Utrecht University

Faculty of Science
Departement of Information and Computing Sciences
Software Systems division

Risk Mediation in Association Rules

The Case of Decision Support in Medication Review

Dr. Marco Spruit, on behalf on Dr. Michiel Meulendijk

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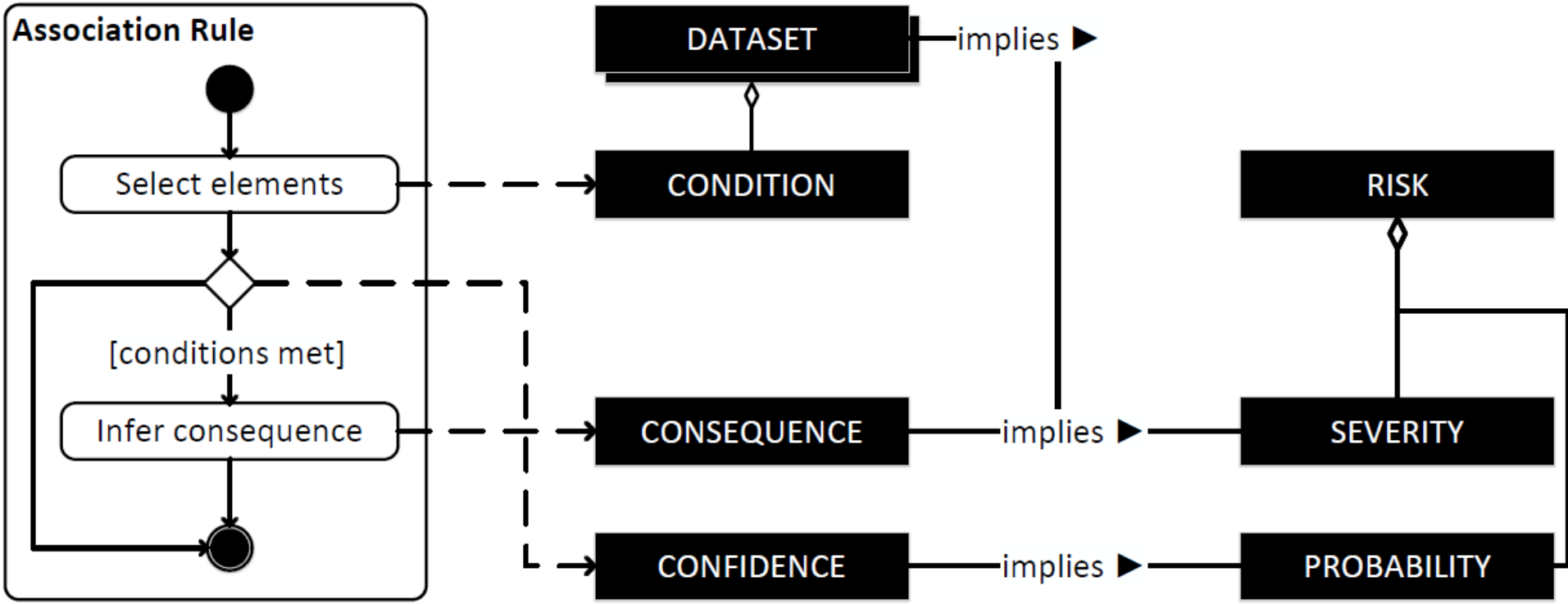
Motivation: Safely Infer Association Rules

Association rule mining is one of the most prominent knowledge discovery methods in use. Applying association rules in precarious domains can have negative consequences, however. Therefore, we propose a model for the incorporation of risk in association rules.

The impact association rules have depends on the sensitivity of the dataset on which they are applied. Figure 1 below shows how association rules' characteristics correspond to those of risk management.

