Does GEM-encoding clinical practice guidelines improve the quality of knowledge bases? A study with the rule-based formalism

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Outline

- Context of the work
  - Evidence-based medicine and clinical practice guidelines
  - Rule base formalism for CPGs
  - Special case of the ASTI project
- An experiment with the GEM approach
- Rule bases comparison
  - Descriptive & operational criteria
- Conclusion

Medical context

- **Variability of health practices**
  - **Evidence-based medicine**
  - **Clinical Practice Guidelines (CPGs)**
- **When disseminated as texts**
  - **No impact on physician behavior**
- **When embedded within KBs of DSSs**
  - **Improved impact on physician compliance**
- **Problem: translation from NLG to CIG**

Canadian CPG for the management of hypertension

Ischemic heart disease

Recommendations

1. *For patients with stable angina and hypertension, β-adrenergic antagonists are preferred as initial therapy (grade D).*

2. *Alternative therapies would include long-acting calcium-channel blockers (grade B). Short-acting calcium-channel blockers should not be used (grade C).*

3. *Patients with hypertension and a recent myocardial infarction should be treated with either β-adrenergic antagonists, ACE inhibitors or both. Both classes of drug protect against reinfarction and death (grade A).*

4. *Alternative therapies would include verapamil (grade A) and diltiazem (grade C), but only in the setting of normal left ventricular function.*

- Chapters correspond to specific clinical situations
- Sequence of therapeutic recommendations

Canadian CPG for the management of hypertension

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Recommendations

1. For patients with stable angina and hypertension, β-adrenergic antagonists are preferred as initial therapy (grade D).

2. Alternative therapies would include long-acting calcium-channel blockers (grade B). Short-acting calcium-channel blockers should not be used (grade C).

3. Patients with hypertension and a recent myocardial infarction should be treated with either β-adrenergic antagonists, ACE inhibitors or both. Both classes of drug protect against reinfarction and death (grade A).

4. Alternative therapies would include verapamil (grade A) and diltiazem (grade C), but only in the setting of normal left ventricular function.

- Incompleteness of clinical situations
  - Pathologies associated to hypertension (HT) are only considered one by one

Canadian CPG for the management of hypertension

Diabetes

Recommendations

...

3. For patients with diabetes who have hypertension without overt nephropathy and are under 60 years of age, preferred therapy is either an ACE inhibitor or a cardioselective β-adrenergic antagonist (grade A).

4. Second-line therapy includes low-dose thiazide diuretics (grade B), long-acting calcium-channel blockers (grade B) and α-adrenergc antagonists (grade C). α-adrenergc antagonists and centrally acting antihypertensive agents should be used with caution in the presence of autonomic neuropathy (grade C).

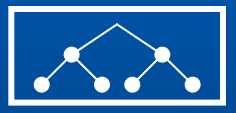
5. Preferred therapy for patients with diabetes, hypertension and overt nephropathy (albuminuria greater than 300 mg/day) is an ACE inhibitor (grade A).

6. When an ACE inhibitor causes adverse effects, an angiotensin II receptor antagonist may be substituted.

- Incompleteness of clinical situations
  - Pathologies associated to hypertension (HT) are only considered one by one
- Imprecision of terms
  - Not defined
  - Imprecise or vague
- Ambiguity of therapeutic recommendations sequence

ASTI project

- Design, development and implementation of a guideline-based DSS in primary care
  - On-demand guided mode
    - Physicians control the navigation within the KB structured as a decision tree



  - Reminder-based critic mode
    - Automatic activation of decision rules to correct physician prescriptions

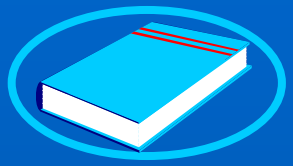
R_i: If - Then

- A classical manual encoding of both KBs by physicians
- First application to hypertension management

Document-centered approaches

- XML mark-up of CPG documents
- GEM
  - Guideline document model of CPGs
  - Defines the structure of basic units of information
  - Multi-level hierarchy of more than 100 elements
- Objective: Test wether GEM could be used to help improving the translation of textual CPGs

Production of GEM-derived decision rules



Canadian CPGs

$S = \{L_1, L_2, \ldots\}$

$L_i = \{INT_{11}, INT_{12}, \ldots\}$

Interpretative framework

<?xml version="1.0"?>
<!DOCTYPE ext_guideline.document
SYSTEM "EXT_GEM_DTD.dtd">

Extended
GEM DTD

<?xml version="1.0"?>
<!DOCTYPE guideline.document
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GEM DTD

