



Insights from Predicting Paediatric Asthma Exacerbations from Retrospective Clinical Data

William Elazmeh¹, Dympna O'Sullivan¹, Wojtek Michalowski¹, Stan Matwin¹ and Ken Farion²

¹University of Ottawa, Canada

²Children's Hospital of Eastern Ontario, Ottawa, Canada



Children's Hospital of Eastern Ontario
Centre hospitalier pour enfants de l'est de l'Ontario



uOttawa

L'Université canadienne
Canada's university



Outline

- Prediction Task
- Baseline Results
- Improving Predictions by Employing Secondary Knowledge Sources
 - The PRAM Scoring System
 - Mapping PRAM attributes to our dataset
 - Inferring and Substituting Missing Values
 - Two-Set Approach using 'Typical' and 'Non-Typical' cases
- Experimental Set Up and Results
- Conclusions and Future Work



What is the Prediction Task?

- Assess pediatric asthma exacerbation with scant available information about patient's condition (part of clinical DSS)
- New patient should be classified as MILD or OTHER
 - MILD stay in ED for less than 4 hours
 - OTHER (moderate/severe) stay in ED up to 16 hours or are admitted to a hospital
- OTHER is critical class
 - Misclassified OTHER more costly than misclassified MILD
 - Physician's tend to diagnose conservatively
- Build predictive model that produces:
 - High Sensitivity (reduce number of false negatives)
 - AND**
 - High Specificity (reduce number of false positives)



Predictions for “OTHER”

- **Sensitivity (O)** =
$$\frac{TP_{OTHER}}{FN_{OTHER} + TP_{OTHER}}$$

- **Specificity (O)** =
$$\frac{TN_{OTHER}}{TN_{OTHER} + FP_{OTHER}}$$

	MILD	OTHER
MILD	TN _{OTHER}	FP _{OTHER}
OTHER	FN _{OTHER}	TP _{OTHER}



Baseline Results

Classifier	Cases	Sens	Spec	Acc	Auc
NB	362	73	70	72	79
J48	362	71	57	65	59
NBT	362	72	65	69	73
LWL _{NB}	362	73	70	72	78



Secondary Knowledge Sources

- Use Secondary Knowledge to preprocess data for classification
- Secondary Knowledge Source: PRAM: Preschool Respiratory Assessment Measure
- Applied by mapping attributes from PRAM to corresponding values in our dataset (Not 1-1)
- PRAM was first used to infer likely values for some missing data
- It was then applied to partition data into separate sets for classification



PRAM Scoring System

- Developed for use in pediatric ED
- Uses 5 core clinical attributes to determine asthma severity
- Discriminates severity using a 12-point scoring scale where:
 - 0-4 = MILD
 - 5-8 = MODERATE
 - 9-12 = SEVERE
- For our dataset:
 - 0-4 = MILD
 - 5-12 = OTHER



PRAM Scoring System

Signs	0	1	2	3
Suprasternal Indrawing	absent		present	
Scalene retractions	absent		present	
Wheezing	absent	expiratory	inspiratory and expiratory	Audible without stethoscope/ absent with no air entry
Air entry	normal	decreased at bases	widespread decrease	absent/ minimal
Oxygen saturation	$\geq 95\%$	92%-95%	$< 92\%$	



Mapping PRAM to our dataset

- Need to infer some of the values because:
 - No Mapping for PRAM 'Suprasternal Indrawing'
 - Retractions in our dataset mapped to 'Scalene Retractions' in PRAM
 - Exp Wheeze and Insp Wheeze (two attributes in our dataset) mapped to one PRAM attribute, 'Wheezing'
 - Air Entry in our dataset has 2 values but PRAM 'Air Entry' has 4 possible values
 - SAO2 in our dataset maps to PRAM 'Oxygen Saturation'
- All mappings approved by ED physician



