Computer-Generated Reminders Improve Quality of Pediatric HIV Care in a Resource-Limited Setting: A Randomized, Controlled Trial

Martin Were, MD, MS; Winstone Nyandiko, MBChB, MMED, MPH; Kristin Huang, MD; James Slaven, MS; Changyu Shen, PhD; William Tierney, MD; Rachel Vreeman, MD, MS
Introduction

• 90% of world’s 2.3 million HIV-infected children live in sub-Saharan Africa

• Several studies suggest that quality of care for HIV-infected children is sub-optimal

• Challenges: early infant diagnosis and treatment, lab monitoring, managing malnutrition
Can Health Information Technology Improve HIV Care?

- Electronic Health Records (EHRs) implemented in resource-limited settings to improve quality of care
- Little rigorous evidence to demonstrate whether these systems improve HIV care
Objective

• Evaluate impact of **clinician-targeted, computer-generated reminders** on compliance with HIV care guidelines for children in a resource-limited setting
Methods

• **Study Design:** Randomized, controlled trial
• **Site:** HIV referral clinic in Eldoret, Kenya run by AMPATH PLUS Partnership
• 135,500 patients enrolled at 65 sites in Kenya
• 15,687 active pediatric patients; 4,963 on ART
• OpenMRS electronic health record system since 2004
Methods

• **Subjects:** HIV-infected and HIV-exposed children less than 14 years of age

• **Intervention:** Clinician-targeted, computer-generated reminders related to overdue clinical care tasks

• **Targeted clinical care tasks:** HIV testing (PCR and ELISA), laboratory monitoring (CD4, chemistries, CBC), screening chest x-rays, initiating ART, referrals for malnutrition
Intervention vs. Control

- **Intervention Group**: Printed patient summaries containing computer-generated, *reminders for overdue clinical care tasks* provided to clinicians at time of visit
- **Control Group**: Clinicians received summaries, but no computer-generated reminders
**AMPATH Pediatric Clinical Summary**

**John Doe**

Male 6 Years, 10 Months (20-Jun-2007)

**HIV STATUS:** POSITIVE

<table>
<thead>
<tr>
<th>First Encounter</th>
<th>Highest WHO Stage</th>
<th>6 Months HIV Rx Adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Sep-2011</td>
<td>WHO STAGE 2 PEDS</td>
<td>Perfect:</td>
</tr>
</tbody>
</table>

**Problem List:**
Remove resolved problems through encounter form.
1. HIV INFECTED (02-Sep-2011)
2. HERPES ZOSTER (02-Sep-2011)

**Immunizations:**
1. HEMOPHILUS INFLUENZA B VACCINATION
2. BACILLUS CAMILE-GUERIN VACCINATION
3. HEPATITIS B VACCINATION
4. MEASLES VACCINATION
5. DIPHTHERIA TIFANUS AND PERTUSSIS VACCINATION
6. POLIO VACCINATION

**Recent ARVs and OI Meds:**
1. TRIMETHOPRIM AND SULFAMETHOXAZOLE

**ARY Side Effects:**
NONE

**Maternal pMTCT:**
Med / Period / Doses Given / Rx Length
NONE

**Flowsheet (Initial + Last Four Value):**

<table>
<thead>
<tr>
<th>WT (KG)</th>
<th>HT (CM)</th>
<th>HBG</th>
<th>CD4</th>
<th>VITAL-LD</th>
<th>SGPT</th>
<th>DNA PCR</th>
<th>ELISA</th>
<th>RFDELA</th>
<th>CREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>93.0</td>
<td>12</td>
<td>1214</td>
<td>02-Sep-2011</td>
<td>12</td>
<td>POSITIVE</td>
<td></td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>02-Sep-2011</td>
<td>02-Sep-2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>01-Mar-2012</td>
<td>01-Mar-2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

