



Risk Mediation in Association Rules

The Case of Decision Support in Medication Review

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

Meulendijk, M., Spruit, M., & Brinkkemper, S. (2017). Risk mediation in association rules: the case of decision support in medication review. In Teije, A. ten, Popow, C., Holmes, J., & Sacchi, L. (Eds.), *LNAI 10259, 16th Conference on Artificial Intelligence in Medicine* (pp. 327 ff). AIME 2017, June 21-24, Vienna, Austria: Springer. [[pdf](#)] [[online](#)]



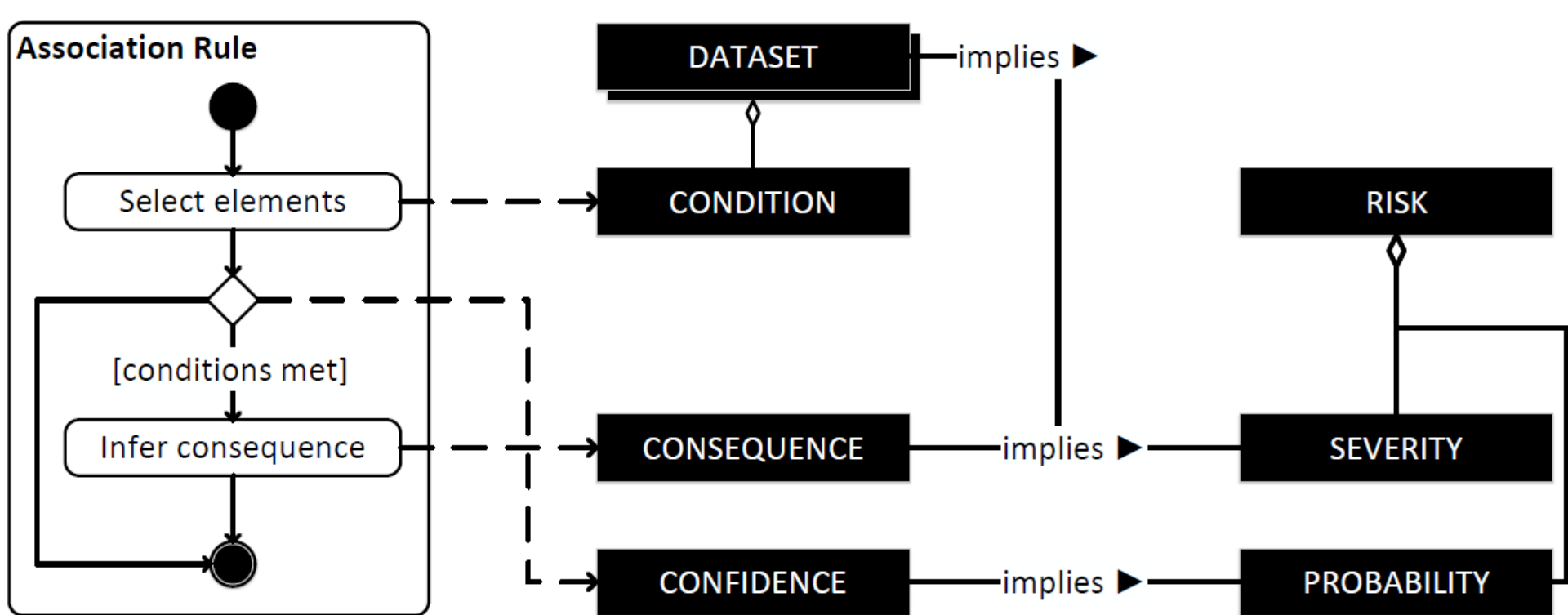
Motivation: Safely Infer Association Rules

