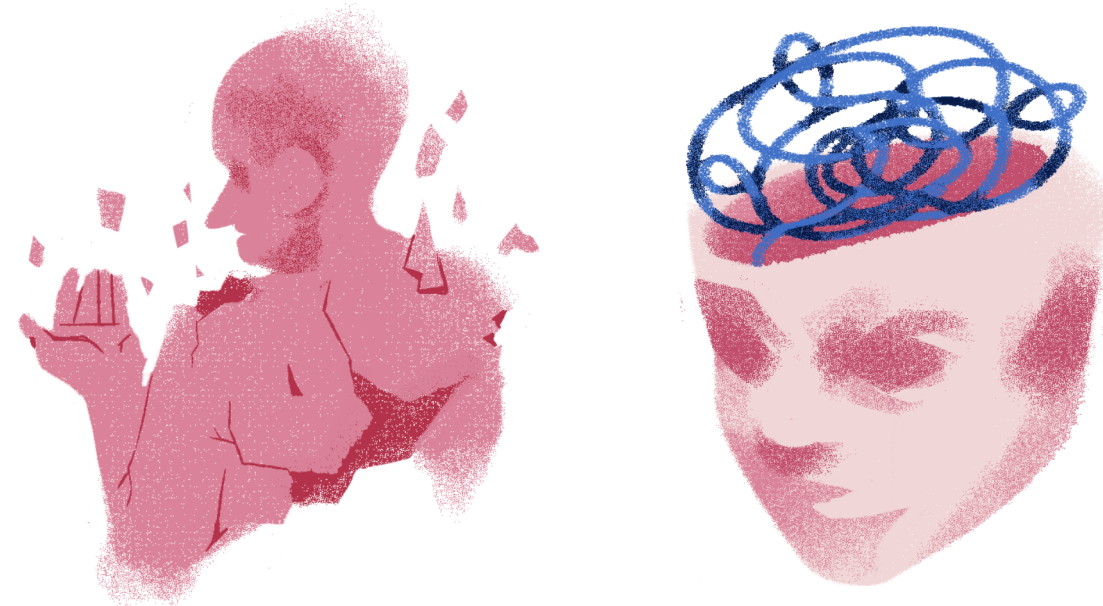# Qu-Alz: Quantum-Enhanced Early Prediction of Alzheimer's in Southeast Asia

Full name of the speaker

Sayed Tahlil Hossain
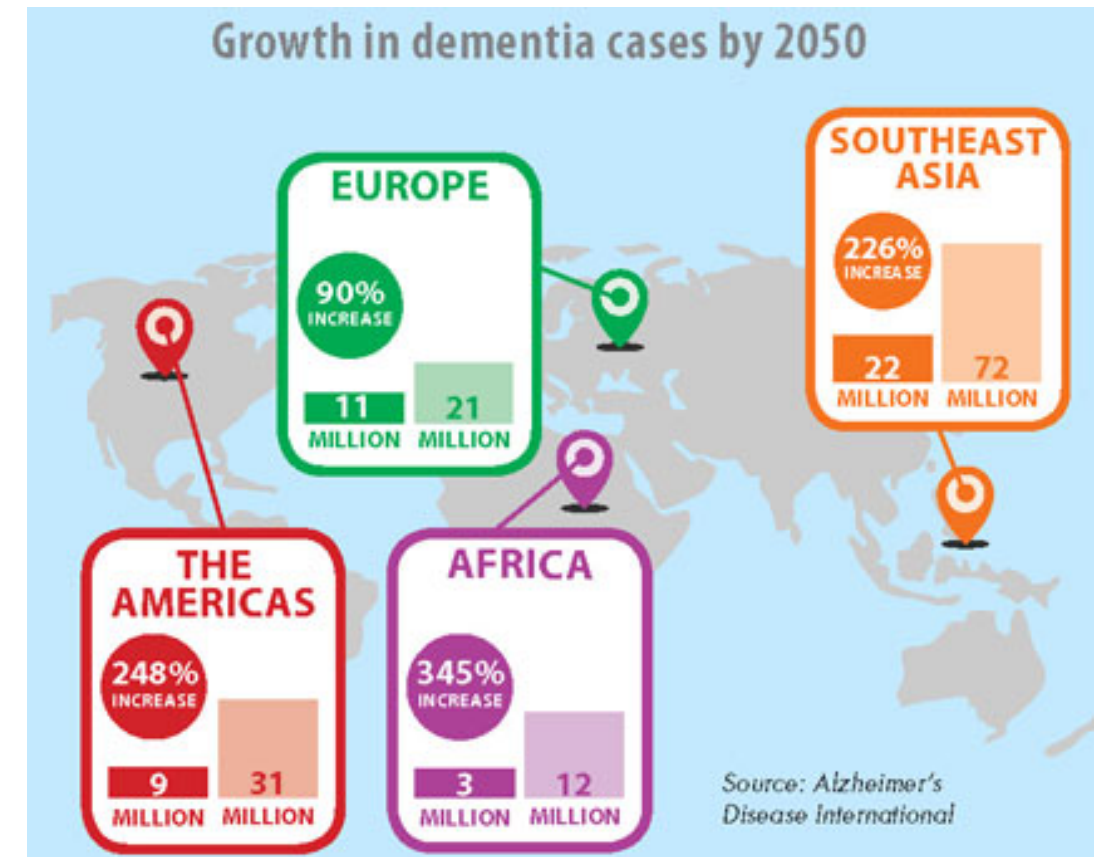
Universiti Teknologi Malaysia, UTM