**Last 2 Chest X-Rays:** check chart as needed for results prior to 14-Feb-2006
No chest x-ray results available.

**Reminders:**
(Write number next to each reminder)
1. Chest X-Ray; 2-Not Applicable (Explain); 3-Previously Ordered; 4-PT Allergic; 5-PT Refused; 6-I Disagree with Remind (Explain); 7-Other (Explain)

1. Please check Chest X-Ray. Positive PCR or ELISA but no Chest X-Ray. (___)
**Clinic Visit Data**

**Clinical Summary**

**Recent ARVs and OI Meds:**

1. **TRIMETHOPRIM AND SULFAMETHOXAZOLE**

**Last 2 Chest X-Rays:** (check chart as needed for results prior to 14-Feb-2006)
No chest x-ray results available.

**Reminders** (Write number next to each reminder):

1. Please check Chest X-Ray. Positive PCR or ELISA but no Chest X-Ray.
Clinic Visit Data

Clinical Summary

AMPATH Pediatric Clinical Summary

**John Doe**
Male, 4 Years, 10 Months (20-Jun-2007)
HIV STATUS: POSITIVE

<table>
<thead>
<tr>
<th>First Encounter</th>
<th>Highest WHO Stage</th>
<th>6 Months HIV Rx Adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Sep-2011</td>
<td>WHO STAGE 2 PEDS</td>
<td>Perfect</td>
</tr>
</tbody>
</table>

**Problem List:**
- HIV INFECTED (02-Sep-2011)
- HERPES ZOSTER (02-Sep-2011)

**Immunizations**
- HEMOPHILUS INFLUENZA B VACCINATION
- BOCIILIE CAMLE-GUERIN VACCINATION
- HEPATITIS B VACCINATION
- MEASLES VACCINATION
- DIPHTHERIA TETANUS AND PERTUSSIS VACCINATION
- POLIO VACCINATION

**Maternal pMTCT: Med / Period / Doses Given / Rx Length**
NONE

**Flowsheet (Initial + Last Four Value)**

<table>
<thead>
<tr>
<th>WT (KG)</th>
<th>HT (CM)</th>
<th>HGB</th>
<th>CD4</th>
<th>VITAL-LD</th>
<th>SOFT</th>
<th>DNA PCR</th>
<th>ELISA</th>
<th>RPDELSA</th>
<th>CREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>93.0</td>
<td>12</td>
<td>1214 (32%)</td>
<td>02-Sep-2011</td>
<td>12</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>02-Sep-2011</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>984 (28%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(z=-0.32 / p=37%)</td>
<td>02-Sep-2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(z=0.57 / p=28%)</td>
<td>01-Mar-2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(z=0.86 / p=19%)</td>
<td>16-May-2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Encounter entered by Super User on 17-May-2012
Next scheduled visit: 15-Jun-2012
Clinical Summary

**John Doe**
Male 4 Years, 10 Months (20-Jun-2007)
HIV STATUS: POSITIVE

<table>
<thead>
<tr>
<th></th>
<th>First Encounter</th>
<th>Highest WHO Stage</th>
<th>6 Months HIV Rx Adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>02-Sep-2011</td>
<td>WHO STAGE 2 PEDS</td>
<td>Perfect</td>
</tr>
</tbody>
</table>

**Problem List:**
- HIV INFECTED (02-Sep-2011)
- HERPES ZOSTER (02-Sep-2011)

**Immunizations:**
- HEMOPHILUS INFLUENZA B VACCINATION
- BACILLUS CAMILE-GUERIN VACCINATION
- HEPATITIS B VACCINATION
- MEASLES VACCINATION
- DIPHTHERIA TETANUS AND PERTUSSIS VACCINATION
- POLIO VACCINATION

