Automating the Multiple Primary Rules

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SEER Multiple Primary Rules

• Project was sponsored by the National Cancer Institute (NCI) Surveillance Epidemiology and End Results (SEER) Program
  • Rules were developed with input from a large diverse group of contributors
    • SEER registries
    • American College of Surgeons (ACoS) Commission on Cancer (CoC)
    • American Joint Committee on Cancer (AJCC)
    • Centers for Disease Control and Prevention (CDC) National Program of Cancer Registries (NPCR)
    • National Cancer Registrars Association (NCRA)
    • North American Association of Central Cancer Registries (NAACCR)
    • Canadian Cancer Registries (CCR)
    • Other registry, clinical, and research experts
SEER Multiple Primary Rules

- Rules were established for use in determining whether two cancer records indicate a single primary or separate primaries.
- There are multiple rules sets that each apply to cases within different ranges of diagnosis years.
- Each rule set is divided into rule groups that each apply to cases with specific types of cancer.
- Rules are documented using detailed step-by-step instructions.
Florida Cancer Data System (FCDS)

- FCDS implemented automated 2007 MP rules
  - Project was started in early 2007 and in production by mid 2008
  - Contributors
    - Gary Levin, BA, CTR
    - Mayra Alvarez, RHIT, CTR
    - Meg Herna, BA, CTR
    - Jill MacKinnon, PhD, CTR
    - Sarah Manson, BS, RHIT, CTR
    - Mehrdad Nadji, MD
    - Wendy Scharber, RHIT, CTR
    - Brad Wohler, MS
    - Minnesota Cancer Surveillance System
KCR FCDS MP Rules Test

- FCDS provided MP rule code to KCR for testing in 2012
  - Project goals
    - Provide feedback to FCDS on their MP algorithm implementation
    - Determine if automated MP rules would be beneficial for use at KCR
  - Code was ported from Oracle tables and procedures to java for KCR use
  - Testing
    - The automated rules were tested on central registry cases
    - Results were manually reviewed by an experienced CTR
    - No problems were found with the algorithm for KCR cases with diagnosis year 2007 and later
    - The automated rules identified 72 cases in the KCR database that were loaded as a new primary but should have been linked to an existing case
KCR Automated MP Rules

- KCR decided to implement automated MP rules
- Development goals
  - Implement MP rules for linking cases from 1988-present
  - Design maintainable and extensible code
  - Provide straightforward mapping between the code and specifications
  - Return results which include the applicable MP rule set, group, and rule number
  - Develop the application as a standalone component
MP Rule Groups Implemented

• 2014 Hematopoietic Rules
• 2007 MP Rules
  • Head And Neck, Colon, Lung, Melanoma, Breast, Kidney, Urinary, Benign Brain, Malignant Brain, and Other Sites
• 2004 MP Rules
  • Solid Malignant Tumors and Benign Brain
• 2001 Hematopoietic Rules
• 1998 Hematopoietic Rules
Implementation Details

- Java language was used for code development
- Each rule group is implemented in a separate java class with a name that identifies the rule set and rule group
  - For example MPRules2007Lung
- Each rule is implemented in a separate method with a name that identifies the rule number
  - For example checkRuleM8
- SEER Data Utility java library is used to perform hematopoietic database lookups
  - Provided by SEER
  - Implemented and supported by IMS
MP Rule Implementation Challenges

- Some rules need to be interpreted
  - Some rules are specified with text that must be translated to coded values for implementation
- Some rules cannot be implemented
  - Data required by a rule may not be available as a coded field in registry records
Flow Diagram

Start check

Valid cases? Yes → Exact match? No → Set result to indicate invalid data

Valid cases? No ↓

Exact match? Yes → Determine rule groups

Same Group? Yes -> For each rule in group

Same Group? No → Set result to indicate multiple primaries

Set result to indicate single primary

Determine rule groups

Result found? Yes

For each rule in group

Check rule

Result found? No

Return result
Test Plans

• Duplicate primary check
  • Test to determine software accurately specifies when two case records indicate a single primary

• Multiple primary check
  • Test to determine software accurately specifies when two case records indicate separate primaries
Duplicate Primary Testing - Methodology

- Find duplicate primaries in KCR Central Registry
  - Input
    - NAACCR file with all cases for KCR Central patients with multiple cases from 1992-early 2012
  - Output
    - Report of cases where multiple primaries at central were determined to be single primaries by the automated MP rules
  - Verification
    - Results were manually reviewed by an experienced CTR
### Duplicate Primary Testing - Results