Normalized
GEM-encoded
instance

Automated
derivation

BR_{-GEM}

GEM-encoded instance

Preferred therapy for patients with diabetes, hypertension and overt nephropathy (albuminuria greater than 300 mg / day) is an ACE inhibitor (grade A).

```
<decision.variable source="explicit"
decision.variable.id="state_patient.pathology">HT
   <value source="implicit" id="HT"/> </decision.variable>

<decision.variable source="explicit"
decision.variable.id="state_patient.pathology">diabetes
   <value source="implicit" id="DIA"/> </decision.variable>

<decision.variable source="explicit"
decision.variable.id="state_patient.pathology"> overt nephropathy
   <value source="implicit" id="O_NEPH"/> </decision.variable>

<action source="explicit" id="treatment.line">first line treatment
   <value source="implicit" id="L1"/> </action>

<action source="explicit" id="treatment.intention">first intention
   <value source="implicit" id="INT1"/> </action>

<action source="explicit" id="treatment.type">monotherapy
    <value source="implicit" id="MONO"/> </action>

<action source="explicit" id="treatment.nature">an ACE
inhibitor
    <value source="implicit" id="ACE_IN"/> </action>

<recommendation.strength  source="explicit" id="A">grade A
< recommendation.strength>
```

Rule base formalism in BR-GEM

```
<decision.variable source="explicit"
decision.variable.id="state_patient.pathology">HT
   <value source="implicit" id="HT"/> </decision.variable>

<decision.variable source="explicit"
decision.variable.id="state_patient.pathology">diabetes
   <value source="implicit" id="DIA"/> </decision.variable>

<decision.variable source="explicit"
decision.variable.id="state_patient.pathology"> overt nephropathy
   <value source="implicit" id="O_NEPH"/> </decision.variable>

<action source="explicit" id="treatment.line">first line treatment
   <value source="implicit" id="L1"/> </action>

<action source="explicit" id="treatment.intention">first intention
   <value source="implicit" id="INT1"/> </action>

<action source="explicit" id="treatment.type">monotherapy
    <value source="implicit" id="MONO"/> </action>

<action source="explicit" id="treatment;nature">an ACE  inhibitor
    <value source="implicit" id="ACE_IN"/> </action>

<recommendation.strength  source="explicit" id="A">grade A
< recommendation.strength>
```

IF

patient_state.pathology = HT
and patient_state.pathology = DIA
and patient_state.pathology = O_NEPH

THEN

treatment.line = L1
and treatment.intention = INT1
and treatment.type = MONO
and treatment.nature = ACE_in

WITH

recommendation.strength = A

Comparison of formalisms

R-GEM

IF
patient_state.pathology = HT
and patient_state.pathology = DIA
and patient_state.pathology = O_NEPH
THEN
treatment.line = L1
and treatment.intention = INT1
and treatment.type = MONO
and treatment.nature = ACE_in
WITH
recommendation.strength = A

IF
- **Inclusion criteria**
  - patient state and pathology
  - current therapy
    - level of association
    - pharmacological class
- **Exclusion criteria**
  - pathologies that the patient is not suffering from

THEN
- **Recommended action**
  - level of association
  - pharmacological class

WITH
- **Grade of the recommendation**

R-ASTI

IF
pathology = HT
and pathology = diabetes
and pathology = overt nephropathy
and level_of_intention = 1
THEN
nature = C09A
and grade = A

IF
- **Inclusion criteria**
  - patient state and pathology
  - therapeutic level of intention
- **Exclusion criteria**
  - pathologies that the patient is not suffering from