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

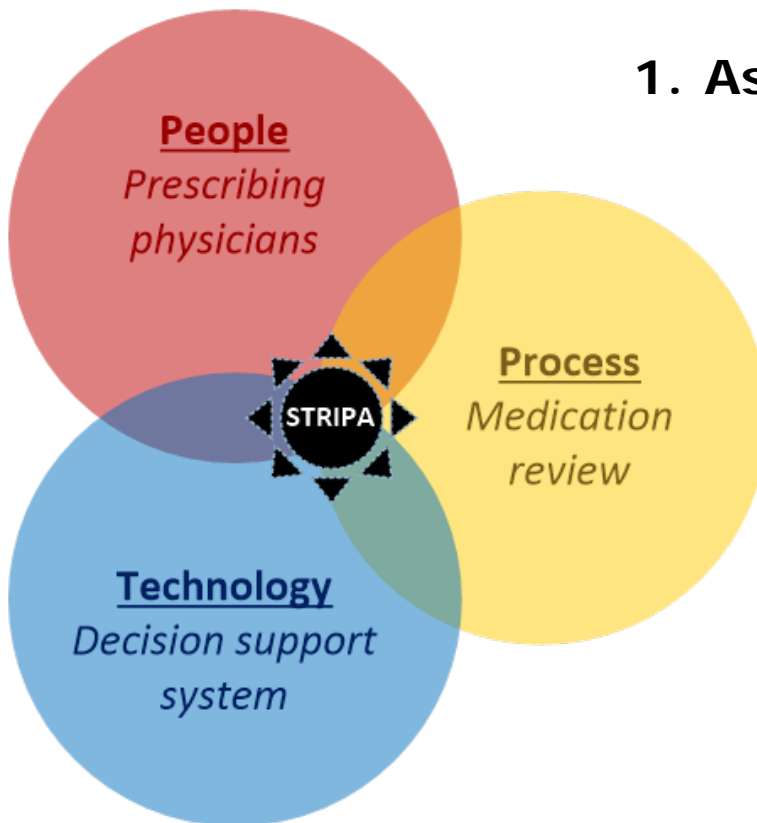
“An association rule’s confidence, conditions, and consequences determine its risk’s probability and severity.”



IMPLEMENTATION CASE STUDY: STRIP ASSISTANT

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

Steps in medication review process:

