**AI-Driven Insights into Early-Onset Multimorbidity Clusters and Long-Term Health Trajectories: A Path Towards Improved Healthcare Planning**

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with the MELD-B Consortium

### Multiple Long-term Condition Multimorbidity

One in four individuals grapples with managing two or more long-term health conditions (LTCs) resulting in lower quality of life and increased mortality risk. Depressed areas experience the onset of these conditions 10-15 years earlier than affluent ones. With an aging population, the prevalence of people having multiple LTCs (MLTCs) is expected to rise significantly, impacting individuals, families, and society, leading to increased human and service costs particularly associated with mental health conditions linked to long-term physical health issues.

### Dataset

Four exploratory indicators of ‘burdensomeness’ were identified from a cohort of 4,896,520 individuals in the SAIL² (Secure Anonymized Information Linkage) Databank between January 2000 and December 2021: age at onset, interval between accrual of LTCs, presence of Mental Health Conditions component of LTC (PMHC), and frequency of hospital appointments.

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### Clustering In Burdensomeness Space

Utilizing unsupervised machine learning clustering methods (k-prototype), the cohort members are grouped/clustered based on the extracted burdensomeness indicators.

**Burdensomeness Indicators**

- Extract Indicators from Database
- Clustering Algorithm
- Unique Grouping

### Clustering Results

Using these four exploratory burdensomeness indicators and the k-prototypes algorithm, we found five clusters in ‘burdensomeness space’, shown below by colour and list of key characteristic features.

- **Early to medium age at onset**
  - PMHC
- **Early age of onset**
  - High frequency of hospital appointments
- **Very high (<1 year) very high (≥6 years) accrual interval between conditions**
  - No PMHC

### Initial Burdensomeness Indicators

The feature characteristics of each cluster are explained via two methods:
1. Shapley Additive explanation (SHAP), which quantifies the magnitude and direction (positive or negative) of an indicator’s effect on cluster membership.
2. Frequency analysis, which shows the prevalence of different categories for a feature. The frequency and SHAP plots for the purple cluster are shown left and right respectively.

### References

4. https://saildatabank.com

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**Primary Burden Indicators**

A qualitative evidence synthesis comprehensively explores the lived experience of individuals with multiple long-term conditions, focusing on understanding the associated burdens. This informs a modified Delphi consensus study to gather feedback from clinicians, academics, patients, and carers on identified indicators. The goal is to validate these indicators for incorporation into clustering analysis.

**WP5 People, Policy and Impact**

- **WP4 Lifecourse prevention**
  - Identity clusters of risk factors and people at risk pre-birth to 18
  - Identify critical timepoints and model prevention scenarios

**WP2 Trustworthy & Responsible AI**

- **WP1 Burden & Complexity**
  - Qualitative evidence synthesis
  - Delphi consensus study

**WP3 Clustering & Sequencing**

- **Cluster on burdensomeness & model sequence of conditions**
  - ‘Connect’ birth cohorts to clusters

**Extract Indicators from Database**

**Clustering Algorithm**

**Unique Grouping**

**Cohort Demographic Characteristics**

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**References**