Application of the Logical Elements Rule Method (LERM) for formalization of clinical rules with the case study of ACOVE-NLI

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LERM
the Logical Elements Rule Method

LERM is a step-by-step method for transforming *clinical rules* to a formal expression for implementation in a *computerized decision support system*.

**Clinical Rule**

a statement of what clinical *action* should be performed under a particular *condition*

**Computerized decision support**

“*All elderly patients should have a letter, containing medication information, written to their general practitioner within 14 days after a hospital stay.*”
Why use LERM?

If you have a set of clinical rules, and you plan to build computerized decision support, LERM may help.

• Ensure that you follow the same steps for every rule.

• Formalize the process of disambiguation.

• Identify problems and dependencies early in the process.
Methods

1. Apply LERM to the ACOVE-NLI quality indicators

Assessing Care of Vulnerable Elders
Netherlands Inpatient

A set of 87 “if-then” clinical rules for which adherence was measured by manual chart assessment in 2009.

2. Assess for a difference in pass rate between rules that could and could not be formalized

Why?

MacLean et al. (Med Care. 2006) observed that adherence was better for rules that could be assessed electronically than for those that could only be assessed by manual chart assessment.
**LERM**
the Logical Elements Rule Method

<table>
<thead>
<tr>
<th>Step</th>
<th>Task</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>restate rule to give a proactive recommendation</td>
</tr>
<tr>
<td>2</td>
<td>formulate each rule as a logical statement</td>
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<tr>
<td></td>
<td>a. identify phrases containing data elements</td>
</tr>
<tr>
<td></td>
<td>b. separate compound rules and state in normal form</td>
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<tr>
<td>3</td>
<td>assess for conflict between rules</td>
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<tr>
<td>4</td>
<td>identify concepts which may be redundant or unnecessary</td>
</tr>
<tr>
<td>5</td>
<td>extract data elements</td>
</tr>
<tr>
<td></td>
<td>a. classify concepts as fuzzy (ambiguous) or crisp</td>
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<td></td>
<td>b. fully specify (enumerate) all concepts, and find clear definitions to use for ambiguous (fuzzy) concepts</td>
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<tr>
<td>6</td>
<td>determine how rules are related</td>
</tr>
<tr>
<td>7</td>
<td>determine availability of data elements in local databases</td>
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</tbody>
</table>

For details of all steps, please refer to Medlock et al. "LERM (Logical Elements Rule Method): A method for assessing and formalizing clinical rules for decision support" IJMI 2011
Application of LERM to ACOVE-NLI

Step 1: Make rules proactive (state in terms of “what to do”): ACOVE-NLI rules are already proactive

Step 2: Separate compound rules and rewrite in normal form:

IF A or B then C, unless D, then E...

A + not D → C
B + not D → C
A + D → E
B + D → E
Application of LERM to ACOVE-NLI

Step 3: Look for conflict between rules

“If a new drug is prescribed, assess for a response within 3 months”

“If pain medication is prescribed, assess for a response within 6 months”

… when do you assess for a response to a new pain medication?

Step 4: Look for unnecessary phrases

“IF a new drug is prescribed to an elder on an ongoing basis for a chronic medical condition..."
Application of LERM to ACOVE-NLI

Step 5a: Disambiguate

Can say for sure if an object is a member of the set

Crisp

Can say for sure if the condition is true or false for an individual patient, or if the actions have been performed.

Fuzzy

Some objects might be members of the set

Condition might apply for some patients, or action may have been inadequately performed.

How do we know if a concept is “ambiguous”?

How do we know when we’re done disambiguating?

Some objects might be members of the set

Condition might apply for some patients, or action may have been inadequately performed.
Application of LERM to ACOVE-NLI

Step 5a: Disambiguate

"has a letter sent within 14 days of discharge"

Determine if the fuzzy concept can be limited to a crisp concept for the purpose of interpreting this rule.

"evaluated for cognitive dysfunction"
Application of LERM to ACOVE-NLI

Step 5b: extract data elements

“has a letter sent within 14 days of discharge”

• date of discharge
• date letter sent

For medications, specify the time: pre-hospital, in-hospital, etc.
Application of LERM to ACOVE-NLI

Step 6: Determine relationships between rules
- understand the workflow

Step 7: Map data elements to local database
Results: Formalization

Able to completely formalize 75% of the 40 rules

Found a total of 76 problems
  48 were due to ambiguous phrases (fuzzy concepts)

5 rules could not be formalized
  all were due to ambiguities in the conditions
    (e.g. “If the attending physician suspects an elder is depressed...”)
Results: Difference in adherence

Average adherence to rules that could be completely formalized (30 rules) was 37.3%

Average adherence to rules that could not be formalized (5 rules) was 9.3%

Significant at p=0.001
Difference in adherence: Why?

- difference in measurement
- checklist effect
- coincidence?

rules that are less ambiguous are easier to remember and follow?

rules that are less ambiguous are easier to assess in manual review?

subject for future research
Difference in adherence: Impact

- There may be a *systematic difference* in adherence to rules that can be measured automatically.

- Use caution when comparing adherence rates for rules / guidelines / quality indicators in studies using automated assessment vs manual chart review.
Conclusions

LERM was used to formalize the ACOVE-NLI rules for implementation, with some minor additions

Still found ~ 2 problems per rule (especially ambiguous phrases), even though these rules have been rigorously developed and used to assess quality of care

Use caution when comparing results from automated measurement of quality to results from manual chart review
Questions?
<table>
<thead>
<tr>
<th>step</th>
<th>number of problems found</th>
<th>number of rules affected</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2b</td>
<td>2</td>
<td>2</td>
<td>Unclear if action is allowable or required “Only amiodarone is allowed...”</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td>unclear if one rule supersedes another:</td>
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<td>“If a new drug is prescribed, assess for a response within 3 months”</td>
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<td>“If pain medication is prescribed, assess for a response within 6 months”</td>
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<tr>
<td>4</td>
<td>1</td>
<td>7</td>
<td>Indication not needed for decision:</td>
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<tr>
<td></td>
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<td>“IF a new drug is prescribed to an elder on an ongoing basis for a chronic medical condition...”</td>
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<tr>
<td>5a</td>
<td>48</td>
<td>23</td>
<td>Ambiguous (fuzzy) concept:</td>
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<td></td>
<td></td>
<td></td>
<td>“evaluated for cognitive dysfunction”</td>
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<tr>
<td>5b</td>
<td>23</td>
<td>5</td>
<td>Ambiguous concept that was not definable:</td>
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<td>“IF the attending physician suspects an elder is depressed...”</td>
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<td>6</td>
<td>1</td>
<td>2</td>
<td>Data elements of 2 rules were identical: “evaluated for cognitive dysfunction” = “MMSE score”</td>
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</tbody>
</table>
Method for calculating quality score (adherence)

Consider each rule for each patient to be independent (each one presents its own chance to follow the rule or not)

sum of adherence / sum of opportunities to adhere

actions / conditions

for multi-part rules, all parts must be adhered to to consider it “adherence”