GLIF:

**Specifying reasons to withhold the X-Ray**

This is done in the choice step: “Withhold X-Ray?” The rule-in for the “yes” option is shown below. PNDScertainty represents the certainty attribute of the current (latest and end time >= now) PNDS observation. PregnancyDueDate is the end time of the current Pregnancy observation.

The data items were all retrieved in a previous step of the top-level algorithm (“Get patient cough-related data” Action_Step). The Let expressions are expressed in a formal expression language (GEL), and so is the specification of the entire criterion for withholding the X-ray.

If ACEI is suspected as the cause of cough, then the patient is taken off the ACEI, and when he comes to another checkup at least 4 weeks later (specified formally by the GEL expression: “(timeACEIStopped + 4 weeks) < now”) then his cough is assessed again. He is not continuing with the main algorithm until his cough is reassessed. The flow of control enforces the constraint that if ACEI is suspected as the cause of cough then you need to stop ACEI and reassess the patient after 4 weeks BEFORE considering an X-Ray.
EON:
Like in the GLIF model, the flow of control takes care of waiting 4 weeks after stopping ACEI before returning to doing X-Ray or treatment, because once the ACEI subguideline was entered, you remain there until 4 weeks passed. The "4 weeks" is formally specified as the precondition of a scenario:
Label:
4 weeks after discontinuing ACE I

Context:

From:
Medication m1

Select:
+

When:
DURATION(PERIOD(NOW, END_OF(m1)), "WEEK") > 4

Where:
drug_name = 'ACE_Inhibitor' and NOT EXISTS (select * from Medication m2 where drug_name = 'ACE_Inhibitor' when AFTER(m2, m1) or OVERLAPS(m1, m2))

☑ Presence
The case step (In GLIF it was a choice step) “presumed PNDS in young non-smoker, pregnant women?” has the following criterion:
“Presumed” is taken to be the value of the domain term PNDS in a note entry.
Possible value types are shown below.
PRODIGY:
The Chest X-Ray action step has the following greyed-out criterion:
Note that “current” non-smoker has a Read code!
Note the “presumed” PNDS was interpreted as the patient complaining about PND, and not as the degree of certainty of the physician about his observation.
Name
Pregnancy

User Name
Pregnancy

Abstract Term
← V C + −

† Pregnancy

☑ Presence

Period
← V C + −

Assumption If Not Found
assume_false
In the presence of ACEI regime, the X-Ray is not recommended. This way, when the patient is taken off ACEI the X-Ray can be done. **How is the 4 week period represented?**

**Asbru:**
(presumed-PNDS equal yes and young equal yes and smoker equal no)
    or pregnant equal yes
    or ((plan administer-ACE-I was activated at (now–4 weeks))
        and (has-chronic-cough equal yes and has-chronic-cough latest starting-shift was 1 week after plan administer-ACE-I was activated)))

All the values of the parameters are entered by the user. There is no mapping to EPR entities or to vocabulary codes.

**PROforma:**
argument := for, ( ACE_related = Yes ) ;
For ACEI-related cough, a message is displayed to the user recommending stopping ACEI for 4 weeks. Nothing is done to check whether the 4 weeks have passed before doing the X-Ray/Treatment.

Like in Asbru, the variables are entered by the user and are not mapped to vocabularies or to EMR terms.

2) Note: When the chest X-ray is normal PNDS, Asthma, and GERD (Gastroesophageal reflux disease) are the likely causes of chronic cough. In PNDS, sinusitis may be the cause up to approximately 30% of the time when cough is nonproductive, and up to approximately 60% of the time when cough is productive.

This note can be represented as supplemental material in plain text in all methods. Only in Asbru it can be formally specified:

The plan cough-overall defines the following effects:
1) chronic-cough is caused by PNDS in the context of chest-X-ray-normal equals yes with a likelihood of 0.33
2) chronic-cough is caused by Asthma in the context of chest-X-ray-normal equals yes with a likelihood of 0.33
3) chronic-cough is caused by GERD in the context of chest-X-ray-normal equals yes with a likelihood of 0.33
4) PNDS is caused by sinusitis in the context of cough-is-productive equal yes with a likelihood of 0.30
PNDS is caused by sinusitis in the context of cough-is-productive equal no with a likelihood of 0.60

Causal dependencies like the above are modeled by effects in Asbru. Effects belong to a particular plan and describe expected behavior occurring during its execution. In our case, an overall (top-level) plan contains (has) the above effects. There are two varieties of effects in Asbru: argument dependency describes the qualitative relation between an argument of the plan and a parameter, and plan effect describes the influence of the plan's execution on the value of a parameter. Both varieties have a context, a time annotation, and a likelihood. In our example, chest X-ray is normal is the context under which PNDS, Asthma, and GERD are likely causes of chronic cough. In Asbru, the likelihood is required. We therefore assumed a likelihood of 0.33 for each of the causes. In practice, these numbers must be acquired from domain experts.
Since the direction of chaining dependencies is forward we model the cause for chronic cough in passive form, i.e. as a is caused by relation between chronic cough and its reasons. The reason for this is the fact that chronic cough is known and its reasons are not known and we can only deduct new finding from know facts. For the causes of PNDS the probability is known (as far as sinusitis is concerned). The type of cough forms the context of the relation between sinusitis and PNDS.
A negative recommendation: Sinus CT scans are not routinely recommended to evaluate for sinusitis as the cause of cough.
Four-view sinus radiographs should be ordered instead.