#### Total Counts

<table>
<thead>
<tr>
<th>Pairs Tested</th>
<th>Reported Duplicates</th>
<th>Verified Duplicates</th>
<th>Verified Different - Case Miscoded</th>
<th>Verified Different - Physician Statement</th>
<th>Verified Different - Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>57,396</td>
<td>290</td>
<td>261</td>
<td>22</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>
## Duplicate Primary Testing - Results

**Over counts by year**

<table>
<thead>
<tr>
<th>Diagnosis Year (Highest Sequence)</th>
<th>Pairs Tested</th>
<th>Reported Duplicates</th>
<th>Verified Duplicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>498</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>1993</td>
<td>777</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>1994</td>
<td>938</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>1995</td>
<td>1217</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>1996</td>
<td>1503</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>1997</td>
<td>1727</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1998</td>
<td>1796</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>1999</td>
<td>2077</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>2000</td>
<td>2318</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>2001</td>
<td>2564</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
## Duplicate Primary Testing - Results

### Over counts by year

<table>
<thead>
<tr>
<th>Diagnosis Year (Highest Sequence)</th>
<th>Pairs Tested</th>
<th>Reported Duplicates</th>
<th>Verified Duplicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>2803</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2003</td>
<td>3103</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>2004</td>
<td>3452</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>2005</td>
<td>3755</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>2006</td>
<td>4008</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>2007</td>
<td>4606</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>2008</td>
<td>4854</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>2009</td>
<td>5149</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>2010</td>
<td>5325</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>2011</td>
<td>4279</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>2012</td>
<td>647</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Duplicate Primary Testing - Results

Rule groups with highest percentage of verified duplicates

<table>
<thead>
<tr>
<th>Rule Group</th>
<th>Pairs Tested</th>
<th>Reported Duplicates</th>
<th>Verified Duplicates</th>
<th>Duplicates (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematopoietic 1998</td>
<td>57</td>
<td>12</td>
<td>10</td>
<td>17.54 %</td>
</tr>
<tr>
<td>Benign Brain 2004</td>
<td>31</td>
<td>4</td>
<td>4</td>
<td>12.90 %</td>
</tr>
<tr>
<td>Urinary 2007</td>
<td>401</td>
<td>38</td>
<td>38</td>
<td>9.48 %</td>
</tr>
<tr>
<td>Malignant Brain 2007</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>7.14 %</td>
</tr>
</tbody>
</table>
# Duplicate Primary Testing - Results

Duplicate counts by rule number for Breast 2007 rule group

<table>
<thead>
<tr>
<th>Rule Number</th>
<th>Pairs Tested</th>
<th>Reported Duplicates</th>
<th>Verified Duplicates</th>
<th>Duplicates (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5</td>
<td>979</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
</tr>
<tr>
<td>M7</td>
<td>785</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
</tr>
<tr>
<td>M8</td>
<td>44</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
</tr>
<tr>
<td>M9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
</tr>
<tr>
<td>M10</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>100 %</td>
</tr>
<tr>
<td>M11</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>100 %</td>
</tr>
<tr>
<td>M12</td>
<td>49</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
</tr>
<tr>
<td>M13</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>25 %</td>
</tr>
</tbody>
</table>
Multiple Primary Testing - Methodology

- Find multiple primaries that should not have been linked as a single primary in KCR Central Registry
  - Input
    - Case records for KCR Central patients that have multiple source records
    - Hospital source records for patients in KCR Central file
  - Output
    - Report of hospital cases not considered the same primary as any of the corresponding patient’s central cases when using the automated MP rules
  - Verification
    - Results were manually reviewed by an experienced CTR
# Multiple Primary Testing - Results

<table>
<thead>
<tr>
<th>Total Counts</th>
<th>Central Cases Tested</th>
<th>Reported New Primaries</th>
<th>Central Cases Reviewed</th>
<th>Verified New Primaries</th>
<th>Verified Same - Case Miscoded</th>
<th>Verified Same - Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8754</td>
<td>898</td>
<td>35</td>
<td>0</td>
<td>35</td>
<td>0</td>
</tr>
</tbody>
</table>
Conclusions

- Automated MP check has benefits
  - Quality analysis
    - Identifies possible improperly linked cases for review
    - Identifies areas to improve MP rule training
  - Automated Linkage
    - May be able to reduce the number of case linkages requiring manual review
Future Development

• Design more useful multiple primary test
• Implement review flags
  • Flag cases subject to rules where manual review is beneficial
  • Flag cases that may be subject to rules that are not implementable
• Implement use in KCR Central merge
Thank You!