THEN
- **Recommended action**
- **Grade of the recommendation**

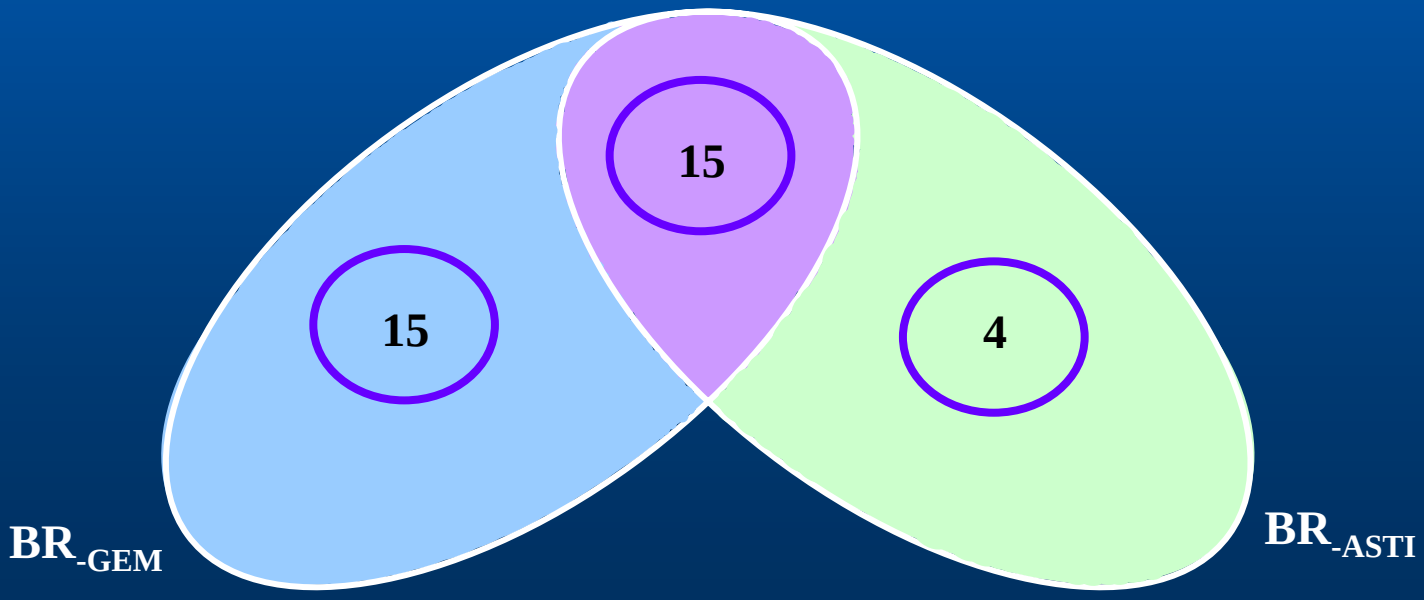
Quantitative comparison of $BR_{\text{-GEM}}$ and $BR_{\text{-ASTI}}$

- More rules in $BR_{\text{-GEM}}$ (104 > 98)
- More specific in average
  - m_{GEM}(premises) > m_{ASTI}(premises)
  - m_{GEM}(actions) > m_{ASTI}(actions)

	$BR_{\text{-GEM}}$	$BR_{\text{-ASTI}}$
# of elementary rules	104	98
# of premises (mean value)	4.49	2.93
# of actions (mean value)	4.42	3.10

Qualitative comparison of BR_{-GEM} and BR_{-ASTI}

- More clinical situations in BR_{-GEM} (30 vs. 19)
- 15 clinical situations covered by both BR_{-GEM} and BR_{-ASTI}
- 15 clinical situations specifically covered by BR_{-GEM}
- 4 clinical situations specifically covered by BR_{-ASTI}



Common clinical situations

"For patients with stable angina and hypertension, alternative therapies would include long-acting calcium-channel blockers (grade B)."

R_{GEM}

IF

patient_state.pathology = HT
and patient_state.pathology = ISC_HEA
and patient_state.pathology = STA_ANG
and treatment.line = L1
and treatment.intention = INT1
and treatment.type = MONO
and treatment.nature = BB
and treatment.response = intolerate

THEN

treatment.line = L1
and treatment.intention = INT2
and treatment.type = MONO
and treatment.nature = CCB_{LA}

WITH

recommendation.strength = B

R_{ASTI}

IF

pathology = HT
and pathology = stable angina
and level_of_intention = 2

THEN

nature = C08C
and grade = B

GEM-specific clinical situations

"If a diuretic is essential for the control of hypertension in a patient with a history of gout, gout can be prevented by the concurrent use of allopurinol (grade D)."

R_{GEM}

IF

patient_state.pathology = HT
and patient_state.pathology = GOUT
and treatment.line = L1
and treatement.intention = INT1
and treatement.type = MONO
and treatment.nature = DIU
and treatment.response = inefficient

THEN

treatment.line = L1
and treatment.intention = INT2
and treatment.type = BI
and treatement.nature = DIU
and treatment.nature = allopurinol

WITH

recommendation.strength = D

No corresponding rule

in BR_{-ASTI}

ASTI-specific clinical situations

"α-adrenergic antagonists … should be used with caution in the presence of autonomic neuropathy (grade C)."