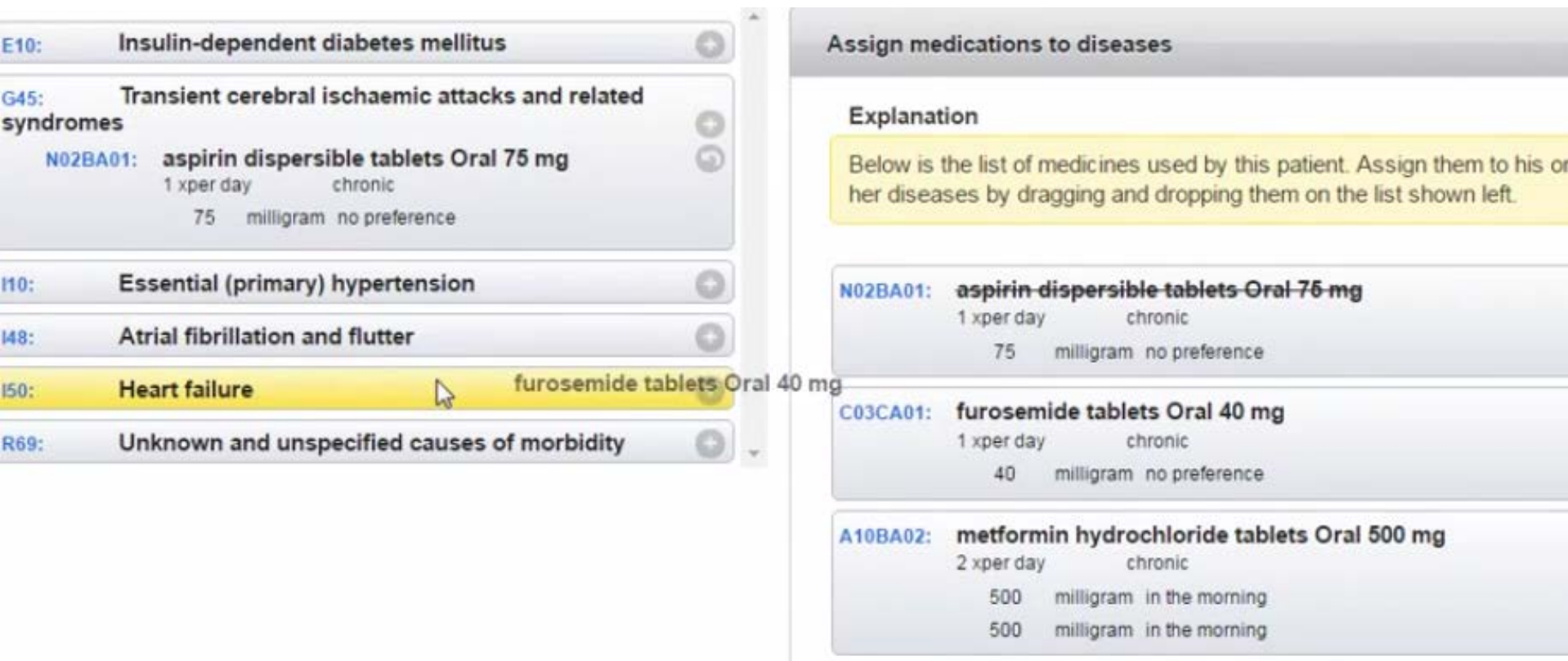


- 1. Assign medications to diseases**
- 2. Undertreatment (START)**
3. Overtreatment (STOPP)
4. Drug-disease interactions
5. Drug-drug interactions
6. Dosage

IMPLEMENTATION CASE STUDY: STRIP ASSISTANT

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

1. Assign medications to diseases



E10: Insulin-dependent diabetes mellitus

G45: Transient cerebral ischaemic attacks and related syndromes

N02BA01: aspirin dispersible tablets Oral 75 mg
 1 xper day chronic
 75 milligram no preference

I10: Essential (primary) hypertension

I48: Atrial fibrillation and flutter

I50: Heart failure furosemide tablets Oral 40 mg

R69: Unknown and unspecified causes of morbidity

Assign medications to diseases

Explanation

Below is the list of medicines used by this patient. Assign them to his or her diseases by dragging and dropping them on the list shown left.

N02BA01: aspirin dispersible tablets Oral 75 mg
 1 xper day chronic
 75 milligram no preference

C03CA01: furosemide tablets Oral 40 mg
 1 xper day chronic
 40 milligram no preference

A10BA02: metformin hydrochloride tablets Oral 500 mg
 2 xper day chronic
 500 milligram in the morning
 500 milligram in the morning

CASE STUDY: STRIPA

2. Undertreatment (START)

Start appropriate beta-blocker

Causes:

- Heart failure

Explanation (START):

Start appropriate beta-blocker (bisoprolol, nebivolol, metoprolol or carvedilol) with stable systolic **Read more >**

Start appropriate beta-blocker

metoprolol succinate modified release tablets Oral 23.75 mg (5)

If necessary, until

1 x

per day

chronic

23.75

milligram

no preference

Comments

Do not perform additional acti

Comments

Perform selected actions

Ignore advice

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 $D = \{d_1, \dots, d_n\}$ 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:

