Making the most of eczema data for prediction, inference and treatment recommendation

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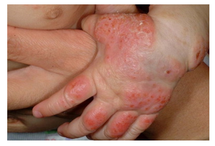
Introduction

- Atopic Dermatitis (AD, eczema) is a most common chronic skin disease characterised by dry, itchy skin.
- Eczema can be managed using treatments.
- Treatment responses are highly heterogeneous.
- Designing personalised treatment recommendations is of high clinical relevance.



Eczema lesions

Objective

We aim to develop a comprehensive model that predicts the patient-dependent dynamic evolution of eczema severity and generates treatment recommendations.

Conclusion

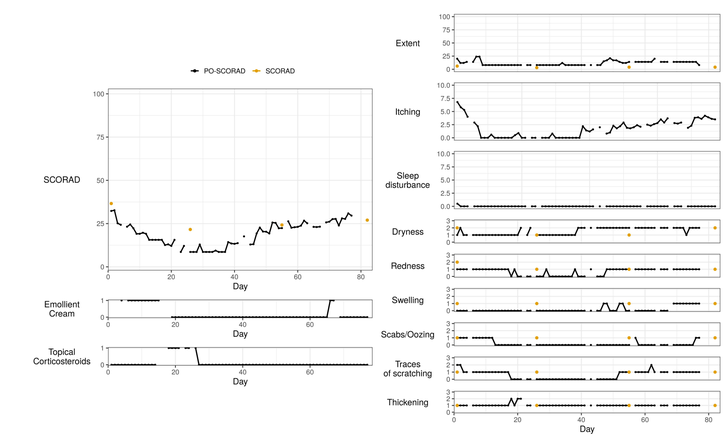
- We developed a computational framework, EczemaPred, to model the evolution of eczema severity. EczemaPred is available as a R package: https://github.com/ghurault/EczemaPred.
- We used EczemaPred to calibrate self-assessments, estimate treatment effects and generate personalised treatment recommendations as a proof-of-concept.

Data

We used the longitudinal recordings of an eczema severity score, PO-SCORAD:

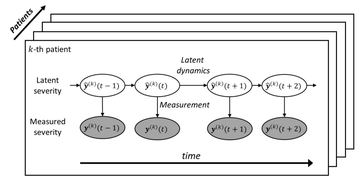
- PO-SCORAD is the weighted combination of 9 severity items:
  - Extent (area covered by eczema): 0-100
  - 6 intensity signs (e.g. dryness, redness): 0-3
  - 2 subjective symptoms (itch, sleep loss; optional): 0-10
- PO-SCORAD is self-assessed by patients; when assessed by clinical staff, we refer to it as SCORAD.

	Dataset 1	Dataset 2
Number of patients	347	16
PO-SCORAD recording	Twice weekly, up to 17 weeks	Daily, up to 12 weeks
Observations	9943	1136
Missing values (daily)	70.3%	13.6%



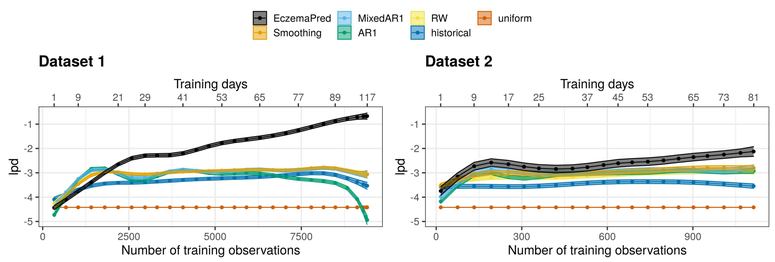
EczemaPred [1]

- EczemaPred is a collection of Bayesian state-space models tailored to the data-generating mechanisms of each severity items.
- The state-space models explicitly describe errors in the measurement of the severity items, including missing values.



State-space model

- We use a Bayesian framework to explicitly quantify uncertainties in parameters and predictions.
- Predictions for aggregate severity score PO-SCORAD are obtained by combining predictions for individual severity items.