The Qure team: Muchammad Dimas Sakti Widyatmaja, Roi Victor Roberto, Mutawally Nawwar, Sayed Tahlil Hossain

IDENTIFYING THE PROBLEM

- Alzheimer's disease accounts for **60–80%** of global dementia cases.
- In Southeast Asia, prevalence rose from **29,000 (1990) → 95,000 (2021).**

- Diagnosis often occurs **too late**, when irreversible neurodegeneration has already set in.

- Current diagnostics rely heavily on symptoms and volumetric MRI, detecting disease only after irreversible brain damage.

- Even with advances like **CNNs, ResNets, and Vision Transformers**, challenges remain:
  - Limited and imbalanced datasets
  - High computational costs
  - Low clinical interpretability and generalizability in low-resource settings

Growth in dementia cases by 2050

EUROPE 90% INCREASE 11 MILLION 21 MILLION

SOUTHEAST ASIA 226% INCREASE 22 MILLION 72 MILLION

THE AMERICAS 248% INCREASE 9 MILLION 31 MILLION

AFRICA 345% INCREASE 3 MILLION 12 MILLION

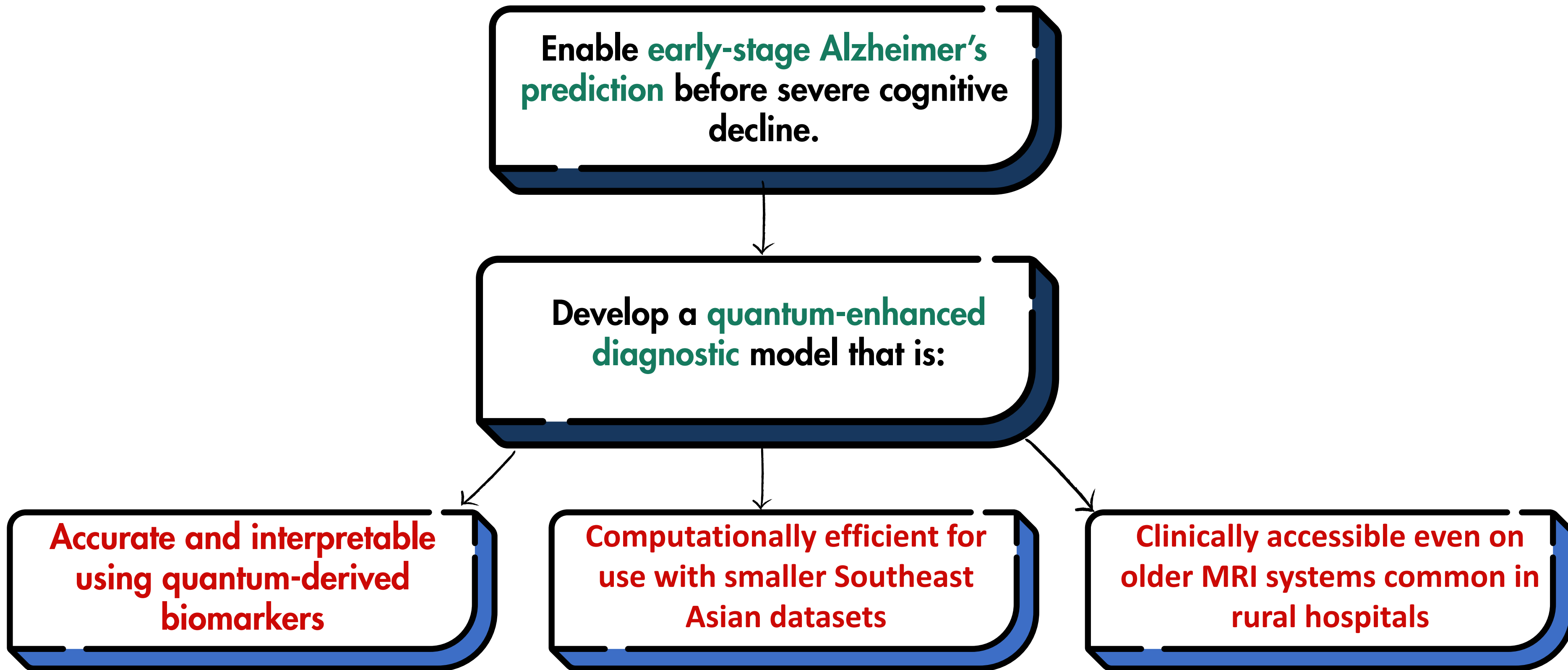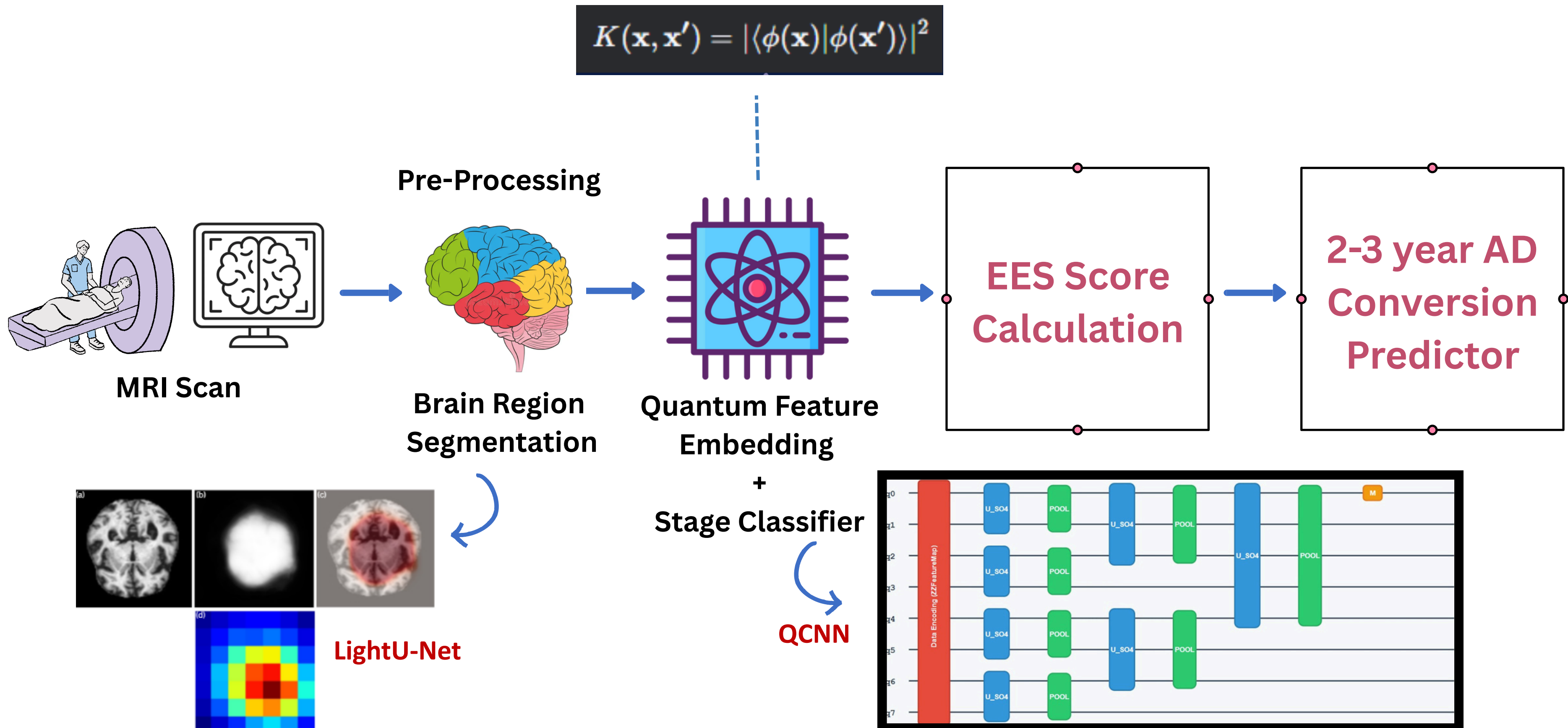Source: Alzheimer's Disease International

