too rigid, and they feel that deviation increases litigation risk
How is our project different?

**Novel Approach:**

- Allow clinical pathways to be dynamic and flexible
- Adaptive clinical pathways are integrated into the EMR with real-time data
- EMR is automatically populated with patient results (labs, radiology reports, data from biomedical devices)
- Provider is alerted to start or to proceed along clinical pathways based on the patient’s data feed to the EMR and clinician’s PDA
- Real-time integrated patient results are reported to the provider automatically via PDA communications
- Result-based clinical decision support messages guide the provider along the clinical pathway
Benefits to Using Adaptive Clinical Pathways

- Able to capture atypical disease presentations
- Adaptable to unexpected patient responses to disease management
- Aligns with traditional physician roles
  - Provider interacts dynamically with the pathway and patient results
  - Provider uses clinical decision support messages to guide management
  - “More personalized patient management”
  - Provider uses clinical judgment more frequently
  - Reduces physician’s blinders i.e. may trigger a pathway that the clinician did not anticipate
What is Sepsis?

- Presence of an infection in the body that causes an inflammatory response
- Leading cause of death in the non-cardiac ICU
- Occurrence: 750,000 cases annually
- Cost: nearly $20 billion/ year
- Mortality rate:
  - severe sepsis: 30-50%;
  - septic shock: 50-60%
- Early goal directed therapy (EGDT) within the first 6 hours has been shown to prevent cardiovascular collapse and early hospital death
GOALS: Central venous pressure (CVP) 8-12 mmHg (12-15 mmHg mechanically ventilated)
Mean arterial pressure (MAP) 65-85 mmHg, central venous oxygen saturation (ScVO₂) ≥70%

HYDRATION:
Place central venous catheter in IJ or subclavian vein. Monitor CVP every one hour.
If initial CVP < 8 mmHg:
☐ 500mL NS IVPB every 30 minutes, repeat until CVP between 8-12 mmHg (12-15 mmHg if mechanically ventilated).
☐ 500mL Ringers Lactate IVPB every 30 minutes, repeat until CVP between 8-12 mmHg (12-15 mmHg if mechanically ventilated).
If initial CVP < 4 mmHg:
☐ Albumin 5% 250mL IVPB over 15 minutes for one dose (in addition to above fluid order).
☐ Other: _________________________________________________________________________________________

VASOPRESSORS:
If MAP < 65 mmHg and CVP > 8 mmHg: Place arterial line and administer vasopressor as below.
☐ Norepinephrine (Levophed®) IV 8mg/250mL continuous infusion via CENTRAL LINE ONLY starting at 5 microgram/minute. Titrate up until MAP > 65 mmHg. (Titrated up by 1 microgram/minute every 5 minutes to a maximum dose of 32 microgram/minute).
☐ If MAP of > 65 mmHg not achieved after maximum dose, administer in conjunction with Vasopressin IV 100 units/100mL continuous infusion at 0.04 units/minute. Do not titrate up. May titrate down by 0.01 units every 30 minutes to maintain MAP > 65 mmHg.
☐ Other: _________________________________________________________________________________________

TISSUE PERFUSION OPTIMIZATION:
Obtain central venous oxygen saturation (ScVO₂) every four hours until ≥70%.
ScVO₂ < 70% and HCT < 30%:
☐ Packed Red Blood Cells (PRBC) at 1 unit/hour until HCT > 30%.
ScVO₂ < 70%, CVP > 8 mmHg, MAP 65-85 mmHg and HCT ≥ 30% CONSIDER:
☐ Dobutamine (Dobutrex®) IV 500mg/250mL continuous infusion (2.5 microgram/kg/minute) ____ microgram/minute.
Titrated up by 2.5 microgram/kg/minute every 60 minutes until ScVO₂ ≥ 70% or to a maximum dose of 20 microgram/kg/minute.
A Typical Clinical Pathway for Sepsis

Pathway Complexity:

- Clinical pathways can be of varying complexity
- Due to issues of complexity, clinical pathways can be difficult to follow
  - This can lead to difficulty in consistently achieving the various elements of the pathway
  - When discussed with other facilities they frequently report realizing less than 10% achievement of all pathway elements
A Typical Clinical Pathway for Sepsis (Loma Linda University Med Center)

