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Machine learning–based prediction of changes in the clinical condition of patients with complex chronic diseases: 2-phase pilot prospective single-center observational study

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Abstract-

Background: Functional impairment is one of the most decisive prognostic factors in patients with complex chronic diseases. A more significant functional impairment indicates that the disease is progressing, which requires implementing diagnostic and therapeutic actions that stop the exacerbation of the disease.

Objective: This study aimed to predict alterations in the clinical condition of patients with complex chronic diseases by predicting the Barthel Index (BI), to assess their clinical and functional status using an artificial intelligence model and data collected through an internet of things mobility device.

Methods: A 2-phase pilot prospective single-center observational study was designed. During both phases, patients were recruited, and a wearable activity tracker was allocated to gather physical activity data. Patients were categorized into class A (BI≤20; total dependence), class B (20<BI≤60; severe dependence), and class C (BI>60; moderate or mild dependence, or independent). Data preprocessing and machine learning techniques were used to analyze mobility data. A decision tree was used to achieve a robust and interpretable model. To assess the quality of the predictions, several metrics including the mean absolute error, median absolute error, and root mean squared error were considered. Statistical analysis was performed using SPSS and Python for the machine learning modeling.

Results: Overall, 90 patients with complex chronic diseases were included: 50 during phase 1 (class A: n=10; class B: n=20; and class C: n=20) and 40 during phase 2 (class B: n=20 and class C: n=20). Most patients (n=85, 94%) had a caregiver. The mean value of the BI was 58.31 (SD 24.5). Concerning mobility aids, 60% (n=52) of patients required no aids, whereas the others required walkers (n=18, 20%), wheelchairs (n=15, 17%), canes (n=4, 7%), and crutches (n=1, 1%). Regarding clinical complexity, 85% (n=76) met patient with polypathology criteria with a mean of 2.7 (SD 1.25) categories, 69% (n=61) met the frailty criteria, and 21% (n=19) met the patients with complex chronic diseases criteria. The most characteristic symptoms were dyspnea (n=73, 82%), chronic pain (n=63, 70%), asthenia (n=62, 68%), and anxiety (n=41, 46%). Polypharmacy was presented in 87% (n=78) of patients. The most important variables for predicting the BI were identified as the maximum step count during evening and morning periods and the absence of a mobility device. The model

exhibited consistency in the median prediction error with a median absolute error close to 5 in the training, validation, and production-like test sets. The model accuracy for identifying the BI class was 91%, 88%, and 90% in the training, validation, and test sets, respectively.
Conclusions: Using commercially available mobility recording devices makes it possible to identify different mobility patterns and relate them to functional capacity in patients with polypathology according to the BI without using clinical parameters.

Index Terms- patients with complex chronic diseases; functional impairment; Barthel Index; artificial intelligence; machine learning; prediction model; pilot study; chronic patients; chronic; development study; prognostic; diagnostic; therapeutic; wearable; wearables; wearable activity tracker; mobility device; device; physical activity; caregiver

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