Relating association rules characteristics with risk management concepts

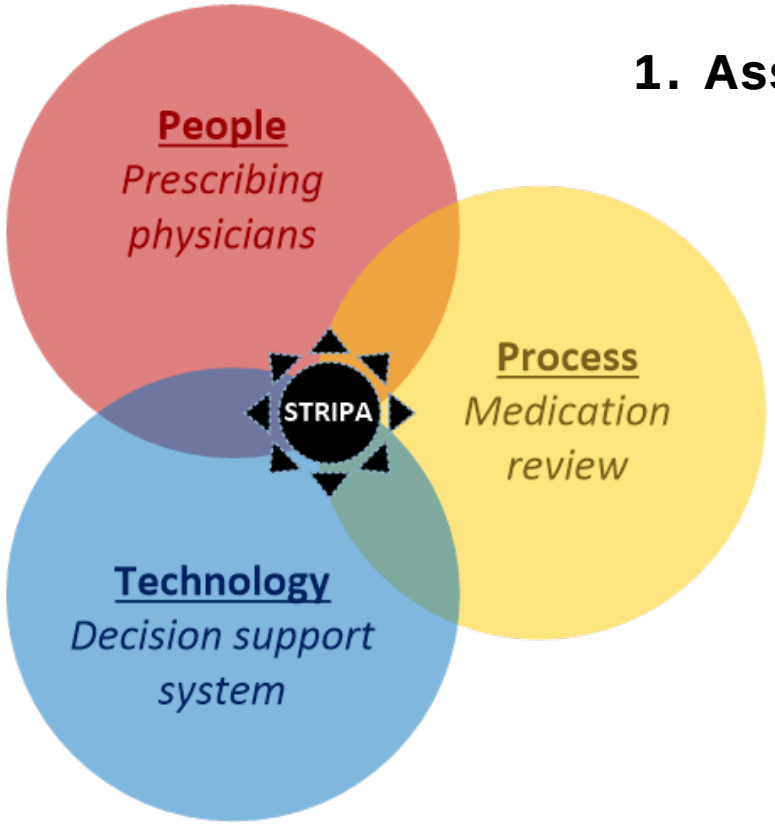
"An association rule's confidence, conditions, and consequences determine its risk's probability and severity."



Implementation case study: STRIP Assistant

http://videodemo.stripa.eu/english/

Steps in medication review process:

