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Supervised Learning Provides Small but Consistent Improvements to Clustering when Predicting Chronic Pain Outcomes Following Treatment

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Abstract. Using registry and questionnaire data from 47,235 chronic pain patients, we evaluated whether supervised learning outperforms clustering in predicting nine one-year outcomes. Supervised models showed small but consistent improvements (best RMSE 5.49 vs. 5.92; R^2 0.34 vs. 0.19), with overall comparable performance.

Keywords. Clustering, Chronic pain, Machine learning

1. Introduction

Chronic pain is pain that lasts for more than three months. One in two adults will experience chronic pain during their lifetime and it is one of the main causes of disability worldwide. In Sweden there are specialized pain clinics that patients are directed to for interdisciplinary treatment (IDT). They are then evaluated for undergoing IDT, where about half are approved for treatment and half are rejected and referred to primary healthcare. For all patients there is a baseline questionnaire where the symptom severity (physical but also mental) is subjectively evaluated by the patients themselves. There is a follow-up questionnaire relating to the treatment effects one year after treatment conclusion for both the treated and the non-treated group. The aim of this study was to

evaluate whether supervised [1] or unsupervised [2] methods better predict specific outcomes at follow-up.

2. Methods

Data from Swedish registries were collected for patients undergoing treatment between 2009–2022, including sick leave spells, medication consumption, and patient questionnaires at baseline and follow-up. About 40 features were selected as predictors and nine clinically relevant outcomes (medication intake, quality of life, pain intensity, sleep difficulties), with baseline values used to predict follow-up outcomes.

In the cohort (n = 47,235), baseline clustering was performed (k-means), and individual follow-up outcomes were predicted using the mean follow-up values of each patient's assigned cluster. Supervised learning (KNN, NN, SVM, Elastic-net, XGBoost, ensemble) predicted the nine outcomes using 5-fold cross-validation, and performance was assessed by RMSE and R^2 from out-of-fold predictions.

3. Results

In total eight clusters were created based on homogeneity and stability measures. The error values show that supervised learning provided modest but consistent improvements over clustering in predicting the nine outcomes. Across nine outcomes, fully supervised elastic-net models achieved the lowest average RMSE (5.49) and highest R^2 (0.34), compared with cluster-mean prediction (RMSE 5.92; R^2 0.19). Although supervised learning improved some predictions, overall performance was similar between methods.

4. Discussion

Supervised learning models achieved modest improvements over clustering-based prediction across outcomes. This likely reflects that both methods rely on the same baseline features and that the clusters efficiently summarize the nonlinear structure of the data. In other words, the cluster memberships act as latent representations of baseline patterns that already capture much of the explainable variation in the outcomes. Consequently, the supervised models had limited but systematic additional signal to exploit beyond what was encoded in the cluster assignments.

References

[1] Mertens MG, van Kuijk SM, Beckers LW, Zmudzki F, Winkens B, Smeets RJ. Prediction models for treatment success after an interdisciplinary multimodal pain treatment program. In Seminars in Arthritis and Rheumatism 2025 Feb 1 (Vol. 70, p. 152592). WB Saunders.

[2] Hsu TC, Whelan P, Armitage CJ, McBeth J. Identifying chronic pain subgroups in the UK biobank for persona development: A clustering analysis. Digital Health. 2025 May;11:20552076251333497.