Early Prediction of Labour Force Dropout in SLE Patients

Integrating Longitudinal Deep Learning through an LSTM RNN with Random Forests

Javier Mencia Ledo[1], Dennisse Bonilla[2], Zahi Touma, MD, PhD[2], Behdin Nowrouzi-Kia, PhD [1]

[1]ReSTORE Lab
University of Toronto

[2]Toronto Western Lupus Clinic
University Health Network

SUDS Showcase, 2025

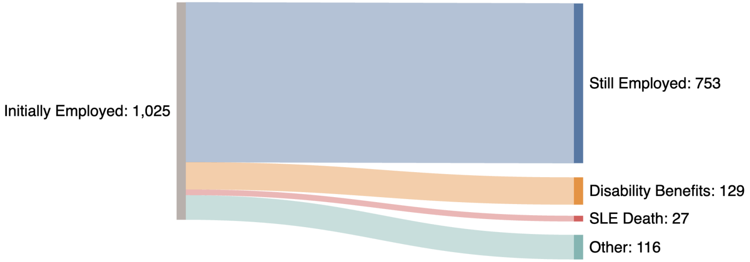
Background & Objectives

- SLE is a chronic autoimmune disease that affects functioning
- **Problem:** 20-40% of SLE patients exit workforce prematurely
- **Impact:**
  - Work gives financial stability and sense of purpose
    $\rightarrow$ Social isolation and mental health decline
  - Socioeconomic burden
- **Solution:**
  - Hybrid RF-LSTM tool to flag at-risk patients *before* departure to allow early clinical intervention

Employment Trajectories

Overview:

- Records at the Toronto Lupus Clinic (UHN) between 1996-2024



Source: Robroek et al., 2015 [1]

- Still employed includes actively working or retired after the retirement age
- Other states: Unemployed, Economically Inactive, Early Retirement

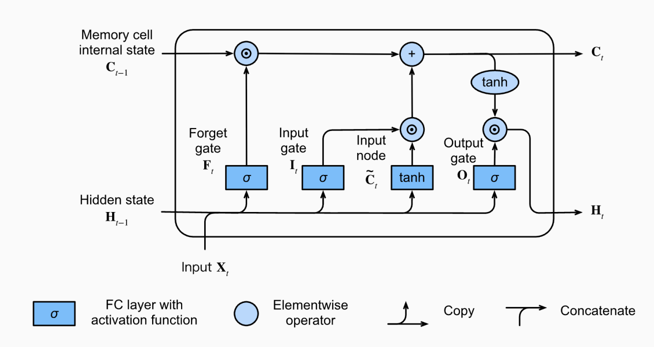
Long-Short Term Memory Model Architecture

Why LSTMs?

- Capture **long-term dependencies** across years of patient visits

Input:
25 clinical features per visit selected w/RF and using class balancing via synthetic minority augmentation: $\mathbf{X} \in \mathbb{R}^{N \times T \times 25}$

Model cell at visit t ($1 \leq t \leq T$):



Source: Hochreiter et al. [2], Zhang et al. [3]

Prediction Pipeline

Hidden state at visit t:

$$\mathbf{H}_t = \text{LSTM}(\mathbf{X}_t, \mathbf{H}_{t-1}, \mathbf{C}_{t-1}) \tag{1}$$

Linear transformation:

$$\mathbf{z_{t,k}} = \mathbf{W}_k \mathbf{H}_t + \mathbf{b}_k \tag{2}$$

1. Class prediction (t = T):

$$p(y = k) = \frac{\exp(z_{t,k})}{\sum_{j=1}^{K} \exp(z_{t,j})} \quad (K = 3 \text{ classes}) \tag{3}$$

$$\hat{y} = \underset{k \in \{\text{employed, disability, mortality}\}}{\arg\max} p(y = k) \tag{4}$$

2. Risk score computation for disability and mortality resp. $(t \leq T)$:

$$\text{risk}_{t,k} = \sigma(\mathbf{z}_{t,k}) = \frac{1}{1 + \exp(-\mathbf{z}_{t,k})} \tag{5}$$

Alert if $\text{risk}_{t,k} \geq \theta_k$ where θ_k is a hyperparameter that optimizes early detection time(Δt)

Model Performance Highlights

Final Employment State Classification
After 5-fold CV:

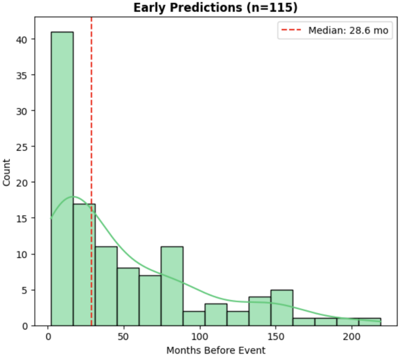
Overall balanced accuracy: **91%**

Early Warning System for Disability

Early warning system achieves **89% case detection**
It has a median lead time of **28.6 Months** (IQR: 14.3–42.1)

Early Intervention Strategies:

- Proactive rehabilitation programs
- Multidisciplinary specialist coordination
- Workplace accommodation planning



Acknowledgements

ReSTORE

LUPUS ONTARIO
Life Without Lupus

DATA SCIENCES INSTITUTE

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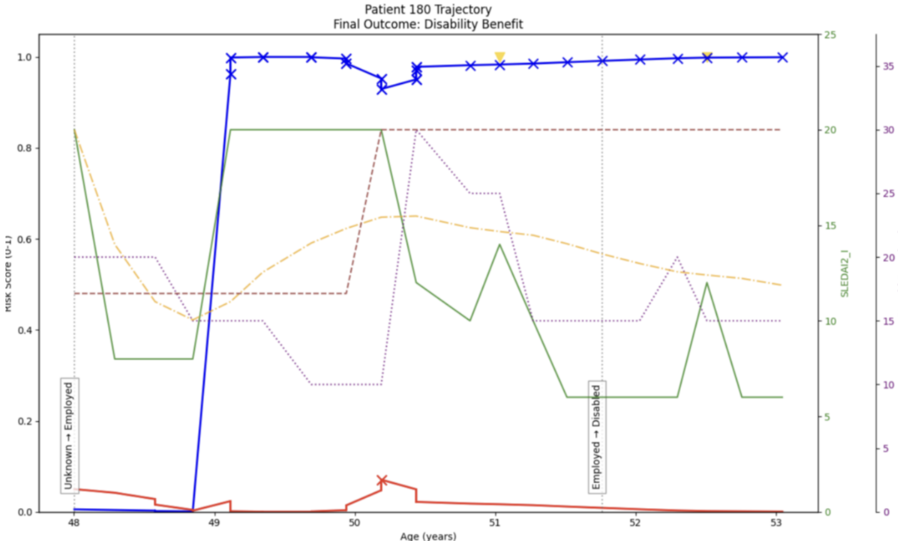
Individual Patient Trajectory



Robroek, S. J., Rongen, A., Arts, C. H., Otten, F. W., Burdorf, A., & Schuring, M. (2015). Educational inequalities in exit from paid employment among Dutch workers: The influence of health, lifestyle and work. *PloS one*, *10*(8), e0134867. https://doi.org/10.1371/journal.pone.0134867

Hochreiter, S., & Schmidhuber, J. (1997). Long short-term memory. *Neural Computation*, *9*(8), 1735–1780. https://doi.org/10.1162/neco.1997.9.8.1735

Zhang, A., Lipton, Z. C., Li, M., & Smola, A. J. (2021). *Dive into Deep Learning*. Cambridge University Press. https://d2l.ai/chapter_recurrent-modern/lstm.html.