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We validated a completely free, cloud-based brain imaging pipeline for dementia research. It worked on every single participant, produced reliable and biologically meaningful results, and required nothing more than an internet browser, making it accessible to researchers across Africa and other resource-limited settings who have traditionally been excluded from global neuroimaging science.

INTRODUCTION

Resting-state fMRI (rs-fMRI) is a powerful neuroimaging technique that characterises spontaneous brain network activity without requiring a task. In Alzheimer's disease (AD) research, rs-fMRI metrics provide complementary insights into disrupted neural dynamics. Neuroimaging in Low- and Middle-Income Countries (LMICs) faces critical barriers, including limited high-performance computing (HPC) infrastructure, restricted neuroimaging expertise, and heterogeneous preprocessing methods that compromise reproducibility^{2,3}. Africa, with 1.4 billion people and a growing dementia burden, contributes minimally to global neuroimaging research, due to infrastructure limitations rather than lack of expertise⁴. Cloud-based platforms offer solutions but require rigorous validation. This study evaluates the reproducibility of a pipeline developed within the CONNExIN 2025 Programme⁵, which provides neuroimaging analysis training to researchers in LMICs. **OBJECTIVE:** Validate a reproducible, cloud-based rs-fMRI pipeline for LMIC contexts, deployed within the CONNExIN training programme using freely available cloud compute.

METHODS

Dataset

PREVENT-AD⁶ (openpreventad.loris.ca)

n

5 cognitively normal individuals

Age

55–82 years, family history of sporadic AD

Scanner

3T Siemens, TR/TE 2000/30 ms, 3 mm isotropic, 200 volumes

Analysts

2 independent CONNExIN trainees

Cloud Platform

- Neurodesk (containerized) via Google Colab
- 32 GB RAM · Intel Xeon 3.10 GHz
- Standard internet connection only, no HPC or local install required
- Containerised environment ensures identical tool versions across all sites
- Freely accessible to any researcher globally

Quality Control

- Motion parameters (framewise displacement threshold)
- Temporal signal-to-noise ratio (tSNR)
- Anatomical alignment to MNI space (visual verification)

rs-fMRI Metrics Computed

ALFF

Amplitude of Low-Frequency Fluctuations
Power spectrum analysis, 0.01–0.1 Hz band

fALFF

Fractional ALFF
Low-frequency power ÷ total power; improves neural specificity

ReHo

Regional Homogeneity
Kendall's W coefficient across 27-voxel neighbourhood

PREPROCESSING PIPELINE

1

Slice Timing Correction
Corrects for sequential slice acquisition timing offsets across the brain volume

2

Motion Correction
Middle volume as reference; 6-parameter rigid-body realignment to correct head motion

3

Spatial Smoothing
FWHM Gaussian kernel applied to improve signal-to-noise ratio (SNR)

4

Skull Stripping
Brain extraction to remove non-brain tissue before registration

5

Spatial Normalisation
MNI152 2 mm template using ANTs registration for inter-subject comparability

6

Bandpass Filtering
0.01–0.1 Hz bandpass preserves low-frequency BOLD fluctuations of neural origin

7

Nuisance Regression
Motion parameters + white matter + CSF signal removal to reduce physiological noise