**Recent ARVs and OI Meds:**
- TRIMETHOPRIM AND SULFAMETHOXAZOLE

**ARY Side Effects:**
NONE

**Maternal pMTCT: Med / Period / Doses Given / Rx Length**
NONE

**Flowsheet (Initial + Last Four Value)**

<table>
<thead>
<tr>
<th></th>
<th>WT (KG)</th>
<th>HT (CM)</th>
<th>HGB</th>
<th>CD4</th>
<th>VITAL-LD</th>
<th>SOFT</th>
<th>DNA PCR</th>
<th>ELISA</th>
<th>RFDEGA</th>
<th>CREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Sep-11</td>
<td>16.0</td>
<td>93.3</td>
<td>12</td>
<td>5114 (ref)</td>
<td>12</td>
<td>02-Sep-2011</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>02-Sep-2011</td>
<td></td>
</tr>
<tr>
<td>02-Sep-11</td>
<td>17.0</td>
<td>93.3</td>
<td>12</td>
<td>5114 (ref)</td>
<td>12</td>
<td>02-Sep-2011</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>02-Sep-2011</td>
<td></td>
</tr>
<tr>
<td>01-Mar-2012</td>
<td>17.0</td>
<td>93.3</td>
<td>12</td>
<td>5114 (ref)</td>
<td>12</td>
<td>02-Sep-2011</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>02-Sep-2011</td>
<td></td>
</tr>
</tbody>
</table>

**Last 2 Chest X-Rays:**
(check chart as needed for results prior to 14-Feb-2006)
No chest x-ray results available.

**Reminders (Write number next to each reminder)**

1. Please check Chest X-Ray. Positive PCR or ELISA but no Chest X-Ray. (___)
**Clinic Visit Data**

**Clinical Summary**

**AMPATH Pediatric Clinical Summary**

**John Doe**
- Male: 4 years, 10 months (20-Jun-2007)
- HIV Status: Positive

<table>
<thead>
<tr>
<th>First Encounter</th>
<th>Highest WHO Stage</th>
<th>6 Months HIV/Rx Adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Sep-2011</td>
<td>WHO STAGE 2 PEDS</td>
<td>Perfcet</td>
</tr>
</tbody>
</table>

**Problem List:**
- HIV INFECTED (02-Sep-2011)
- HERPES ZOSTER (02-Sep-2011)

**Immunizations:**
- HEMOPHILUS INFLUENZA B VACCINATION
- BACILLUS CALMET-GUERIN VACCINATION
- HEPATITIS B VACCINATION
- MEASLES VACCINATION
- DIPHTHERIA TETANUS AND PERTUSSIS VACCINATION
- POLIO VACCINATION

**Recent ARVs and OI Meds:**
- 1. TRIMETHOPRIM AND SULFAMETHOXAZOLE

**ARV Side Effects:**
- NONE

**Maternal pMTCT Med/Period/Doses Given/Rx Length:**
- NONE

**Flowsheet (Initial + Last Four Value):**

<table>
<thead>
<tr>
<th>WT (KG)</th>
<th>HT (CM)</th>
<th>HGB</th>
<th>CD4</th>
<th>VITAL-LD</th>
<th>S0FT</th>
<th>DNA PCR</th>
<th>ELISA</th>
<th>FPDEL-ELA</th>
<th>CREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>93.0</td>
<td>12</td>
<td>1214</td>
<td>20-Sep-2011</td>
<td>02-Sep-2011</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>02-Sep-2011</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>12</td>
<td>934</td>
<td>01-Mar-2011</td>
<td>02-Sep-2011</td>
<td>12</td>
<td></td>
<td>02-Sep-2011</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>12</td>
<td>934</td>
<td>01-Mar-2011</td>
<td>02-Sep-2011</td>
<td>12</td>
<td></td>
<td>02-Sep-2011</td>
<td></td>
</tr>
</tbody>
</table>

**Last 2 Chest X-Rays:**
- Check chart as needed for results prior to 14-Feb-2006
- No chest x-ray results available.

**Reminders (Write number next to each reminder):**
- 1-Ordered Today, 2-Not Applicable(Explain), 3-Previously Ordered, 4-Pl Allergic, 5-Pl Refused, 6-I Disagree with Reminder(Explain), 7-Other(Explain)