ALL SECTIONS   SEARCH   THE DIPLOMAT
READ THE DIPLOMAT, KNOW THE ASIA-PACIFIC

ASEAN BEAT

Is Southeast Asia Ready for a Future Dementia Epidemic?

Governments need clear plans to tackle an expected surge in dementia cases as the region ages.

Enable **early-stage Alzheimer's prediction** before severe cognitive decline.

Develop a **quantum-enhanced diagnostic** model that is:

Accurate and interpretable using quantum-derived biomarkers

Computationally efficient for use with smaller Southeast Asian datasets

Clinically accessible even on older MRI systems common in rural hospitals

$$K(\mathbf{x}, \mathbf{x'}) = |\langle \phi(\mathbf{x})|\phi(\mathbf{x'})\rangle|^2$$

Pre-Processing

MRI Scan

Brain Region Segmentation

LightU-Net

Quantum Feature Embedding + Stage Classifier

QCNN

EES Score Calculation

2-3 year AD Conversion Predictor

EES (**Entanglement Entropy Score**) is a quantum-inspired metric derived from MRI slices. It quantifies how disordered or entangled a brain region appears [1][2].

$$EES = -\text{Tr}(\rho_A \log_2 \rho_A)$$

As Alzheimer's progresses, **the brain's spatial structure becomes noisier and more disorganized**, especially in critical regions like the **hippocampus.**