Rules to Compute PRAM Scores

RETRACTIONS=absent, AIR_ENTRY=good --> 0

RETRACTIONS=absent, AIR_ENTRY=reduced --> 1

RETRACTIONS=absent, AIR_ENTRY=? --> 1

RETRACTIONS=present --> 2

EXP_WHEEZE=absent, INSP_WHEEZE=absent --> 0

EXP_WHEEZE=present, INSP_WHEEZE=absent --> 1

EXP_WHEEZE=present, INSP_WHEEZE=present --> 2

EXP_WHEEZE=absent, INSP_WHEEZE=present **** Undefined

AIR_ENTRY=good --> 0

Class=mild, AIR_ENTRY=reduced --> 1

Class=other, AIR_ENTRY=reduced --> 3

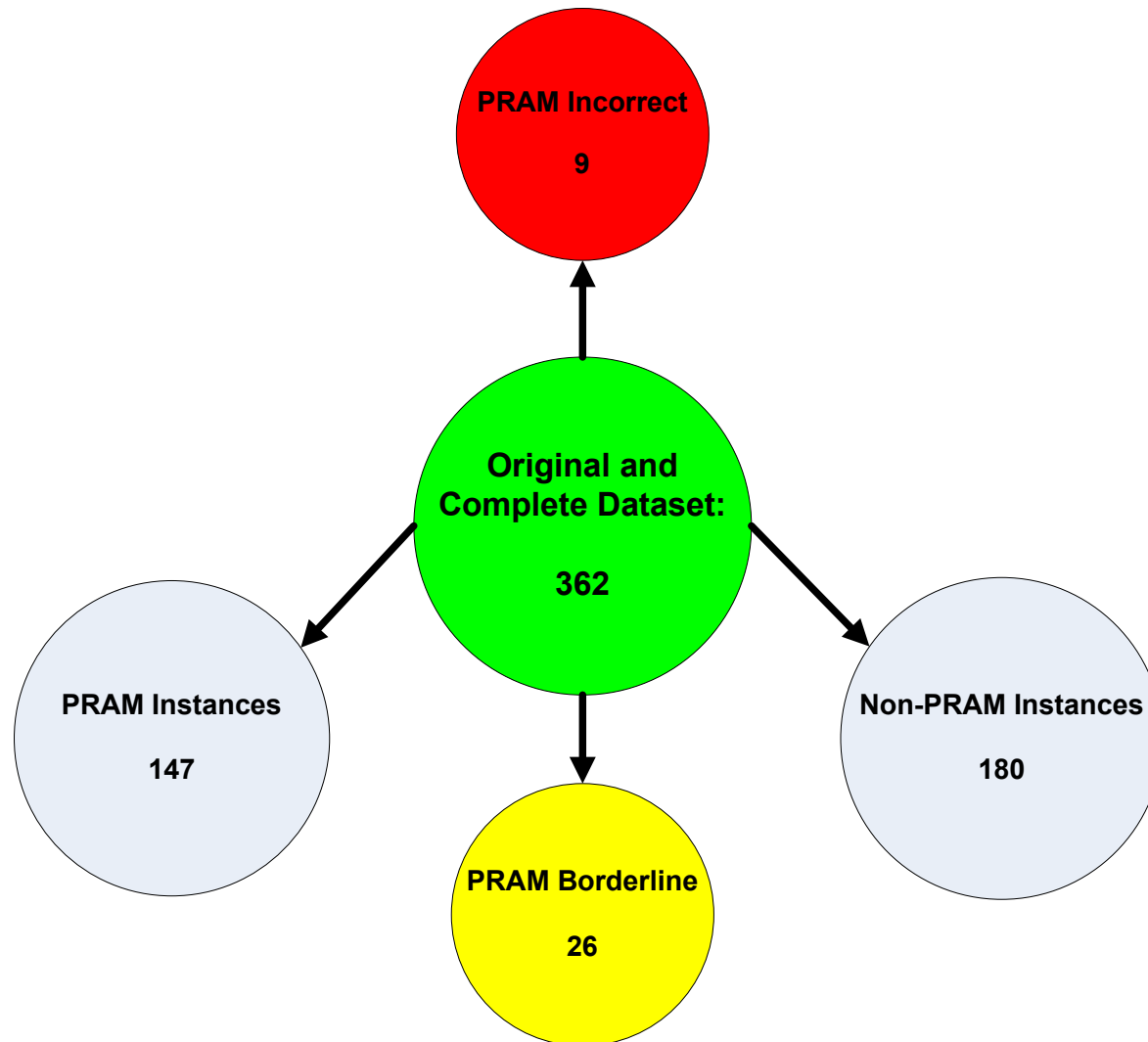
SAO2=ge_95 --> 0

SAO2=ge_93_lt_95 --> 1

SAO2=ge_88_lt_93 --> 2

SAO2=lt_88 --> 3

Dataset as Divided by PRAM Scores



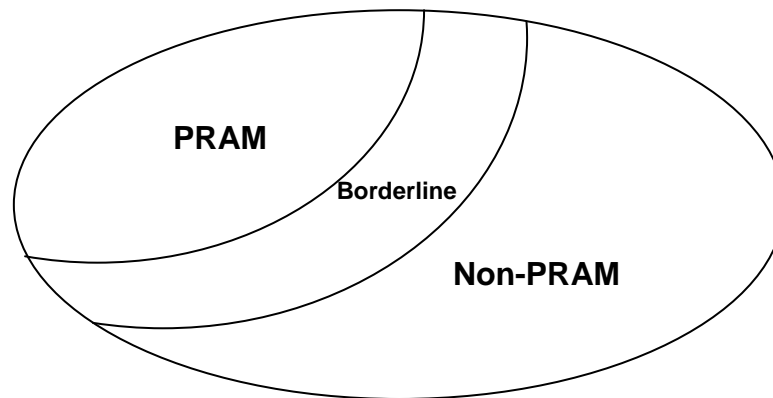


Computing Missing Values using PRAM – Experimental Design

- Extracted complete and correct PRAM cases
- Attempted to mine rules from these examples with which to perform substitution of other PRAM values
