



Neuro Vasc Map: An Automated Multimodal MRI Platform For Quantifying And Mapping Neurovascular Damage

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Koushik Biswas, Fatima Mubarak, Ashish Singh, Saima Rathore

Emory University, Decatur, GA, USA; Neuro Radiology, Agha Khan University Hospital, Karachi, Pakistan; Biomedical Informatics, Emory University, GA, USA.

INTRODUCTIONS

- Alzheimer's disease (AD) is the leading cause of dementia [1].
- Neurovascular damage plays a critical and independent role in disease onset and progression [2].
- Disruption of cerebral blood vessels and BBB impairs cerebral blood flow, nutrient delivery, and clearance of neurotoxic proteins, accelerating amyloid accumulation, tau pathology, chronic inflammation, and hypoxia [3].
- These vascular abnormalities manifest as white matter hyperintensities (WMH), microbleeds, and infarcts, and are strongly associated with cognitive decline [4], gait impairment, and increased stroke risk.

METHODS

- Developed **NeuroVascMap** for automated delineation/quantification of neurovascular damage.
- It operates on BIDS-formatted data and is being developed using R- and Python-based scripts.
- Features:** Structural MRI preprocessing includes DICOM conversion, N4 bias correction, reorientation, and volumetric and cortical thickness estimation using widely adopted brain atlases, along with spatially normalized and smoothed tissue segments for voxel-based morphometry.
- FLAIR, SWI, and T2 images are registered to processed T1 images and segmented to detect imaging abnormalities, including WMH, microbleeds, and amyloid-related imaging abnormalities.
- Ground-truth manual segmentations used to train the algorithms were generated using semi-automated methods, including region growing, and iteratively refined with expert neuro-radiologist input.

RESULTS

- Evaluated on multimodal MRI datasets from ADNI and Emory cohorts.
- Achieved robust and scalable WMH segmentation.
- Benchmarked against manually refined expert annotations demonstrated recall of 0.74.
- Microbleeds detected by the framework were significantly associated with ADAS-Cog11.
- Quantified WMH burden was also strongly predictive of cognition ($P < 0.001$).

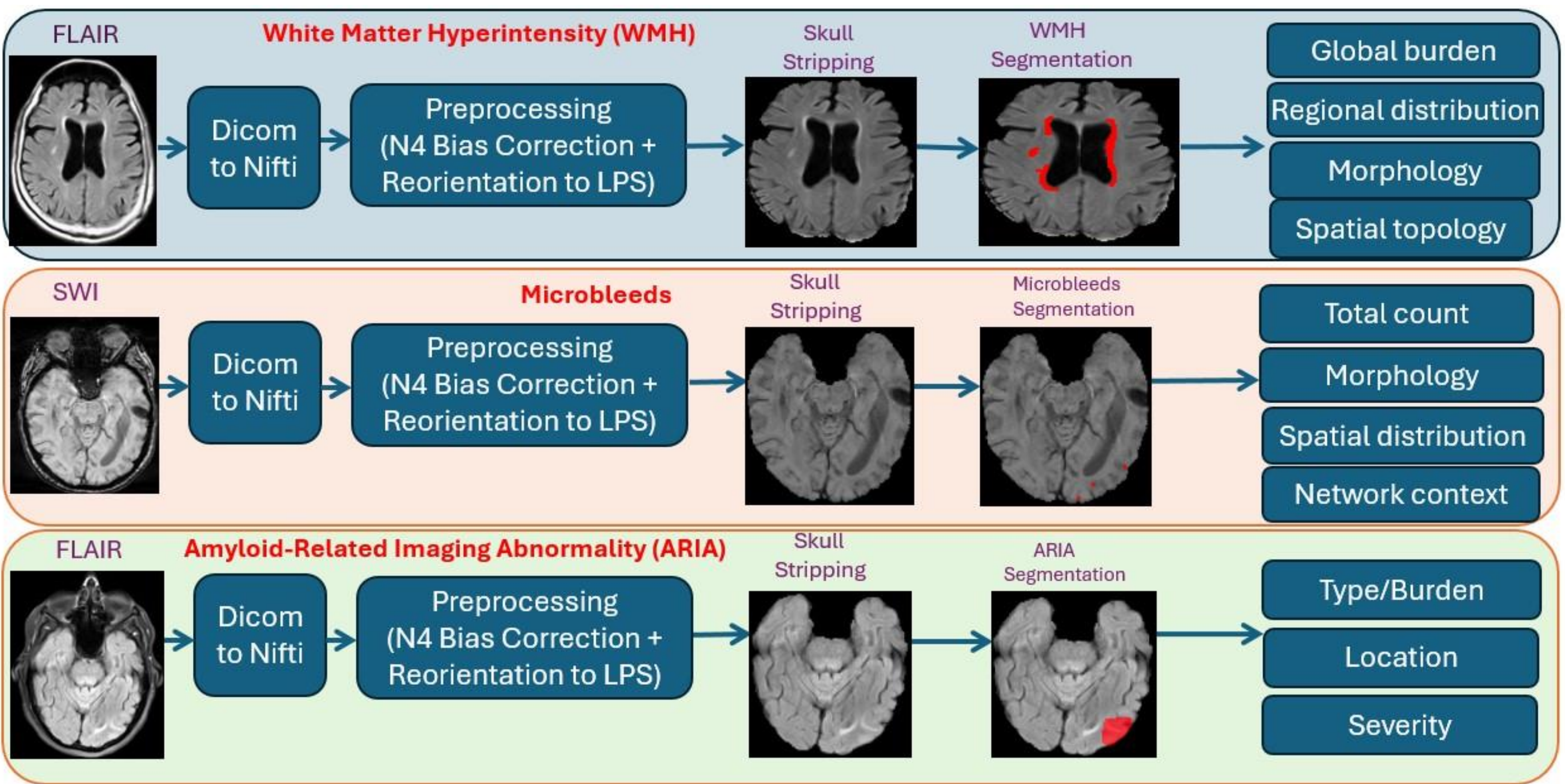


Figure 1: NeuroVascMap: Framework for preprocessing structural imaging modalities, including FLAIR, T1-w, T2-w, and SWI; segmentation of neurovascular abnormalities with examples of white matter hyperintensities (top row), microbleeds (middle row), and amyloid-related imaging abnormalities; and extraction of quantitative measures from the segmented lesions.