CVP: central venous pressure
MAP: mean arterial pressure
ScvO$_2$: central venous oxygen saturation

Above parameters from biomedical devices will automatically populate the EMR
A Typical Clinical Pathway for Sepsis (pg. 2)
Pathway Complexity: Strategies

• Numerous strategies have been attempted to increase compliance:
  • Various education strategies have been utilized
  • Ongoing monitoring and analysis
  • Cue sheets and checklists have been created for care providers
  • There is a danger in cue sheets and checklists as they may be utilized as substitute documentation which in fact does not belong in the medical record
  • Loma Linda’s cue sheet/checklist is on its 12th version, its primary purpose is to cue the bedside RN to follow the pathway steps, e.g., notifying or asking the MD to write orders for the next appropriate pathway element
A Typical Clinical Pathway for Sepsis: Workaround Checklist

Severe Sepsis/Septic Shock Pathway Checklist

**Arrival Time:** ED or ICU, **Meet Pathway Entry Criteria (Time Zero)** @: Date Time

- Two or more signs of systemic response to infection
  - Temperature > 100.9°F or < 96.8°F
  - HR > 90
  - RR > 20
  - WBC > 12,000 / μL or < 5,000 / μL
  - Acute or altered mental status
  - Glucose > 120 mg/dL

- Suspected infection* or positive cultures
  - Positive blood cultures
  - Positive CSF/pleural fluid

- AND
  - SBP < 90 mm Hg after 20 ml/kg fluid bolus
  - OR Lactate > 4
  - OR mechanical ventilation
  - OR vasoressor dependent
  - OR evidence of ≥ 2 acute organ dysfunction* (Note Definitions on back of this form)

**Pathway Process Measures:** Provide name of both RN & MD even if measure not completed.

<table>
<thead>
<tr>
<th>Step</th>
<th>Comp/Doc</th>
<th>RN</th>
<th>Attending MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCL</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood Culture – prior to antibiotic administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALS</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad spectrum antibiotics (within 4 hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOSP</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiate and document CVP &amp; ScvO2 monitoring (within 2 hours)</td>
<td>ALERT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVP: 5 ml/kg (achieved within 6 hours and documented)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP: 55-65 mm Hg (or SBP: 90-100 mm Hg) (achieved within 6 hours and documented)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ScvO2 &gt; 70% (achieved within 6 hours and documented)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALERT: Inform Team Leader if CVP monitor is unavailable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OXYGENATION</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVP: 5 ml/kg (achieved at all times and documented)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP: 55-65 mm Hg (or SBP: 90-100 mm Hg) (maintained at all times and documented)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ScvO2 &gt; 70% (maintained at all times and documented)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALERT: Inform Team Leader if monitor is unavailable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCL</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactate (grey-top tube on ice) (repeated within 12 hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APACHE II Score (computed by MD) (Check MAP documentation for this result)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastroenteral fluids activated (Xylocaine given within 24 hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IF APACHE II &gt; 15 and Vasopressor Dependent, without contraindication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood Glucose level &lt; 150 mg/dL (average of values obtained 24 hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ScvO2 Catheter Placement:** check reason(s) catheter was not placed and provide explanation:

- **Reason:** Physician states lactate result doesn’t meet criteria (Note: sepsis pathway entry criteria does not require elevated lactate).
- **Reason:** Delayed physician response due to other critical patients (describe below).
- **Reason:** Physician states the patient is stable (see below).
- **Reason:** Contraindicated for ScvO2 catheter placement (describe below).
- **Reason:** DNR or other documented limitations of treatment precluded placement (describe below).
- **Reason:** Resident has not been proctored on catheter placement (see below).
- **Reason:** Other:

- If ScvO2 Catheter not placed:
  - **Discuss** sepsis pathway entry criteria with physician.
  - Were the severe sepsis orders discontinued?
  - Notify senior resident, fellow or attending MD.
  - Develop plan for catheter placement.