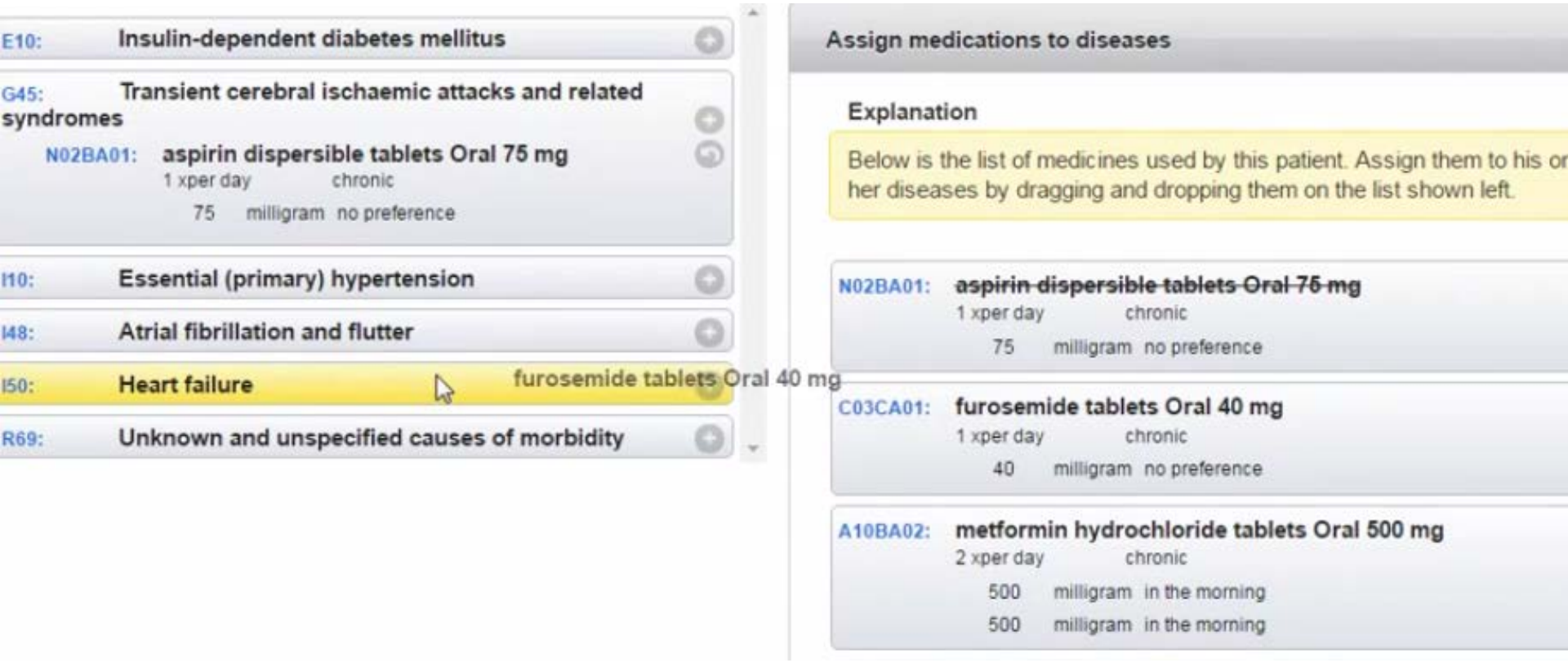


1. **Assign medications to diseases**
2. **Undertreatment (START)**
3. Overtreatment (STOPP)
4. Drug-disease interactions
5. Drug-drug interactions
6. Dosage

IMPLEMENTATION CASE STUDY: STRIP ASSISTANT

http://videodemo.stripa.eu/english/

1. Assign medications to diseases



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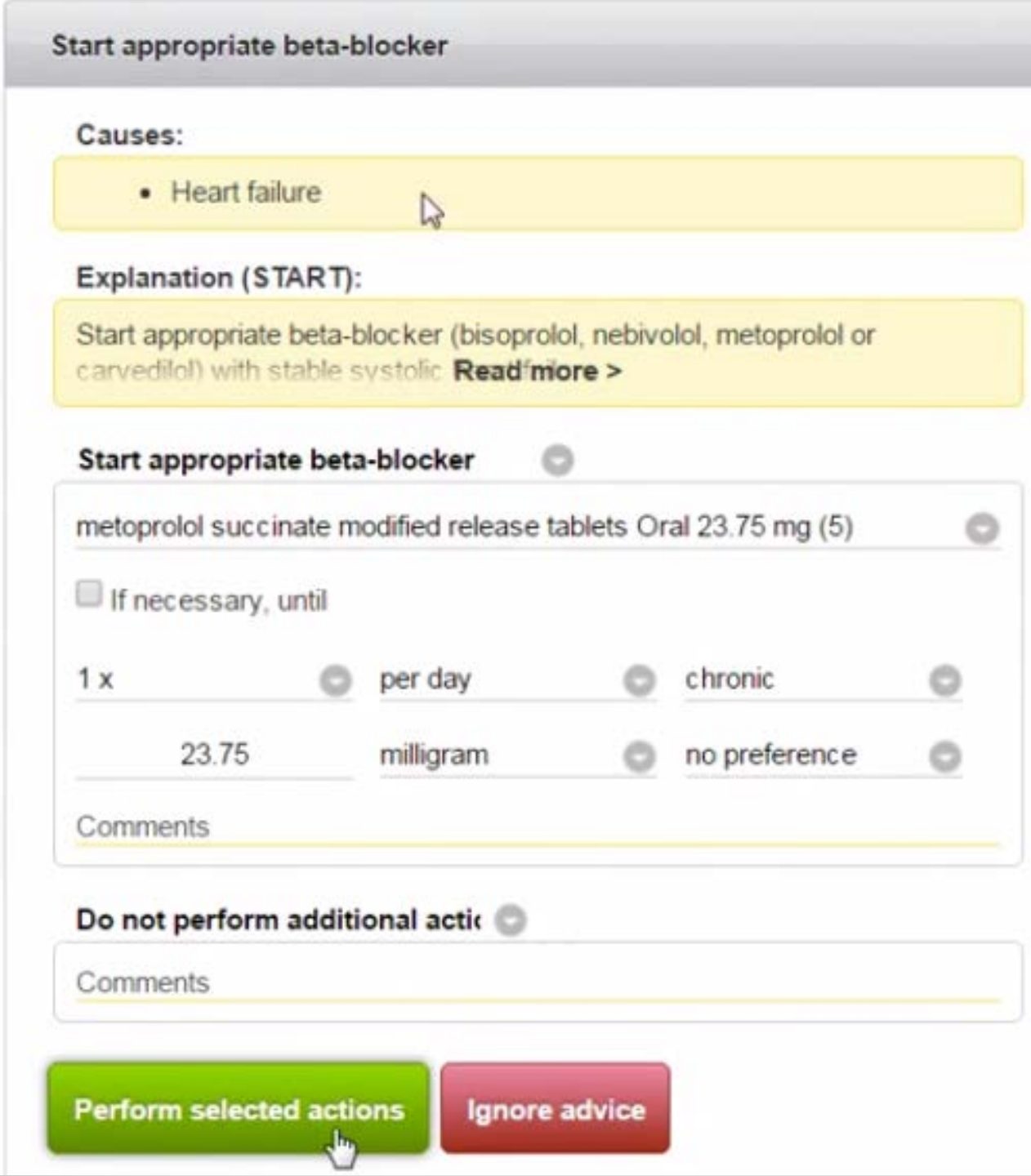
CASE STUDY: STRIPA

