Reducing the Economic Burden of Dementia Diagnosis: An AI-Driven Screening Framework Using Routine Clinical Data and Structural MRI

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Motivation. Alzheimer's disease and related dementias (AD/ADRD) cost the U.S. healthcare system an estimated $384 billion annually, projected to exceed $1 trillion by 2050 [1]. A primary driver is delayed diagnosis: over 60% of dementia cases go undetected in the community [2], and the average time from symptom onset to confirmed diagnosis is 3.5 years [3]. These delays lead to avoidable hospitalizations, premature institutionalization, and missed windows for disease-modifying therapies whose efficacy depends on early-stage administration—therapies costing $26,500–$32,000 per patient per year [4]. The Medicare Annual Wellness Visit (AWV), utilized by approximately 25% of eligible beneficiaries [5], represents an underutilized economic lever: a low-cost encounter where AI screening could identify at-risk patients years earlier, redirecting them toward cost-effective care pathways.

Approach. Building on multimodal deep learning frameworks for dementia assessment [7,8], we substantially redesign and extend their architecture into a two-tier screening system designed for integration at two distinct points in the clinical workflow. Tier 1 is an EHR-only model targeting neurologists and primary care physicians: it operates on 187 clinical features from routine EHR data—demographics, medical history, medications, cognitive assessments, and neurological exam findings—requiring no additional imaging or specialist workup. This model enables population-level screening at near-zero marginal cost. Tier 2 augments the clinical model with structural T1-weighted brain MRI, adding a 3D convolutional neural network to assist radiologists with volumetric analysis and interpretable attention heatmaps that highlight disease-specific atrophy patterns. Because the AI overlay processes an already-ordered MRI in under two minutes on a standard GPU, the incremental computational cost and time per scan is negligible making it possible to assist radiologists in real-time and increasing their productivity. Both tiers are trained on 57,569 patient visits from NACC and 7,411 MRI scans from NACC/ADNI, employing a hierarchical three-stage pipeline: (1) dementia vs. non-dementia, (2) cognitive impairment subtyping(CN, MCI, iMCI), and (3) dementia subtype classification (AD, LBD, VD, FTD).

Results. The three-stage EHR screening tier achieves an AUROC of 0.958 for dementia detection (Stage 1), 0.865 for three-way cognitive impairment subtyping among non-dementia patients—normal cognition vs. MCI vs. functionally impaired MCI (Stage 2)—and 0.7 for dementia subtype classification using clinical data alone (Stage 3). When augmented with structural MRI in Tier 2, subtype discrimination improves markedly, with per-class AUROCs of 0.942 for frontotemporal dementia, 0.891 for Lewy body disease, 0.790 for Alzheimer's disease, and 0.676 for vascular dementia (mean AUROC 0.825). On an independent external validation cohort of 80 patients from Carle Foundation Hospital—not used in training—97.5% (78/80) of dementia cases were correctly identified, with a mean confidence score of 76.1% (range 46.6–95.5%; cutoff 50%). GradCAM++ and SHAP-based heatmaps correctly localized hippocampal and temporal lobe atrophy in AD and ventricular enlargement in vascular dementia, providing interpretable visual evidence for radiologist review. MRI interpretation completes in under 2 minutes on a standard GPU, enabling real-time decision support.

Economic Implications. This framework targets several economic dimensions of AD/ADRD care. First, embedding screening into routine AWVs converts an existing billing encounter into a diagnostic opportunity at population scale. Earlier identification can shift patients from costly late-stage inpatient pathways toward outpatient management; a health-economic model found that early intervention at the MCI stage yields a net benefit of up to £13,996 (~$21,400) per patient for disease-modifying treatments, and that each year of delayed diagnosis reduces the net economic benefit by 17% for symptomatic therapies [6]. Second, the tiered design optimizes resource allocation: the EHR tier screens broadly while the MRI tier is deployed selectively, reducing unnecessary imaging for low-risk patients and accelerating radiologist interpretation for flagged cases. Third, accurate subtype classification helps avoid wasteful spending on misdiagnosed patients. Finally, reducing the current 3.5-year diagnostic odyssey [3] decreases repeat specialist visits, redundant testing, and caregiver productivity losses—unpaid dementia caregiving alone is valued at $413 billion annually in the U.S. [1].

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