1. Please check Chest X-Ray. Positive PCR or ELISA but no Chest X-Ray. (___)

**Clinical Health Record**
**John Doe**

Male 4 Years, 10 Months (20-Jun-2007)

**HIV STATUS**: POSITIVE

**First Encounter**
02-Sep-2011

**Highest WHO Stage**
WHO STAGE 2 PEDS

**6 Months HIV Rx Adherence**
Perfect.

**Problem List:**
- HIV INFECTED (02-Sep-2011)
- HERPES ZOSTER (02-Sep-2011)

**Immunizations**
- HEMOPHILUS INFLUENZA B VACCINATION
- BACILLE C Camille GUERIN VACCINATION
- HEPATITIS B VACCINATION
- MEASLES VACCINATION
- DIPHTHIA TETANUS AND PERTUSSIS VACCINATION
- POLIO VACCINATION

**Recent ARVs and OI Meds:**
- 1. TRIMETHOPRIM AND SULFAMETHOXAZOLE
- ARV Side Effects:
  - NONE

**Maternal pMTCT Med / Period / Doses Given / Rx Length**
- NONE

**Flowsheet (Initial + Last Four Value)**

<table>
<thead>
<tr>
<th>WT (KG)</th>
<th>HT (CM)</th>
<th>HBG</th>
<th>CD4</th>
<th>VITAL-LD</th>
<th>SOFT</th>
<th>DNA PCR</th>
<th>ELISA</th>
<th>RFDELSA</th>
<th>CREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 kg</td>
<td>93.0 cm</td>
<td>12</td>
<td>1214</td>
<td>02-Sep-2011</td>
<td>12</td>
<td>02-Sep-2011</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>17.0 kg</td>
<td>93.0 cm</td>
<td>01-Mar-2012</td>
<td>984</td>
<td>01-Mar-2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.0 kg</td>
<td>93.0 cm</td>
<td>16-May-2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Last 2 Chest X-Rays**
- check chart as needed for results prior to 14-Feb-2006
- No chest x-ray results available.

**Reminders (Write number next to each reminder)**
1-Ordered Today, 2-Not Applicable (Explain), 3-Previously Ordered, 4-Pl Allergic, 5-Pl Refused, 6-I Disagree with Reminder (Explain), 7-Other (Explain)

1. Please check Chest X-Ray. Positive PCR or ELISA but no Chest X-Ray. (___)
Clinical Summary

**John Doe**
Male 4 Years, 10 Months (20-Jun-2007)
HIV STATUS: POSITIVE

<table>
<thead>
<tr>
<th>First Encounter</th>
<th>Highest WHO Stage</th>
<th>6 Months HIV/Rx Adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-Sep-2011</td>
<td>WHO STAGE 2 PEDS</td>
<td>Perfect</td>
</tr>
</tbody>
</table>

**Problem List:**
Remove resolved problems through encounter forms.
1. HIV INFECTED (02-Sep-2011)
2. HERPES ZOSTER (02-Sep-2011)

**Immunizations:**
1. HEMOPHILUS INFLUENZA B VACCINATION
2. BACILUS CAMILE-GUERIN VACCINATION
3. HEPATITIS B VACCINATION
4. MEASLES VACCINATION
5. DT/PERTUSSIS Meningitis
6. POLIO VACCINATION

**Recent ARVs and OI Meds:**
1. TRIMETHOPRIM and SULFAMETHOXAZOLE

**ARY Side Effects**
NONE

**Maternal pMTCT:** Med/Period/Doses Given/Rx Length
NONE

**Flowsheet (Initial + Last Four Value):**

<table>
<thead>
<tr>
<th>WT (KG)</th>
<th>HT (CM)</th>
<th>HGB</th>
<th>CD4</th>
<th>VITAL-LD</th>
<th>SOFT</th>
<th>DNA PCR</th>
<th>ELISA</th>
<th>RFDE-LSA</th>
<th>GCREAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>93.0</td>
<td>12</td>
<td>1214</td>
<td>02-Sep-2011</td>
<td>02-Sep-2011</td>
<td>POSITIVE</td>
<td>0.4</td>
<td>02-Sep-2011</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>01-Mar-2012</td>
<td>93.0</td>
<td>01-Mar-2012</td>
<td>01-Mar-2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>93.0</td>
<td>16-May-2012</td>
<td>93.0</td>
<td>16-May-2012</td>
<td>16-May-2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Last 2 Chest X-Rays:** (check chart as needed for results prior to 14-Feb-2006)
No chest x-ray results available.