No corresponding rule

in BR_{-GEM}

R_{ASTI}

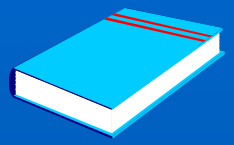
IF

pathology = HT
and pathology = diabetes
and demography = under 60 years
and level_of_intention = 1

THEN

nature = C02C A
and grade = C

Production of GEM-derived decision rules



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Normalized GEM-encoded instance

Automated derivation

BR_{-GEM}

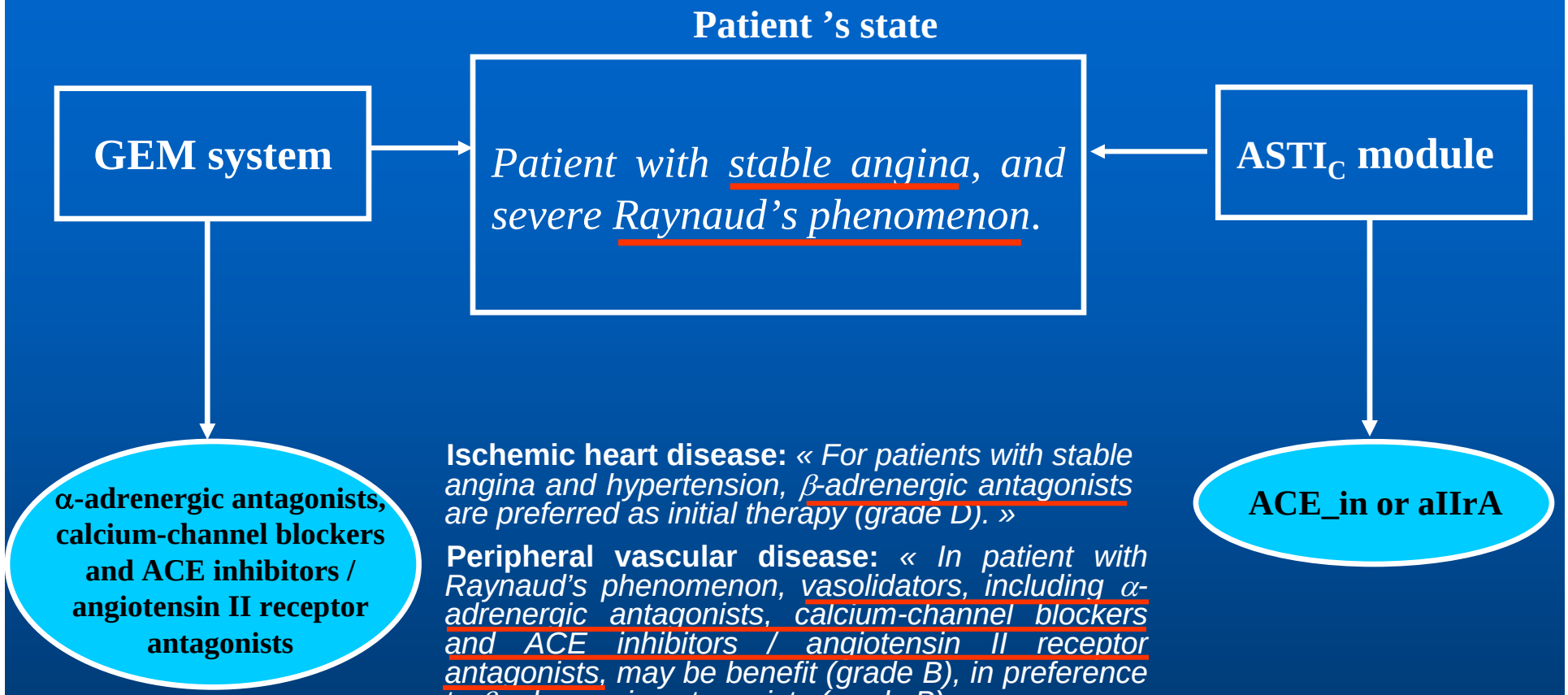
Inference engine

Patient's state

Patient-specific therapeutic recommendations

AMIA 2003

Operational comparison of BR_{-GEM} and BR_{-ASTI}



Ischemic heart disease: *« For patients with stable angina and hypertension, β-adrenergic antagonists are preferred as initial therapy (grade D). »*

Peripheral vascular disease: *« In patient with Raynaud's phenomenon, vasolidators, including α-adrenergic antagonists, calcium-channel blockers and ACE inhibitors / angiotensin II receptor antagonists, may be benefit (grade B), in preference to β-adrenergic antagonists (grade B).»*