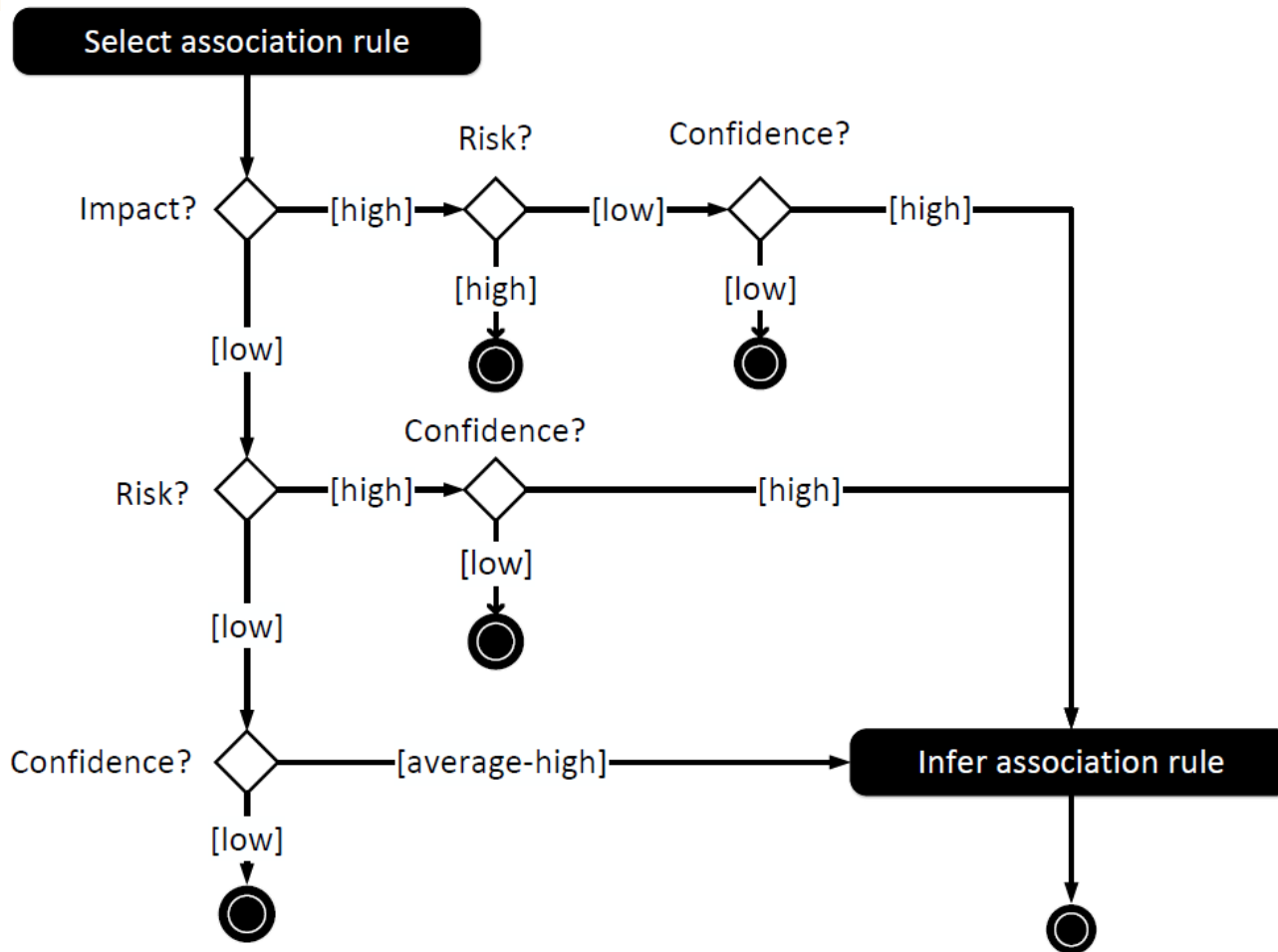
$$risk(x \rightarrow y) = (1 - probability(x \rightarrow y)) \sum_{i=D,y} severity(i)$$

RISK MODEL FORMULATION

Implementation case study: STRIPA (EHR data)

1. $D = \{\text{Disease}_n, \text{Drug}_m, \text{Contraindication}_p, \text{Measurement}_q, \text{Allergy}_r\}$
2. $\text{risk}(x \rightarrow \text{drug}) =$
 $(1 - \text{probability}(x \rightarrow \text{drug})) * (\text{severity}(D) + \text{severity}(\text{drug}))$
3. $\text{severity}(D) = \sum_{\text{riskFactor} \in D} \text{riskFactor}$
4. $\text{severity}(\text{drug}) = \text{toxicity}(\text{drug}) * \text{harm}(\text{drug})$
5. $\text{toxicity}(\text{drug}) = \frac{\text{prescribedDailyDose}(\text{drug})}{\text{definedDailyDose}(\text{drug})}$
6. $\text{harm}(\text{drug}) = \sum_{e \in E} e. \text{frequency}$, Adverse effects set $E = \{e_1, \dots, e_n\}$

A "RECIPE" FOR SAFE INFERENCE OF ASSOCIATION RULES





Michiel C. Meulendijk¹, Marco R. Spruit², Sjaak Brinkkemper²

¹Leiden University Medical Center, ²Utrecht University

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.

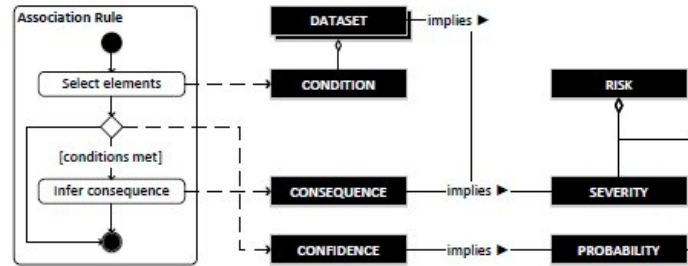
The impact association rules have depends on the sensitivity of the dataset on which they are applied. Figure 1 below shows how association rules' characteristics correspond to those of risk management.

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 $D = \{d_1, \dots, d_n\}$ 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:

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

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 ($M = 2.57$, $SD = 0.60$); $t(623) = 3.040$, $p = .002$.

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.

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.