- Tried association rules, but were either empty (none) or involved too many attributes (very few examples to sufficiently support the rules)
- Therefore, used simple logical (rule-based) classifiers for substitution
- Re-ran original classifiers on substituted data
- Substitution, however did not significantly improve results

Using PRAM Scores for Classification

- Observation from applying PRAM scores:
 - PRAM is a very reliable identifier of 'typical' cases
 - How about using PRAM as a classifier?





Two Set Approach

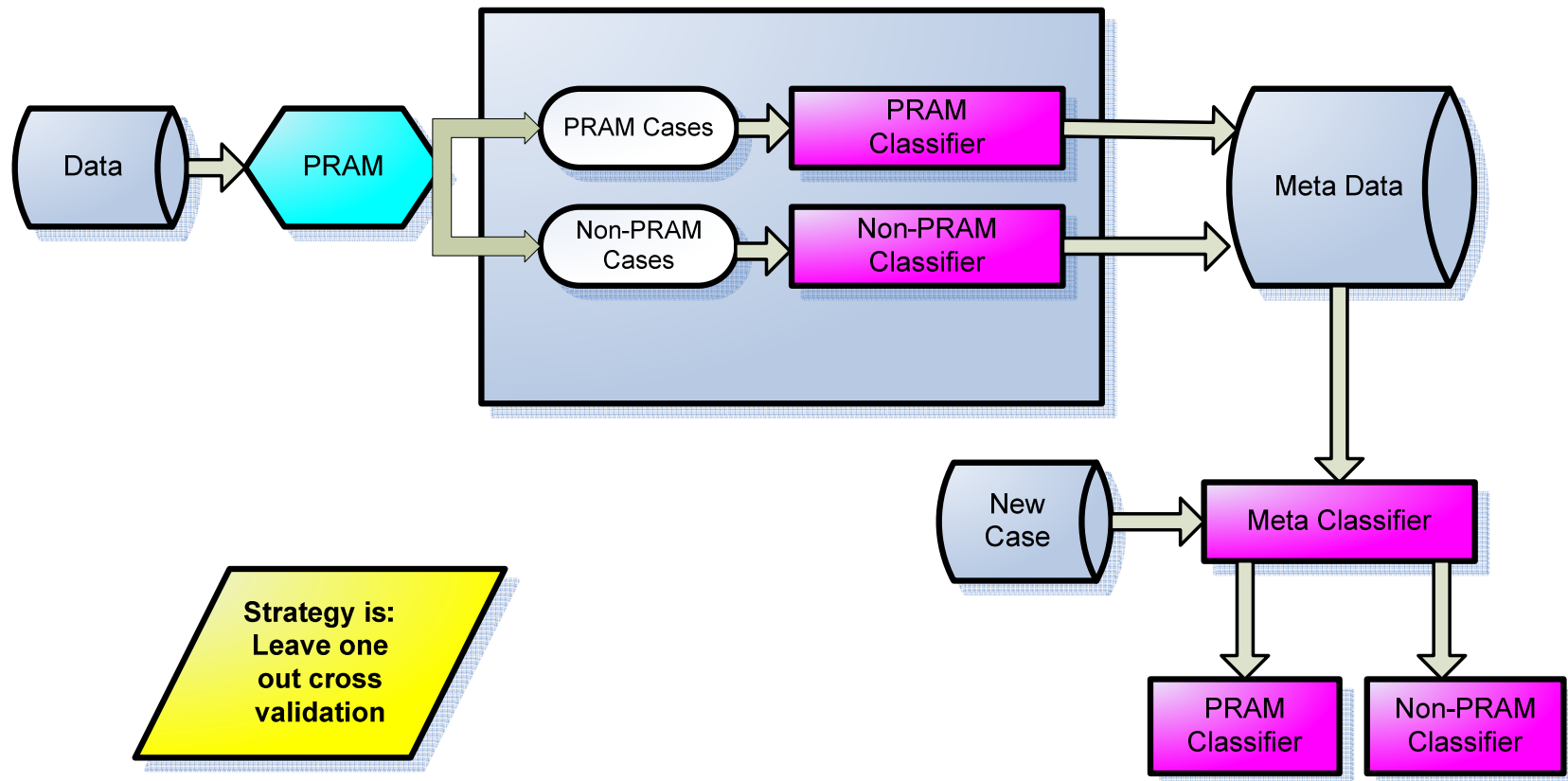
- Inspired by Two-Tiered Approach:
 - Bergadano, F., Matwin, S., Michalski R.S. and Zhang, J., "Learning Two-tiered Descriptions of Flexible Concepts: The POSEIDON System", 1992
- Set is partitioned based on concept representation where the first set captures explicitly basic concept properties, and second set characterizes allowable concept modifications