This increases **entanglement in the quantum state → higher EES**. Thus, EES could serve as a **stage-sensitive biomarker.**

```python
def compute_ees(self, mri_features: np.ndarray) -> Tuple[float, dict]:
    # Step 1: Encode features in quantum circuit
    circuit = self.create_feature_map(mri_features)

    # Step 2: Compute reduced density matrix (5:5 partition)
    rho_reduced = self.compute_reduced_density_matrix(circuit)

    # Step 3: Calculate von-Neumann entropy - this is the EES!
    ees_score = self.von_neumann_entropy(rho_reduced)
```

```python
def von_neumann_entropy(self, rho: np.ndarray) -> float:
    # S = -Tr(ρ log₂ ρ) = -Σ λᵢ log₂(λᵢ)
    eigenvals = np.linalg.eigvals(rho)
    eigenvals = eigenvals[eigenvals > 1e-12]  # Remove ~0 eigenvalues
    entropy = -np.sum(eigenvals * np.log2(eigenvals + 1e-12))
    return float(entropy)
```
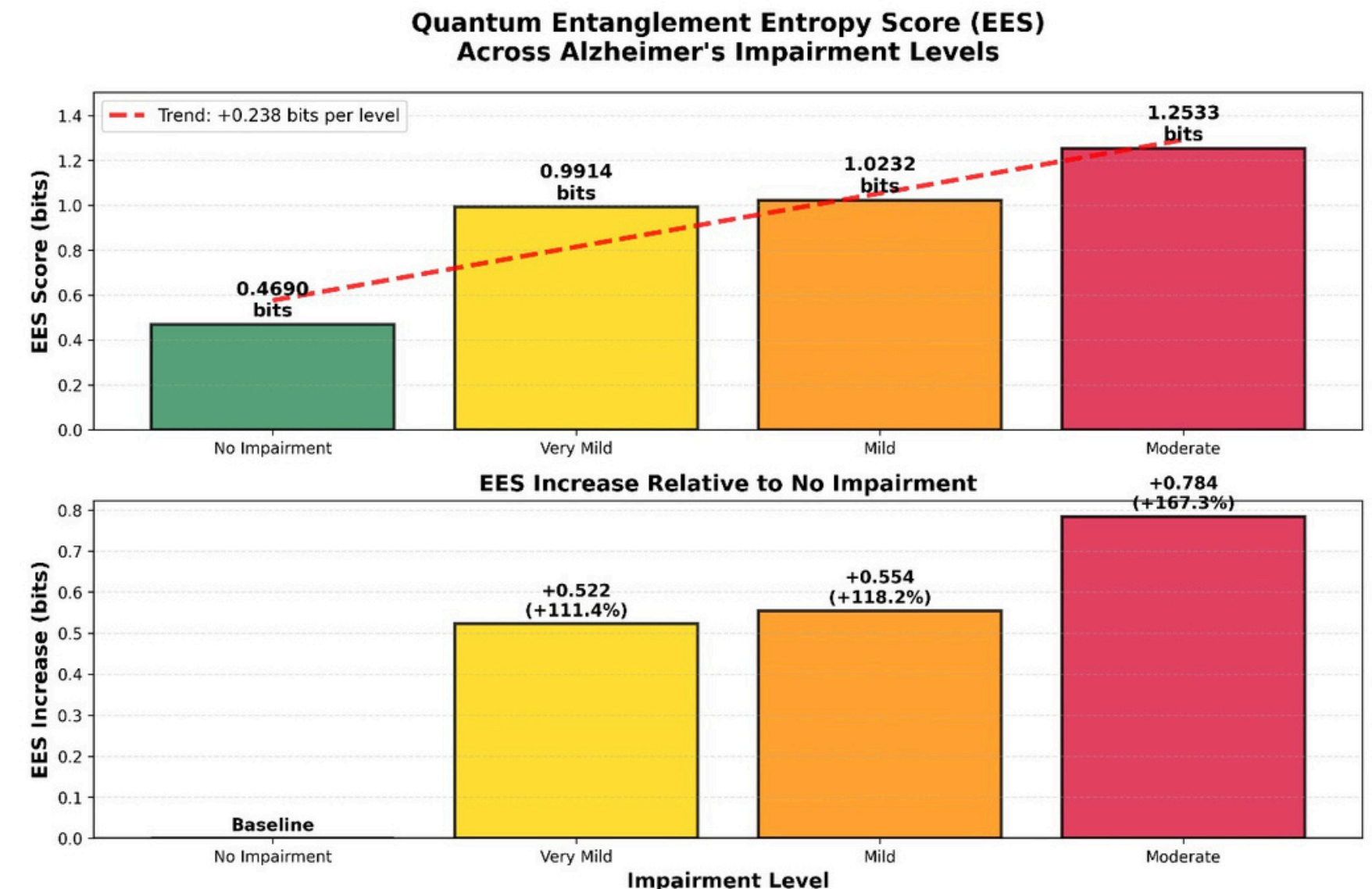