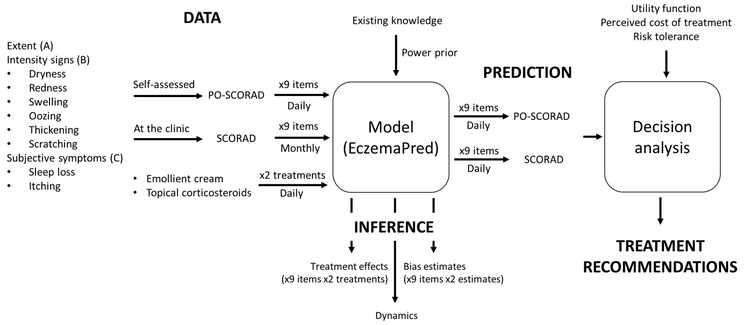


Learning curves for PO-oSCORAD predictions. Performance was assessed using the log predictive density (lpd, predictive log-likelihood) in a forward chaining setting (model updated every week) and compared to that of standard time-series forecasting models.

Extending the model

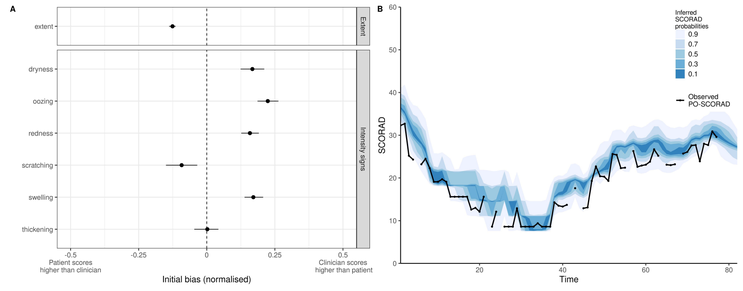
We extended EczemaPred using Dataset 2 to:

- Calibrate self-assessed severity measurements (PO-SCORAD, daily) with clinically assessed measurements (SCORAD, monthly).
- Estimate treatment effects from treatment usage data.
- Generate treatment recommendations using Bayesian decision theory.
- "Pre-train" the model with Dataset 1 using a power prior.



Calibrating measurements

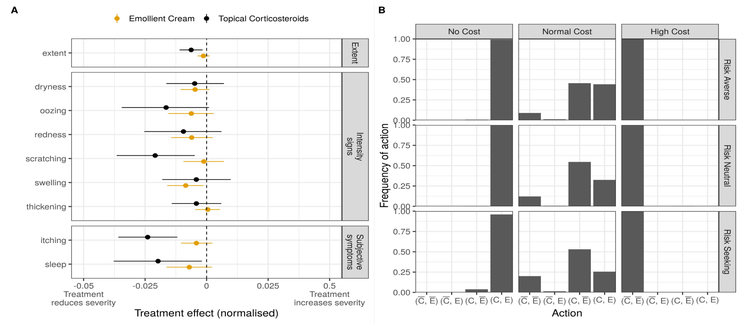
- We specify a second, more precise, measurement process to include monthly measurements by clinicians (SCORAD).
- We estimated the biases between patients and clinician assessments and calibrate the self-assessments.



A) Estimate of biases between patients and clinicians assessments. B) Observed PO-SCORAD (patient-assessed) trajectories vs calibrated (SCORAD, blue) trajectories

Treatment inference and recommendations

- We estimated average treatment effects of topical corticosteroids (C) and emollient cream (E).
- Treatment effects are confounded by the clinical phenotype of patients (pattern of disease signs).
- We generated treatment recommendations for different decision profiles ("perceived" cost of using treatment vs risk-aversion).
- The model is not causal and making counterfactual predictions ("what would have happened if...?") to evaluate the recommendations is challenging.



A) Treatment effects estimates. B) Distribution of recommendations for different decision profiles.

Acknowledgements & References

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[1] G. Hurault, J. F. Stalder, S. Mery, *et al.*, "EczemaPred: A computational framework for personalised prediction of eczema severity dynamics," *Clinical and Translational Allergy*, vol. 12, no. 3, e12140, Mar. 2022.