**Further explanation/description:**

---

For CQ Purposes Only: Do NOT include in Medical Record

For CQ Purposes Only: Do NOT include in Medical Record

*Note: Definitions on back of this form*
Technology Requirements:

• Solution requires the integration of a number of technological hardware components
• Solution must interface and integrate with many biomedical devices and provide graphical user interfaces for:
  • Integration with the current EMR system
  • Laboratory Equipment
  • Radiology Equipment
  • Hospital Recording/Reporting Systems
  • Decision Support Systems
• Must tie together information related to clinical knowledge and economic goals, tasks and processes in a real-time environment
Technological Solutions for Adaptive Clinical Pathway

**Technological Solution:**

- Solution will enable assessments of real-time patient results that are sent via interface directly from patient’s biomedical devices.
- At a minimum, the following patient results need to be captured:
  - Heart Rate (HR)
  - Systolic Blood Pressure (SBP)
  - Mean Arterial Pressure (MAP)
  - Central Venous Oxygen Saturation (ScvO₂)
  - Central Venous Pressure (CVP)
- Patient results and pathway notifications populate into multiple locations such as the patient’s EMR, patient roster/whiteboard and Physician’s PDA.
- It is a critical requirement that computers are available at the bedside, all nursing stations and physician lounges.
- Physicians may carry computer tablets which may eliminate the need for redundant hardware.
- Computer on wheels (COWs) should be available on each floor.
Technological Solutions for Adaptive Clinical Pathway

**Technological solution:**

- Will apply adaptive reasoning over the course of the clinical pathway
- Rule-based engine tracks and monitors the progression and prognosis of the patient along the clinical pathway
- System will follow the specific business use cases and decision triage points that are presented as solution requirements
- System will adapt to new requirements/parameters introduced during patient treatment
- Technical cycle is fluid and dynamic, adapting the pathway in real-time
- All information is captured and stored for future analysis
Unique Aspects of the Product

- Graphical interface pulls all relevant clinical information relating to the diagnosis and management of sepsis onto a single panel display
- Displays graphs, trends, medical calculations (e.g. I/O’s)
- Interactive
- Real time data is used to for decision making
- Clinical decision support is evidence-based to current literature
- Direct links to CPOE, so orders can be performed immediately
- Patient can be put on or taken off pathway with ease
- Pathway adjusts and new triggers/alerts fired if patient condition changes
- Ability to send triggers, communications and alerts directly to clinicians, supporting staff, and supporting systems via bidirectional interfaces
Clinical Data Flow Diagram

- Medical Devices
- Servers
- Patient
- Clinicians
- EMR
- Clinical Pathway Application (CPA)
- CPA Processor
- Radiology Applications
- Laboratory Applications
- Bidirectional interface
Pulling Patient into the Pathway:

- Patient data will automatically populate the EMR via interfacing and integration between biomedical devices, laboratory equipment, radiology equipment, reporting system, and the EMR.
- Real-time patient results will automatically trigger clinicians via PDA alerts.
  - Some examples include:
    - Temperature, Heart Rate, Respiratory Rate, WBC, PaCO2
    - SBP after IV fluid bolus
    - Lactate Level
- Medical calculations (e.g. total amount of IV fluid given) will be performed and reported to the clinician.
- Clinical decision-support messages will prompt the clinician to implement the EGDT clinical pathway, if desired.
- The clinician will use a bi-directional PDA to access the EMR and initiate orders for the clinical pathway.
Electronic Adaptive Clinical Pathway-Severe Sepsis/Shock

Pulling patient into the pathway:

- SBP < 90 after fluid bolus
- Lactate >/= 4 mmol/L or > 1 organ dysfunction

Suspected infection

Two or more of the following:
1) Temperature > 38.3 C or < 36.0 C
2) HR > 90
3) RR > 20 or PaCO2 < 32
4) WBC > 12K, < 4K, or > 10% bands

Start early goal directed therapy

SEVERE SEPSIS

SEPTIC SHOCK
Logic Involved in One of Many Possible MD Alerts

- Temp > 38.3°C
- Temp < 36°C
- HR > 90
- RR > 20
- PaCO2 < 32
- WBC > 12
- WBC < 4
- >/= 10% Bands
- SBP < 90

Suspected Infection?
- Yes
- No

500 ml of Normal Saline Bolus completed?
- Yes
- No

Lactate ordered?
- Yes Result: < 4  >/= 4
- No

Clinical Decision Support Message:
Definitions of Sepsis and Septic Shock
Link to Reference about Early Goal Directed Therapy

Do you want to start the Adult Severe Sepsis Pathway?