**Reminders** (Write number next to each reminder)

1. Please check Chest X-Ray. Positive PCR or ELISA but no Chest X-Ray. (___)

**Electronic Health Record**

**Clinic Visit Data**
Analysis

• Compared differences between intervention and control groups in completion of overdue clinical tasks

• Analysis unit was response to a specific recommended action at a particular visit (ordered vs. not ordered)

• Looked at each type of reminder and all reminders combined
Results

• 3,993 children randomized from clinic
• Over 5 months: 1,611 children (49% female, 70% HIV-infected) were eligible to receive at least one reminder (ie, had an overdue clinical task)
• No significant differences between control and intervention group
Results: Higher Cumulative Rates of Correcting Overdue Tasks

- Four-fold increase in completion of overdue clinical tasks when reminders were availed to providers over 5-month study period

<table>
<thead>
<tr>
<th>All Overdue Care Tasks</th>
<th>1st Visit</th>
<th>2nd Visit</th>
<th>3rd Visit</th>
<th>4th Visit</th>
<th>5th Visit</th>
<th>6th Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.07</td>
<td>0.11</td>
<td>0.13</td>
<td>0.14</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Intervention</td>
<td>0.22</td>
<td>0.38</td>
<td>0.48</td>
<td>0.56</td>
<td>0.63</td>
<td>0.68</td>
</tr>
</tbody>
</table>

\((p<0.0001)\)
### Cumulative Rates for Each Reminder Type

<table>
<thead>
<tr>
<th>Targeted Clinical Care Tasks</th>
<th>Cumulative Order Rate</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Order HIV ELISA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>0.40</td>
<td>(p&lt;0.0001)</td>
</tr>
<tr>
<td><strong>Order CXR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>0.63</td>
<td>(p&lt;0.001)</td>
</tr>
<tr>
<td><strong>Order Other Labs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>0.76</td>
<td>(p&lt;0.0003)</td>
</tr>
<tr>
<td><strong>Refer to Nutrition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>0.89</td>
<td>(p&lt;0.0001)</td>
</tr>
</tbody>
</table>
Results: Orders Occurred Earlier

- Mean time from overdue task to completion of task: 77 days for intervention group vs. 104 days for control group (p<0.001)
Response Rates to Reminders

• Rates of following reminders ranged among clinicians: 11-32% per encounter

• Majority of clinicians had significantly higher rates of correcting overdue tasks when reminders present
Not All Reminders Resulted in Suggested Task

• Why?
  – Test previously ordered: 28%
  – Will order next visit, patient refused or other deferral: 25%
  – Provider disagreed with reminder or considered not applicable: 13%
  – No reason provided: 13%
Limitations

• Single HIV clinic
• Some settings may not have robust EHRs
• Not randomized by clinician → could not predict which clinician would see patient
• Reliance on completeness and quality of EHR data
Conclusions

• Reminders increase completion of overdue HIV clinical care tasks for children in resource-limited setting

• Computerized decision support offers scalable approach to improve quality of pediatric HIV care

• Improved quality of care may improve pediatric patient outcomes
Implementation

• AMPATH program in Kenya has now rolled out computer-generated reminders for pediatric HIV care at all 65 clinical sites, for 24,000+ children
Acknowledgements

• Primary funding from Abbott Fund and CDC grant R18 HK000058
• Support for the USAID-AMPATH Partnership from the United States Agency for International Development (USAID)
• Thanks to research team, Nyoman Ribeka, AMPATH patients and providers