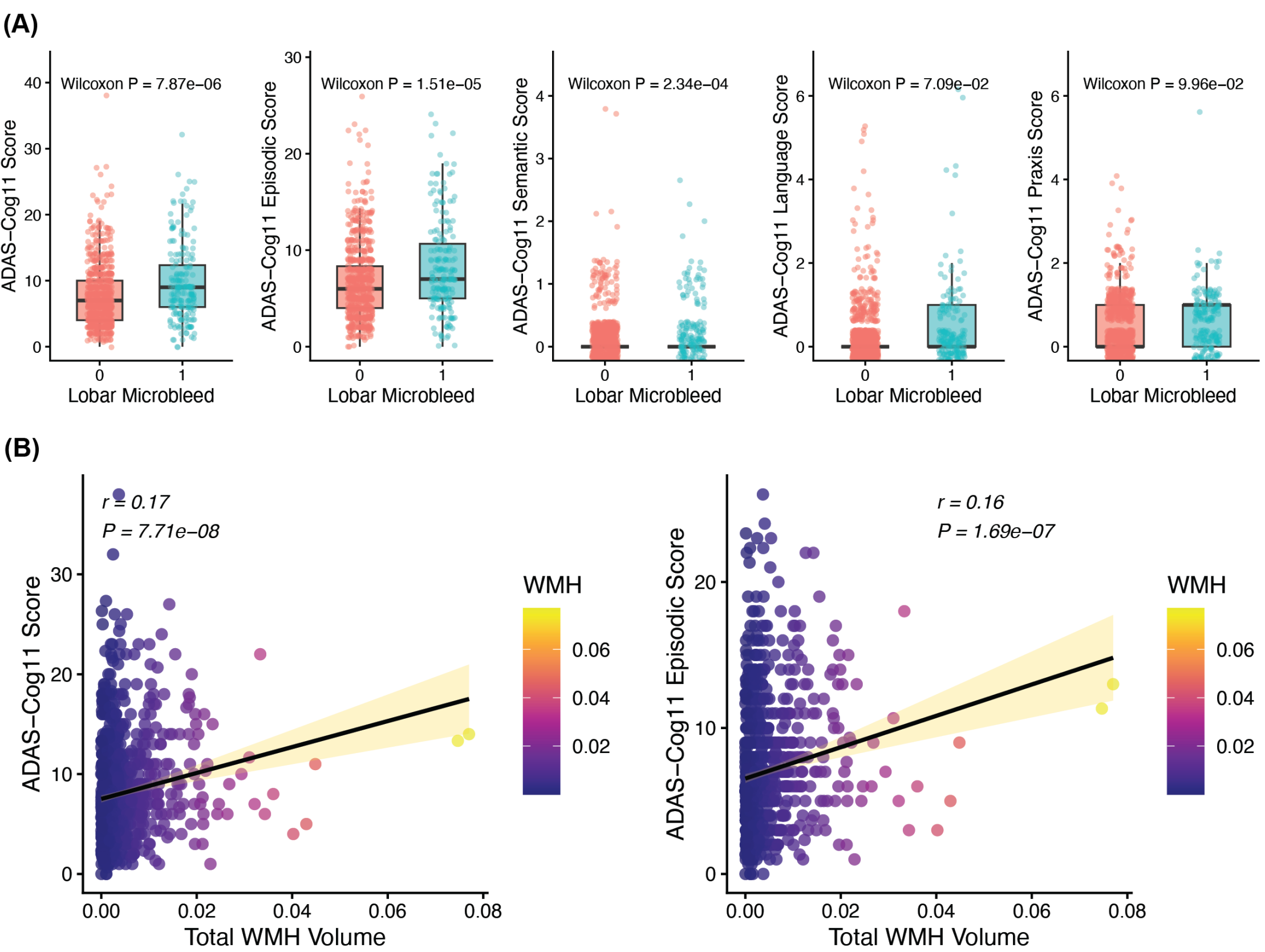


Figure 2: Association of neurovascular damage with global and domain-specific cognitive performance. **(A)** Boxplots show baseline ADAS-Cog11 and domain-specific cognitive scores stratified by lobar microbleed status, defined as present (≥ 1 lobar microbleed) versus absent (0 microbleeds) ($n=955$). Group differences were assessed using a two-sided Wilcoxon rank-sum test. **(B)** Scatter plots depict the relationship between total WMH volume and baseline global cognition (ADAS-Cog11) and episodic memory performance ($n=1,040$). Associations were evaluated using Pearson correlation with a fitted linear regression line and 95% CI.

Automated, scanner-robust mapping of neurovascular damage (WMH and microbleeds) tracks with cognitive impairment in AD, offering a scalable tool for vascular risk stratification.

CONCLUSION

- NeuroVascMap has the potential to become a clinically scalable, automated framework for detecting and characterizing neurovascular damage.
- Advance understanding of the vascular contribution to AD and provide a foundation for personalized risk stratification and therapeutic targeting across degenerative and cerebrovascular disorders.

Acknowledgements/Contacts

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Email: saima.rathore@email.emory.edu

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