

ABSTRACT

Background: Rural zip code residents are underrepresented in cognitive aging research, limiting the generalizability of biomarkers and risk models. These communities also face disproportionate disease burden and mortality, higher prevalence of vascular and other modifiable risk factors, and structural barriers that can delay diagnosis and reduce access to high-quality specialty care. We developed the MindCrowd mobile laboratory (MC-mLab) to deliver multimodal cognitive aging research directly to communities across Arizona, with intentional outreach to rural zip codes.

Methods: The MC-mLab is a truck and customized trailer with dedicated wet laboratory space and a neuroimaging suite, supporting an approximate 90-minute study visit. Recruitment is targeted to prioritize rural communities and other understudied groups alongside urban participants. Cognitive phenotyping includes MindCrowd-based measures of processing speed and verbal associative memory, enabling benchmarking against our large online normative cohort of ~900K participants. Frailty and cardiometabolic measures include bilateral grip strength, blood pressure, and biometric-based body composition. Olfaction is assessed using a 16-item forced-choice odor identification panel (Sniffin' Sticks). Brain MRI is acquired using ultra-low-field (64 mT) Hyperfine Swoop imaging (T1, T2, FLAIR; 1.5 mm isotropic). Retinal fundus images are collected using the Optomed Aurora IQ. Capillary blood is collected and processed on-site for genome-wide SNP genotyping (Illumina GSA), methylation profiling (Illumina MSA), and plasma biomarkers (Alamar NULISA CNS 120, including Aβ fragments, phospho-tau, NFL, and GFAP). Participants are invited for annual follow-up.

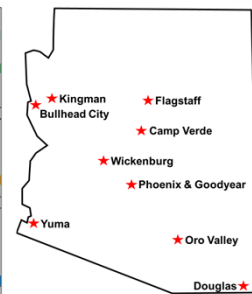
Results: As of June 2026, the MC-mLab has completed 1,831 baseline visits, 276 one-year follow-up visits, and 114 two-year follow-up visits. Recruitment demonstrates strong reach into understudied populations, including substantial participation from rural zip codes (35%) and representation of Hispanic ethnicity (19%), lower educational attainment (15% high school diploma or less), and lower socioeconomic status (22% household income ≤\$35K).

Conclusion: The MC-mLab provides a scalable, field-deployable platform for longitudinal, multimodal brain health research that reduces barriers for rural community participation. Integrating portable MRI-derived neuroanatomy and white matter disease, retinal imaging, cognitive and frailty phenotypes, and genetics and plasma biomarkers supports discovery of aging trajectories and risk and resilience signatures that better reflect the diversity of Arizona and similar regions.

THE MOBILE LAB

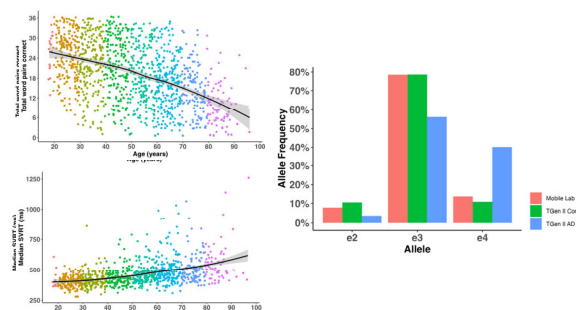


Demographic	Value	Proportion
Age Decade	18-19	1.5%
	20-29	16.5%
	30-39	16.7%
	40-49	16.6%
	50-59	15.7%
	60-69	17.2%
	70-79	9.8%
	80-89	5.9%
	90+	0.9%
Sex	Male	32.4%
Highest Education Level Attained	Up to 8 Years	0.1%
	Completed 8th Grade	0.2%
	Some High School	2.7%
	High School Diploma	37.5%
	Some College	26.9%
	College Degree	34.2%
Ethnicity	Post Graduate Degree	24.6%
	Hispanic or Latino	18.8%
	American Indian or Alaska Native	2.1%
Race	Asian	4.5%
	Black or African American	1.5%
	I prefer not to answer	2.8%
	Multiracial or Mixed Race	6.7%
	Native Hawaiian or Other Pacific Islander	0.4%
	White	82.7%
Rural Resident	TRUE	34.6%