Quantum Entanglement Entropy Score (EES) Across Alzheimer's Impairment Levels

1] Babu, A., Ghatnekar, Saurabh G, Saxena, A., & Mandal, D. (2024). Can Entanglement-enhanced Quantum Kernels Improve Data Classification? ArXiv (Cornell University). https://doi.org/10.48550/arxiv.2406.0194
[2] Belanche-Muñoz, L. A., & Wiejacha, M. (2023). Analysis of Kernel Matrices via the von Neumann Entropy and Its Relation to RVM Performances. Entropy, 25(1), 154. https://doi.org/10.3390/e25010154

```python
def predict_alzheimer_risk(image_path, category):
    # 1. Extract MRI features (64-D)
    mri_features = extractor.extract_features(image_path)

    # 2. Compute quantum EES score
    ees_score = quantum_ees.von_neumann_entropy(
        quantum_ees.compute_reduced_density_matrix(
            quantum_ees.create_feature_map(mri_features)
        )
    )

    # 3. Neural network: [MRI + EES + Category] → Risk probability
    risk_prob = model(mri_features, ees_score, category).item()

    return risk_prob  # [0, 1]
```

```
🧠 ALZHEIMER'S RISK ASSESSMENT REPORT
==================================================

🔢 RISK PREDICTION:
   Primary Assessment: 78.6% chance of Alzheimer's within 36 months
   Uncertainty Band: ±0.2%
   Risk Range: 78.4% – 78.8%

⚛ QUANTUM BIOMARKER:
   EES Score: 0.926294 bits
   Category: Moderate Impairment

📈 INTERPRETATION:
   🔴 VERY HIGH RISK – Urgent clinical assessment advised
```

Phase 1 (Clinical Validation) (1-2 YEARS)
Collaborate with neuroscience labs using datasets in South East Asia

Phase 2 (3-4 YEARS)
Integrate via cloud with SEA hospitals/clinics.

Phase 3 (Global Collaboration) (5-6+ Years)
Scale to LMICs and global partners.

3 GOOD HEALTH AND WELL-BEING

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Developing Qu-Alz requires collaboration between quantum research, clinics, and governments.

By enabling affordable, accessible, and early-stage Alzheimer's prediction, we bridge the diagnostic gap between high- and low-resource settings in SE Asia
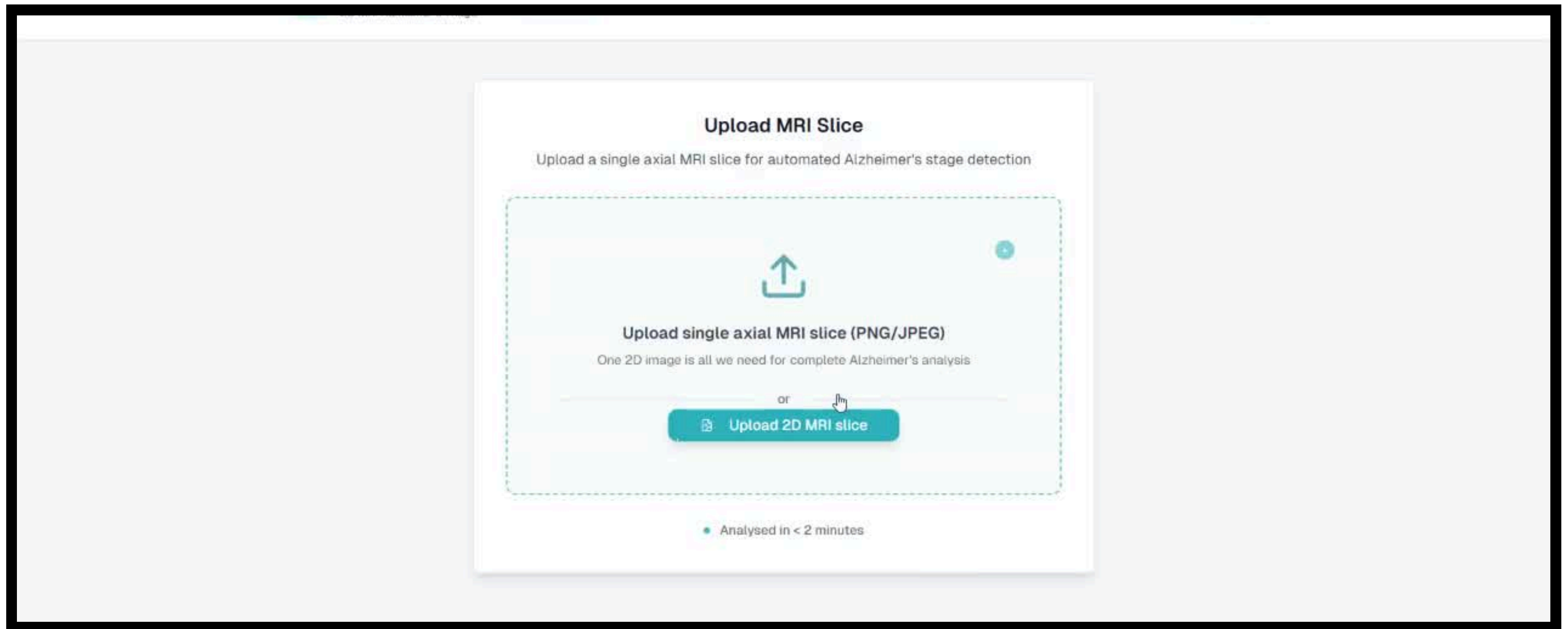
Targets early detection and reduces burden of Alzheimers