NO

YES

Takes MD to CPOE
For Adult Severe Sepsis
Standard, formal procedural language that represents medical algorithms in clinical information systems as knowledge modules (Medical Logic Modules (MLMs))
(http://openclinical.com/gmm_ardensyntax.html)
Physician PDA Display

MRN: 7723152 (Smith)
Sepsis Alert: Patient has T > 38.3 C, HR > 90, RR > 20 and WBC < 4K, SBP < 90 after fluids, Lactate > 4 mmol/L

- Acknowledge
- Evidence
- CPOE
- Results Review
- Call NS
- Invoke Sepsis Pathway
Cooke County General Hospital Patient Dashboard

MRN: 7723152  Name: Smith, John  Location: ICU – 6th Floor
Allergies: Penicillin, Beansprouts
Attending: Carlson, Vivian  Differential Dx: Pneumonia

Monitors
March 10, 09 20h15
Temp: 39.2 C
BP: 86/58
HR: 140 bpm
O₂ Sat: 98%
RR: 35
PaCO₂: 35 mmHg
ScvO₂: 75%
MAP: 70 mmHg
CVP: 10 mmHg

Laboratory
March 10, 09 20h00

<table>
<thead>
<tr>
<th></th>
<th>20h15</th>
<th>19h15</th>
<th>18h15</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>2000</td>
<td>4500</td>
<td>5000</td>
</tr>
<tr>
<td>Hb</td>
<td>8.6</td>
<td>10.2</td>
<td>10.5</td>
</tr>
<tr>
<td>Lactate</td>
<td>4.5 mmol/L</td>
<td>3.5 mmol/L</td>
<td>3.2 mmol/L</td>
</tr>
<tr>
<td>Creatinine</td>
<td>2.0 mg/dL</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>INR</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platelets</td>
<td>98000</td>
<td>110000</td>
<td>120000</td>
</tr>
<tr>
<td>Glucose</td>
<td>150 mg/dL</td>
<td>175 mg/dL</td>
<td>190 mg/dL</td>
</tr>
</tbody>
</table>

Radiology
March 10, 09

Sepsis Alert:
Temp > 38.3 C, HR > 90, RR > 20, SBP <90
WBC < 4K, Hb < 10, Lactate > 4, Cr > 1.4, Plts <100K, Gluc > 150

Notifications:
Attending MD – Carlson, Vivian – ACK via PDA
Resident On Call - NACK
Nursing Station – ACK

MAR
March 10, 09 20h15

<table>
<thead>
<tr>
<th></th>
<th>20h00</th>
<th>12h00</th>
<th>6h00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dopamine</td>
<td>300 mcg/min/AB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levaquin</td>
<td>750 mg/AB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room</td>
<td>Bed</td>
<td>MRN</td>
<td>Name</td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
<td>-------</td>
<td>------------</td>
</tr>
<tr>
<td>100</td>
<td>A</td>
<td>7723152</td>
<td>Smith, John</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>65701</td>
<td>Brown, Dale</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>A</td>
<td>998402</td>
<td>Cole, John</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>104</td>
<td>A</td>
<td>896250</td>
<td>Bitton, Josie</td>
</tr>
<tr>
<td>105</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>106</td>
<td>A</td>
<td>905025</td>
<td>Carter, Vicki</td>
</tr>
<tr>
<td>107</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>A</td>
<td>785021</td>
<td>Silver, Ricky</td>
</tr>
<tr>
<td>109</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Second MD Alert

ScvO2 < 70%

Link to Clinical Decision Support Message

Hb < 10
  Transfuse _____(#) units PRBC
Hb >/= 10
  HR < 100 and SBP > 100
    • Start Dopamine according to orders
    • Intubation