2. Undertreatment (START)



Risk Model

Association rules are run on datasets that are usually part of a system. In propositional logic inference rules can be written as $x \rightarrow y$, with a dataset $D=\{d_1,\ldots,d_n\}$ and $x \in D$. The risk associated with a rule is a function of its unwanted consequences and their likelihood of occurring. The formula to determine the risk of an inference rule $x \rightarrow y$ reads:

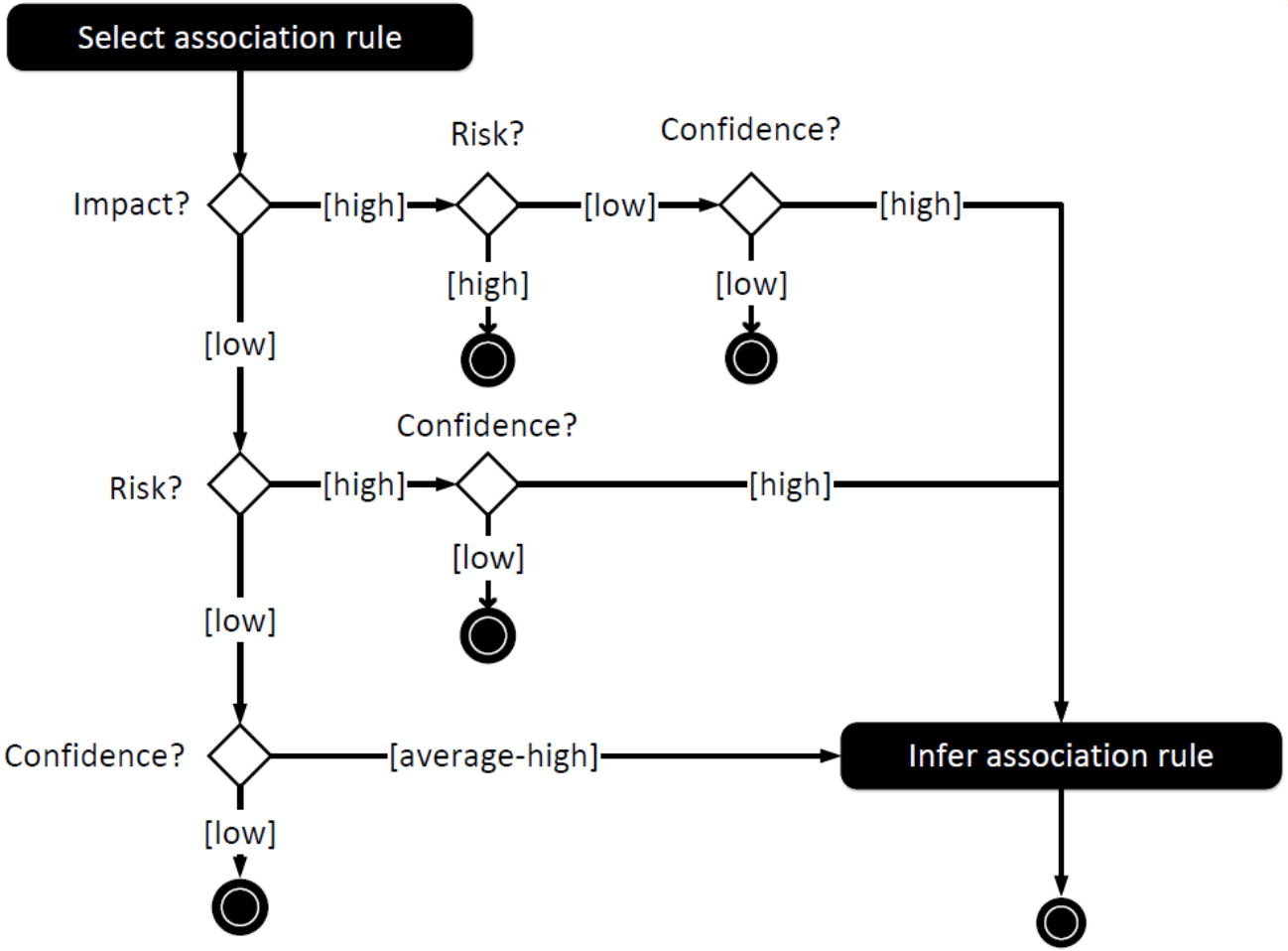
$$risk(x \rightarrow y) = \big(1 - probability(x \rightarrow y)\big) \sum_{i=D,y} severity(i)$$

