Multi-Dimensional Migraine: A Comprehensive AI-Assisted Framework for Headache Diagnosis, Risk Detection, and Patient Experience Enhancement

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Headache disorders are among the top three most common neurological conditions, affecting 40% of the global population, yet 50–80% of migraine patients are misdiagnosed due to fragmented diagnostic pathways and inconsistent patient data. This gap leads to poor headache management, causing migraine to be the third leading cause of disability worldwide. Thus, this project presents a multi-dimensional approach for subtype diagnosis, personalized management, and proactive migraine detection. First, the diagnostic system integrates cache- and retrieval-augmented generation with Llama 3.3 LLM to determine headache type by comparing patient responses to a structured questionnaire based on refined criteria of Red Flags, Green Flags, and clinical features. The management system incorporates a structured diary model that extracts triggers and identifies headache patterns, and a Cognitive Behavioral Therapy (CBT) chatbot that targets psychological comorbidities. The proactive detection system predicts migraine attack risk across future time windows via diary inputs and physiological patterns. After experimentation, the diagnostic framework was evaluated on three datasets: 710, 100, and 36 cases, achieving 93.1%, 99.5%, and 100%, respectively. The management system reduced headache attack duration ($p < 0.001$), with mean reductions of 68–75% and very large effect sizes (mean Cohen's $d = 3.21$), while the CBT chatbot reduced Migraine disability assessment scores (MIDAS) ($F(1,43) = 96.14$, $p < 0.001$). The proactive detection system showed perfect alignment of all actual onsets with predicted intervals. Ultimately, this system addresses limitations of delayed and inaccurate diagnosis, poor management, and early prediction to improve patient care and reduce migraine-related disability.

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