Repeat MD Alert in 30 mins.
Cooke County General Hospital Patient Dashboard

MRN: **7723152**
Name: **Smith, John**
Location: **ICU – 6th Floor**

Allergies: Penicillin, Beansprouts
Attending: Carlson, Vivian
Differential Dx: Pneumonia

### Monitors
- **March 10, 09 21h15**
  - Temp: **39 C**
  - BP: **98/72**
  - HR: **110 bpm**
  - **O₂ Sat: 98%**
  - RR: **30**
  - PaCO₂: **30 mmHg**
  - ScvO₂: **80%**
  - MAP: **12 mmHg**
  - CVP: **12 mmHg**
  - Hourly Output: **300 cc**

### Laboratory
- **March 10, 09 21h15**
  - **WBC**
    - 21h15: **3800**
    - 20h15: **2000**
    - 19h15: **4500**
  - **Hb**
    - 21h15: **8.8**
    - 20h15: **8.6**
    - 19h15: **10.2**
  - **Lactate**
    - 21h15: **4.9 mmol/L**
    - 20h15: **4.5 mmol/L**
    - 19h15: **3.5 mmol/L**
  - **Creatinine**
    - 21h15: **2.2 mg/dL**
    - 20h15: **2.0 mg/dL**
    - 19h15: **1.8**
  - **INR**
    - 21h15: **1.5**
    - 20h15: **1.6**
    - 19h15: **1.5**
  - **Platelets**
    - 21h15: **87000**
    - 20h15: **98000**
    - 19h15: **110000**
  - **Cortisol**
    - 21h15: **228 mg/dL**
    - 20h15: **150 mg/dL**
    - 19h15: **175 mg/dL**

### Radiology
- **March 10, 09**
- **March 9, 09**
- **175 mg/dl**
- **150 mg/dL**
- **228 mg/dL**
- **98000**
- **87000**
- **110000**
- **3.5 mmol/L**
- **4.5 mmol/L**
- **3.5 mmol/L**
- **2.2 mg/dL**
- **2.0 mg/dL**
- **1.8**
- **1.5**
- **1.6**
- **1.5**
- **228 mg/dL**
- **150 mg/dL**
- **175 mg/dL**

### MAR
- **March 10, 09 21h15**

<table>
<thead>
<tr>
<th></th>
<th>21h00</th>
<th>20h00</th>
<th>6h00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dopamine</td>
<td>300 mcg/min/AB</td>
<td>300 mcg/min/AB</td>
<td></td>
</tr>
<tr>
<td>Levaquin</td>
<td>750 mg/AB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pathway(s): Sepsis
ON VASOPRESSORS FOR 60 MINS. - consider Adrenal Insufficiency


- ✗ Baseline cortisol
- ✗ Administer ACTH 250 mcg IV and measure cortisol level at 30 min and 60 min

### Notifications:
- Attending MD – Carlson, Vivian – ACK via PDA
- Resident On Call – NACK
- Nursing Station – ACK
Second MD Alert to PDA

Sepsis Alert #2:
- Patient on sepsis pathway
- Scv02 < 70%, Hb > 10, SBP > 100
- Suggest dopamine □
- Suggest intubation □

Acknowledge
CPOE
Results Review
Call NS
Continue Sepsis Pathway

Sepsis Alert #3:
- Patient on sepsis pathway
- Scv02 > 70%, SBP > 100, HR 100
- Recheck Lactate Level □

Acknowledge
CPOE
Results Review
Call NS
Continue Sepsis Pathway

3rd alert 30 min later
Reporting

Reporting From The Application

• Reports play an integral role in the management of a healthcare organization.
• Reporting allows administration, clinical directors, and quality control personnel to track how well the pathway is working and adjustments required.
• Real-time standard reports include, but are not limited to:
  • Patient alerts and their distribution with ack/nack monitoring.
  • Patients put on or taken off pathway in the past $X$ hours ($X = \# \text{ hours}$).
  • Unit and building monitoring of sepsis prevalence.
  • Costs associated with patients on the pathway.
  • Patient length of stay, patient progress tracking by hour, day, month.
  • Patient quality measurement.
• Customized reports
  • Customized reports can be created using Crystal Reports.
Cost-Benefit Analysis of an Adaptive Clinical Pathway