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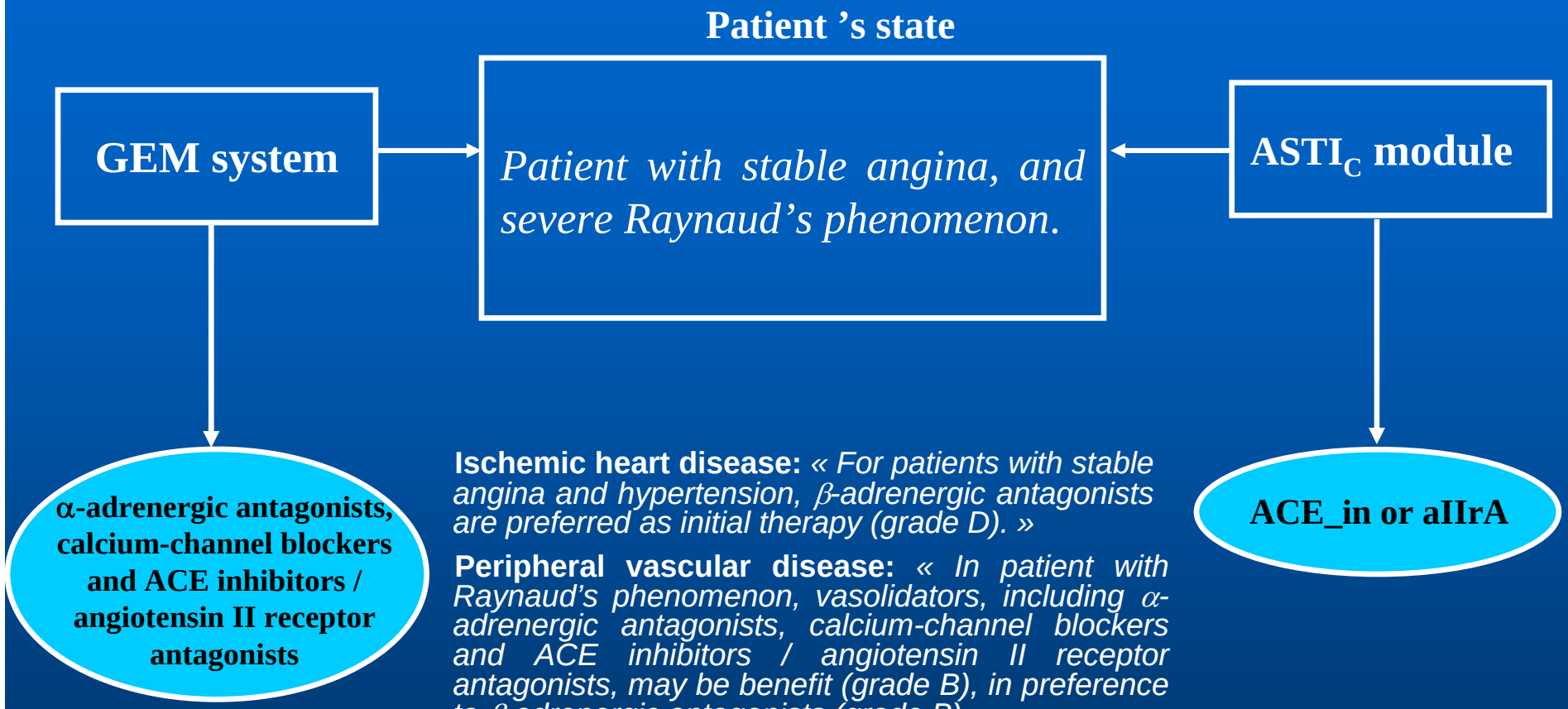

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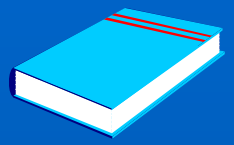
- Evaluation on a sample of 10 patient cases
  - Identity of recommendations in 30% of the cases
  - GEM system better than $ASTI_C$ module in all the remaining cases

Conclusion

- Evaluation of the impact of GEM-encoding in the translation from textual guidelines to formalized KBs
- Comparison between $BR_{\text{-GEM}}$ and $BR_{\text{-ASTI}}$
  - Rules generated with GEM are more specific and richer
  - $BR_{\text{-GEM}}$ covers a larger number of clinical situations
  - GEM system 's performance better than $ASTI_C$ on 10 patient cases
- Confirmation of results on a larger scale evaluation to come

Production of GEM-derived decision rules



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AMIA 2003

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- Importance of the interpretation step when creating the GEM instance