Two Set Approach – Our Dataset

- PRAM complete and correct cases are 'typical' and correspond to the first set (PRAM set)
- All other cases (PRAM incomplete and PRAM incorrect) are 'atypical' and correspond to the second set (Non-PRAM set)
- Build a classifier for each outlined set
- For each new case must decide which set to assign it to (achieved by a meta-classifier)

Two Set Approach – Our Dataset



Two Set Approach – PRAM Set

- All classifiers work well on PRAM set

Classifier	Cases	Sens (BL)	Spec (BL)	Acc (BL)	Auc (BL)
NB	147	88 (73)	71 (70)	89 (72)	97 (79)
J48	147	93 (71)	96 (57)	95 (65)	98 (59)
NBT	147	86 (72)	92 (65)	89 (69)	96 (73)
LWL _{NB}	147	90 (73)	88 (70)	89 (72)	96 (78)



Two Set Approach – Non-PRAM Set

- Much bigger variation among classifiers

Classifier	Cases	Sens (BL)	Spec (BL)	Acc (BL)	Auc (BL)
NB	206	74 (73)	59 (70)	68 (72)	73 (79)
J48	206	90 (71)	53 (57)	75 (65)	78 (59)
NBT	206	74 (72)	51 (65)	65 (69)	69 (73)
LWL _{NB}	206	76 (73)	60 (70)	69 (72)	71 (78)



Ongoing Work

- o Aiming to improve results on the Non-PRAM set
 - o In particular focusing on methods to improve Specificity
 - o Clustering, Automatic and Expert Feature Selection
 - o Contextual Normalization
- o Implementation of Meta-Classifer
 - o Simplest based on presence/absence of PRAM values
 - o May also consider voting and ranking mechanisms



Conclusions

- Retrospectively collected clinical data provides many difficulties for data mining and machine learning
- Our approach has been to apply Secondary Knowledge Sources (PRAM) to preprocess data for classification
- Employ a two set approach based on concept representation for data partitioning
- Approach will be tested on new data that is prospectively collected in ED
- To learn more about the research:
<http://www.mobiledss.uottawa.ca>