Risk Model Formulation

Implementation case study: STRIPA (EHR data)

1. $D = \{Disease_n, Drug_m, Contraindication_p, Measurement_q, Allergy_r\}$
2. $risk(x \rightarrow drug) =$
$$\big(1 - probability(x \rightarrow drug)\big) * (severity(D) + severity(drug))$$
3. $severity(D) = \sum_{riskFactor \in D} riskFactor$
4. $severity(drug) = toxicity(drug) * harm(drug)$
5. $toxicity(drug) = \frac{prescribedDailyDose(drug)}{definedDailyDose(drug)}$
6. $harm(drug) = \sum_{e \in E} e.frequency$, Adverse effects set E= $\{e_1, \dots, e_n\}$

A "RECIPE" FOR SAFE INFERENCE OF ASSOCIATION RULES



RISK MEDIATION IN ASSOCIATION RULES: THE CASE OF DECISION SUPPORT IN MEDICATION REVIEW

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Motivation: Safely Infer Association Rules

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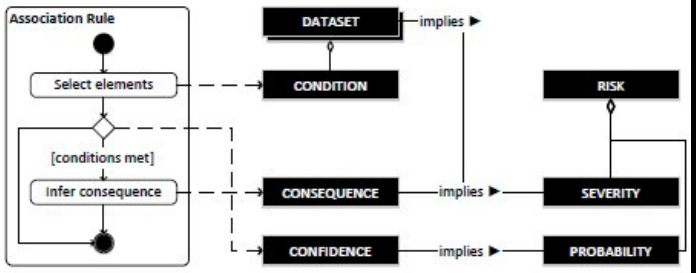
The impact association rules have depends on the sensitivity of the dataset on which they are applied. Figure 1 below shows how association rules' characteristics correspond to those of risk management.

Risk Model

Association rules are run on datasets that are usually part of a system. In propositional logic inference rules can be written as $x \rightarrow y$, with a dataset $D=\{d_1,..,d_n\}$ and $x \in D$. The risk associated with a rule is a function of its unwanted consequences and their likelihood of occurring. The formula to determine the risk of an inference rule $x \rightarrow y$ reads:

$$risk(x \rightarrow y) = \big(1 - probability(x \rightarrow y)\big) \sum_{i=D,y} severity(i)$$

Figure 1 (right):
An association rule's confidence, conditions, and consequences determine its risk's probability and severity.



Implementation & Validation

The risk model was implemented in a medical recommender system, the STRIP Assistant, which incorporates association rules. It was validated using data gathered in a randomized controlled trial.

The model's outcomes are found to have predictive value when tested against decisions made by physicians on 261 patients' health records. An independent t-test showed a statistical difference in the risk associated with actions proposed by the recommender system which were followed (M = 2.42, SD = 0.57) and the risk of proposed actions which were not followed (M = 2.57, SD = 0.60); $t(623) = 3.040$, $p = .002$.

Application: Reusing the Risk Model

Our risk model can be implemented in any system relying on association rules. Figure 2 to the right illustrates how generic decisions, taken with domain-dependent values, can be followed to determine whether or not an association rule can be safely inferred.

Figure 2 (below):
This activity diagram illustrates when an association rule can be safely inferred. This is determined by a combination of the dataset's domain-dependent variables and the association rule's characteristics.