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Upfront capital equipment costs (ED and ICU)</td>
<td>• Reduction in in-hospital mortality</td>
</tr>
<tr>
<td>• Necessary technical upgrades</td>
<td>• Improved patient outcomes</td>
</tr>
<tr>
<td>• Maintenance costs</td>
<td>• Improved patient satisfaction</td>
</tr>
<tr>
<td>• IT personnel requirements and training</td>
<td>• Reduced ALOS in ED</td>
</tr>
<tr>
<td>• Supplies</td>
<td>• Reduced ALOS in ICU</td>
</tr>
<tr>
<td>• Increased administrative oversight</td>
<td>• Reduced ALOS in hospital</td>
</tr>
<tr>
<td></td>
<td>• More efficient patient management</td>
</tr>
<tr>
<td></td>
<td>• Improved hospital “throughput”</td>
</tr>
<tr>
<td></td>
<td>• Improved ED/ ICU productivity</td>
</tr>
<tr>
<td></td>
<td>• Allows providers to use more clinical judgment in decisions</td>
</tr>
</tbody>
</table>
Bringing in Medical Informatics

Java based programming
  • Allows for cross platform GUI creation

HL7 standards will be employed

DICOM standards for radiology image transfer

Arden syntax will be employed
  • Standard, formal procedural language that represents medical algorithms in clinical information systems as knowledge modules
  • To create medical algorithms
  • To evoke triggers and alerts
  • May come with some limitations

GLIF3 in next generation
  • GLEE provides standard interfaces to the hosting clinical information system at a local institution
  • These standard interfaces are used to integrate GLEE with a local EMR at the back-end and associated clinical applications (e.g., a physician order entry system) at the front-end.
Security: 
- Clinical Information must be accurate, available, and protected 
- Communication of clinical information must be HIPPA compliant 
- Ensuring robust security to protect clinical information access requires dynamic response 
- Security goals 
  - Access and authentication controls 
  - Audit trail for tracking user and data synchronization 
  - Emergency access of stored information 
  - Prevention of virus transmission 
  - Prevention of interception of orders
Security Answers for a Wireless Platform

Security Solutions:

- Security efforts accomplished in two ways
  - Authentication
  - Encryption
- Authentication - the act of ensuring the person accessing the system is indeed authorized to do so.
  - Accomplished by employing user IDs and passwords
  - Authentication server
- Encryption - the process of transforming information using an algorithm to make it unreadable to anyone except those possessing a “key”, or appropriate software.
  - Wi-Fi protected access (WPA2)
    - Meets HIPPA standards
    - Not backward compatible!
Security Solutions Continued:

- Interference with and from other signals must be maintained
- IEEE802.XX based systems offer multiple advantages
  - Flow control protocol
  - Collision detection
  - Error recovery techniques
  - Resistant to interference
  - Operate at power levels below those associated with non-wireless medical devices
Conclusion

Importance of Adaptive Clinical Pathways

- Incorporates the electronic date/time stamp of all clinical decisions i.e. orders entered, lab results obtained etc
- Reporting on quality indicators is easy to complete as the information is easily extracted from the EMR
- Application reporting enables the measurement of physicians’ adherence to pathway and can be used to track the pathways’ effectiveness on patient outcomes and physician behaviors
- Enables aggregation of clinical data for patients
- Allows for atypical disease presentations to be managed appropriately
- Real time data integration enables clinicians to get “at the moment” results
- Permits analysis of the effect of individual patient circumstances and co-morbidities on management along the pathway, adding to new clinical knowledge.
Items for Consideration
(To Do List)

- Need to perform a **Design Analysis** Prior to Implementation
  - User analysis
  - Environmental analysis
  - Task Analysis
  - Functional Analysis
  - Representational Analysis

- Need to perform an **Evaluation** of the Process
  - Heuristic evaluation
  - Keystroke level evaluation
  - Cognitive walkthrough
  - Usability study