RESULTS

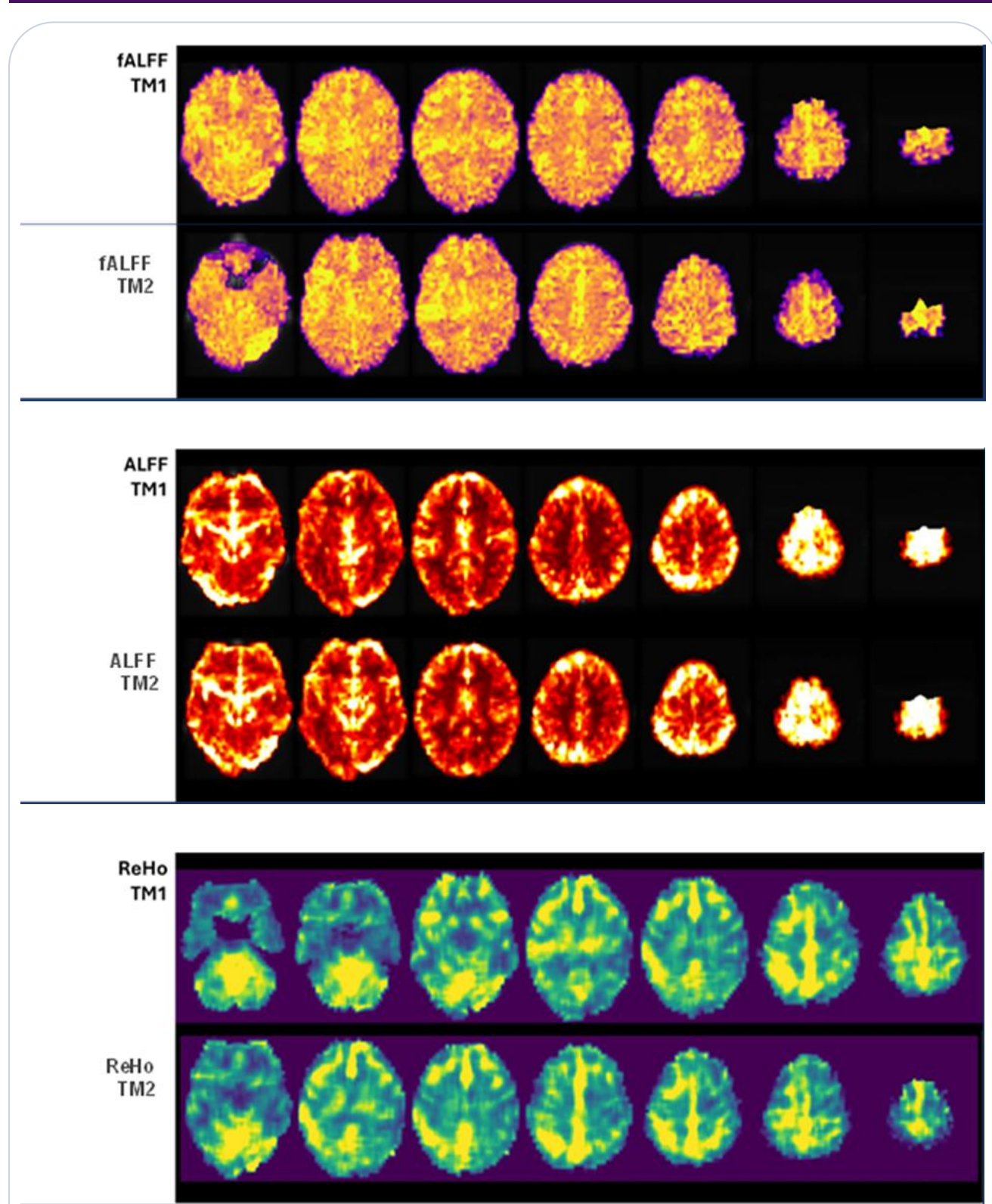


Figure 1 rs-fMRI Metrics (ALFF, fALFF, ReHo): Orthogonal view of group-level rs-fMRI analysis. Top: ALFF (low-frequency BOLD fluctuations, 0.01–0.1 Hz). Middle: fALFF (ALFF normalised by total signal power). Bottom: ReHo (local temporal synchrony, Kendall's W, 27-voxel neighbourhood). All metrics normalised (ALFF/fALFF by whole-brain mean; ReHo by Z-score). Higher intensity (yellow–white) indicates stronger signal.

Table 1: Reproducibility metrics computed on the MNI-normalised maps

Map	Spatial r	ICC(2,1)	Dice (top 10%)	Dice (top 5%)	Dice (top 1%)
ALFF	0.439 ± 0.351	0.436 ± 0.351	0.384 ± 0.243	0.314 ± 0.236	0.190 ± 0.172
fALFF	0.459 ± 0.348	0.453 ± 0.346	0.303 ± 0.186	0.237 ± 0.173	0.145 ± 0.128
ReHo	0.673 ± 0.272	0.673 ± 0.272	0.468 ± 0.249	0.407 ± 0.269	0.328 ± 0.290

Note: Spatial r: Excellent(≥ 0.95), Acceptable(0.90 - 0.95), Investigate(< 0.90); ICC(2, 1): Excellent(≥ 0.75), Acceptable(0.50 - 0.75), Investigate(< 0.50); Dice (top 5%): Excellent(≥ 0.80), Acceptable(0.70 - 0.80), Investigate(< 0.70)

CONCLUSIONS

This study demonstrates that a cloud-based rs-fMRI pipeline running on freely available infrastructure (Neurodesk + Google Colab). This study demonstrates that the CONNExIN rs-fMRI pipeline is capable of reproducibility when ANTs normalisation converges consistently. However, reproducibility is currently inconsistent across subjects, with three of five subjects showing poor agreement attributable to differences in MNI-space normalisation.

Remediation should focus exclusively on standardising the ANTs registration inputs and verifying normalisation quality per-subject before group-level analysis. Group-level maps faithfully reproduce established functional brain architecture, validating neurobiological fidelity. By democratising validated, accessible neuroimaging tools, this pipeline enables African researchers to investigate population-specific dementia mechanisms, validate biomarkers, and build sustainable research capacity, contributing to the global neuroimaging knowledge base from under-represented populations.

FUTURE DIRECTIONS

- ❖ African dementia cohorts - validate with diverse scanner types, protocols, and populations across Sub-Saharan Africa
- ❖ Inter-user reproducibility - formal assessment with multiple independent analysts processing identical subjects
- ❖ Biomarker validation - apply pipeline to investigate AD-specific mechanisms and validate diagnostics in diverse populations
- ❖ Capacity building - embed pipeline into CONNExIN training to build long-term local neuroimaging expertise

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