17 PARTNERSHIPS FOR THE GOALS

Qu-Alz enables cutting-edge medical technology, driving innovation in healthcare infrastructure.

10 REDUCED INEQUALITIES

Developed Qu-Alz prototype with EES metric and hybrid LightU-Net + QCNN architecture.

Create a regional Alzheimer's MRI dataset and designed a cloud-based platform for hospital integration.

Establish multinational research team and training programs in quantum AI for healthcare.

Produce publications on entanglement-based entropy in biomedical feature extraction.

Agency for Science, Technology and Research
SINGAPORE

Parkinson's disease (PD)

Huntington's disease (HD)

CONCLUSION

🎯Targets
Early, accurate, and accessible Alzheimer's detection in Southeast Asia using quantum-enhanced MRI analysis.

⚙Method
Integrates classical and quantum models using EES as a novel biomarker for Alzheimer's stages.

🔬Scientific & Societal Impact
Introduce quantum diagnostic tool for small datasets and standard MRI, promoting regional health equity.

🌏Future Outlook
Validate clinically, expand the framework to other neurodegenerative diseases and scale through ASEAN collaborative networks.

REFERENCES

- Abebech Jenber Belay, Yelkal Mulualem Walle, & Melaku Bitew Haile. (2024). Deep Ensemble learning and quantum machine learning approach for Alzheimer's disease detection. Scientific Reports, 14(1). https://doi.org/10.1038/s41598-024-61452-1

- Babu, A., Ghatnekar, Saurabh G, Saxena, A., & Mandal, D. (2024). Can Entanglement-enhanced Quantum Kernels Improve Data Classification? ArXiv (Cornell University). https://doi.org/10.48550/arxiv.2406.01948

- Belanche-Muñoz, L. A., & Wiejacha, M. (2023). Analysis of Kernel Matrices via the von Neumann Entropy and Its Relation to RVM Performances. Entropy, 25(1), 154. https://doi.org/10.3390/e25010154

- Bomasang-Layno, E., & Bronsther, R. (2021). Diagnosis and treatment of Alzheimer's disease. Delaware Journal of Public Health, 7(4), 74–85. https://doi.org/10.32481/djph.2021.09.009

- Dementia cases set to triple by 2050 but still largely ignored. (2012, April 11). Www.who.int. https://www.who.int/news/item/11-04-2012-dementia-cases-set-to-triple-by-2050-but-still-largely-ignored

- Gopalakrishna, G., Joshi, P., Tsai, P.-H., & Patel, N. (2023). Advances in Alzheimer's Dementia: An update from Banner Alzheimer's Institute. The American Journal of Geriatric Psychiatry, 31(3, Supplement), S18–S19. https://doi.org/10.1016/j.jagp.2022.12.300

- Marcus, D. S., Fotenos, A. F., Csernansky, J. G., Morris, J. C., & Buckner, R. L. (2010). Open Access Series of Imaging Studies (OASIS): Longitudinal MRI Data in Nondemented and Demented Older Adults. Journal of Cognitive Neuroscience, 22(12), 2677–2684. https://doi.org/10.1162/jocn.2009.21407

- Modupe Odusami, Robertas Damaševičius, Egle Milieškaitė-Belousovienė, & Rytis Maskeliūnas. (2024). Alzheimer's disease stage recognition from MRI and PET imaging data using Pareto-optimal quantum dynamic optimization. Heliyon, 10(15), e34402–e34402. https://doi.org/10.1016/j.heliyon.2024.e34402