

ARTIFICIAL INTELLIGENCE MODELS FOR PREDICTING MILD COGNITIVE IMPAIRMENT PROGRESSION TO ALZHEIMER'S DISEASE: A SYSTEMATIC REVIEW OF NEUROIMAGING-BASED APPROACHES

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BACKGROUND

Accurate prediction of progression from mild cognitive impairment (MCI) to Alzheimer's disease (AD) is critical for early intervention and patient stratification. Artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL), applied to neuroimaging data, offers promising prognostic tools. This systematic review evaluates current AI-driven neuroimaging approaches for predicting MCI-to-AD conversion.

METHOD

Following PRISMA guidelines, we analyzed 18 primary studies published between 2014 and 2024. Inclusion criteria comprised human studies applying ML or DL to neuroimaging modalities (MRI, FDG-PET) for MCI progression prediction. Exclusion criteria included reviews, duplicates, and non-primary research. Data extraction captured study design, cohort characteristics, imaging modalities, preprocessing, AI model architecture, validation, performance metrics, explainability, class balance, follow-up duration, and bias risk (assessed via PROBAST). Narrative synthesis and summary tables were used for consolidation.

RESULTS

Sample sizes ranged from 79 to 2,146 participants (median ~400), predominantly from ADNI (n=15). Study designs included prospective and retrospective cohorts. Imaging modalities were structural MRI (n=9), FDG-PET (n=7), and multimodal combinations (n=6). AI methods included DL (CNNs, hybrid models; n=9) and classical ML algorithms (SVM, RF; n=6). Preprocessing approaches encompassed voxel- and ROI-based normalization, segmentation, and feature extraction. Predictive performance varied: AUC 0.76–0.94 (median 0.86), accuracy 75–94%, with multimodal DL consistently outperforming single-modality approaches (AUC gains 0.05–0.10). Follow-up periods ranged from 18–96 months (common 3 years). Class imbalance was common (median converter: non-converter ratio 1:1.5), typically managed with cross-validation or oversampling. Explainability was limited; saliency maps were reported in four studies. External validation was rare (n=5), with survival-based models achieving C-index up to 0.86. Limitations included small cohorts, potential overfitting, and reliance on single-site datasets.

CONCLUSION

Neuroimaging-based AI models, particularly multimodal DL frameworks, demonstrate strong potential for predicting MCI-to-AD progression. To advance clinical translation, future studies should prioritize larger, multi-center datasets, robust external validation, and explainable AI techniques.