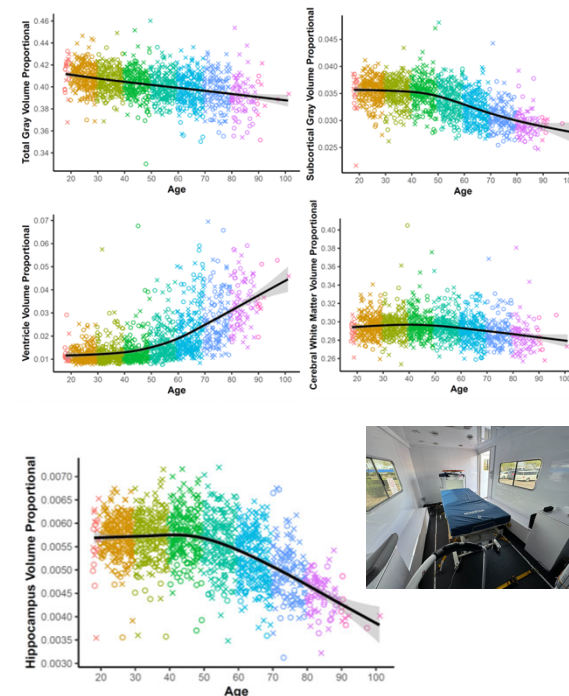
The mobile lab (mLab) trailer, the Optomed Aurora retinal imaging device, and the Hyperfine Swoop ultra-low-field MRI instrument. The table illustrates the current demographic profile of the mLab cohort. The map of Arizona indicates the cities that are current mLab visit sites.

COGNITIVE TEST RESULTS



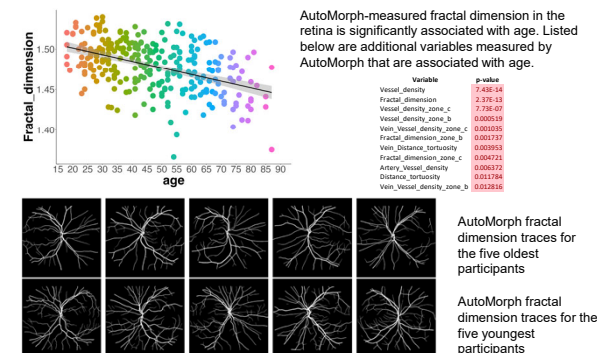
Shown above are the cognitive test results for the mLab cohort – verbal memory (paired-associate learning) and processing speed (simple visual reaction time). On the right side is shown the APOE allele frequencies for the mLab cohort in red and a reference cohort of cognitively characterized and neuropathologically verified Alzheimer's disease cases (blue) and controls (green).

ULF-MRI RESULTS

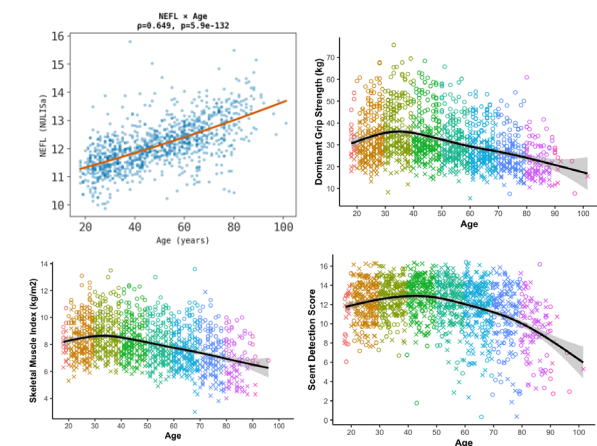


The Swoop volumetric results for ventricles, cortical gray matter, cerebral white matter, and total gray matter are shown above for the mLab cohort. The volumetric results for hippocampus are shown below. The picture shows the Swoop inside of the neuroimaging room in the mLab trailer.

RETINAL CHANGES ASSOCIATED WITH AGE



OTHER PHENOTYPING RESULTS



The plots show other phenotyping results associated with age; NULISA measured NFL, dominant hand grip strength, skeletal muscle mass, and Sniffin' Sticks scent identification.

CONCLUSIONS

- The mobile laboratory approach is feasible and can successfully recruit participants from rural zip codes and across a wide range of demographics. We average 65 visits per month.
- The cognitive results in the mLab cohort mirror what we observe in the much larger MindCrowd cohort.
- APOE frequency in the mLab cohort is distributed similar to what is expected from a random population-based sample.
- The ultra low field MRI results replicate the known trends for global brain measures as well as for hippocampal volumes.
- Retinal imaging, grip strength, skeletal muscle mass, scent detection, and NULISA all demonstrated age-associated findings.