Please model: evaluating sinusitis as the cause of cough, ordering Four-view sinus radiographs, not ordering sinus CT scan. (dimensions 2, 6, 9, 10)

GLIF:

Figure 1. The medically-oriented task of the “No Sinus CT Scan” action step is modeled as a Procedure that has an “order-not-to” mood
Figure 2. The medically-oriented task of the “Four View Sinus Radiograph” action step

EON:

Domain term added to the medical domain class hierarchy
Not ordering a sinus CT scan is modeled as a message to the user:

**PRODIGY**

- **Name**: request 4-view sinus radiograph
- **Comment**:
- **Trend Prompt**: CT normal
- **Action Prompt**: request 4-view sinus radiograph
- **Trend Term**:
- **Action**:
- **Rule In Condition**:
- **Greylevel In Condition**:
- **Greylevel Out Condition**:
- **Rule Out Condition**:
- **Review Window Maximum**:
- **Review Window Minimum**:
- **Next Step**: Evaluate possible causes
Asbru:

Negative recommendations can be modeled in intentions in Asbru. In our example the type of the intention is intermediate-action and the verb is achieve for four-view sinus radiographs avoid for sinus CT scan. Intentions are properties of plans, in our example they belong to the plan evaluating-sinusitis.

The plan “evaluating-sinusitis” has the following intentions:
- achieve intermediate-action where the action that should be activated during the execution of the plan is four-view-sinus-radiographs
  - avoid intermediate-action where the action that should not be activated during the execution of the plan is sinus-CT

PROforma:

action :: Sinus_radiographs ;
  caption :: 'Sinus radiographs' ;
  procedure :: '4 view sinus radiographs' ;
  context :: 'Sinusitis may be the cause of PNDS 30% of the time (60% if the cough is productive). Sinus CT scans are not routinely recommended to evaluate for sinusitis as the cause of cough.' ;
end action .

The un-recommended action is represented as a comment in free text (the context slot).
3) While 24 hour esophageal pH monitoring is the most diagnostically useful test for assessing for GERD as the cause of cough, conventional indices used by gastroenterologists to assess for esophagitis may be misleadingly normal. Therefore, until future studies provide better guidelines, the test should be read as normal when conventional indices are within the normal range and no suspicious reflux-induced coughs appear during the monitoring session (Grade II-2).

Please model the criterion that would be used to indicate that the test results are interpreted as normal. (dimension 7)
Please model the grade of evidence. (dimension 8)

Grade of evidence was shown in the beginning of the document.

GLIF:

The pH monitoring test result is a RIM observation. It has a slot called "interpretation_code" that accepts the usual sets of codes for test results, such as "normal, abnormal, improving, etc. There is no code for suspicious reflux. We therefore modeled that as a didactic, as shown below.
<table>
<thead>
<tr>
<th>Name</th>
<th>24h esophageal pH monitoring test results is normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification</td>
<td>Let Expressions</td>
</tr>
<tr>
<td>esophageal_pH_monitoring_test_result_interpretation = &quot;normal&quot;</td>
<td></td>
</tr>
<tr>
<td>Didactics</td>
<td></td>
</tr>
<tr>
<td>Encoding Language</td>
<td></td>
</tr>
<tr>
<td>Get Data Items</td>
<td></td>
</tr>
<tr>
<td>Get esophageal pH monitoring test result</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3. The didactic for interpretation of the pH monitoring test results

EON:
The interpretation of the results is done in the scenario “evaluate for GERD”, shown below.
PRODIGY:
The “treat GERD” action step has the following rule-in:
Asbru:

We model both the conventional indices and the suspicious reflux-induced coughs as qualitative parameters. The criterion indicating that the test results are interpreted as normal is the conjunction of normal indices and suspicious coughs being absent during 24 hour esophageal pH monitoring.

The Boolean parameter suppose-GERD is defined as:

(conventional-indices equal yes) and (suspicious-coughs equal no where the latest starting time of the suspicious-coughs is 0h after the esophageal-ph-monitoring plan was activated and the earliest finishing time is 24 hours after the esophageal-ph-monitoring plan was activated

The latter is represented by a user perform plan with a typical duration of that extend. There is no mentioning, that such a monitoring last for exactly such duration, therefore we do not define minimum or
maximum duration, but only the estimated typical duration. Suspicious-coughs are considered, if they end or start during the 24 hours following the start of the monitoring plan.

<plan name="esophageal-ph-monitoring">
  <defaults>
    <typical-duration>
      <numerical-constant unit="h" value="24"/>
    </typical-duration>
  </defaults>

PROforma:
decision :: Oesophageal_pH_monitoring_interpretation ;
caption :: 'Oesophageal pH monitoring interpretation';
description :: 'Conventional indices used by gastroenterologists to assess for esophagitis may be misleading normal. Until further studies provide better guidelines, the test should be read as normal when conventional indices are within the normal range and no suspicious reflux-induced coughs appear during the monitoring session (Grade II-2)';
  choice_mode :: single ;
support_mode :: symbolic ;
candidate :: Normal ;
    argument :: for, ( Conventional_indices = 'Within normal range' and Suspicious_coughs = No ) ;
    recommendation :: Netsupport( Oesophageal_pH_monitoring_interpretation, Normal ) >= 1 ;
candidate :: Abnormal ;
    argument :: for, ( Conventional_indices = 'Outside normal range' ) ;
    argument :: for, ( Suspicious_coughs = Yes ) ;
    recommendation :: Netsupport( Oesophageal_pH_monitoring_interpretation, Abnormal ) >= 1 ;
end decision .

Conventional_indices is a parameter whose value is entered by the user that can assume two Boolean values: true_value :: 'Within normal range' ;
false_value :: 'Outside normal range' ;

Suspicious_coughs is a parameter whose value is entered by the user that can assume two Boolean values: Yes and No.