

Detecting MCI and Dementia through Passive Sensing of Lifestyle Behavior with Machine Learning Analysis : A Scoping Review

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Background – Why is it important?

Early detection and management of Mild Cognitive Impairment (MCI) and dementia is a global priority due to the lack of curative treatments. **Passive sensing**—utilizing wearables, smart-home sensors, and in-vehicle systems—offers an unobtrusive way to quantify subtle functional and behavioral changes in natural environments. By leveraging **machine learning** to analyze these complex datasets, we can identify objective **digital biomarkers**, providing a scalable and cost-effective approach for early prevention and intervention.

Methodology – What did we analyse?

Literature Search

PRISMA-ScR
guidelines:
6 databases

Study Selection

31 Studies
(2015–2025)

Sensing Modalities

Wearables
Carry-on devices
Smart-home
systems
In-vehicle monitoring

Behaviour Domains

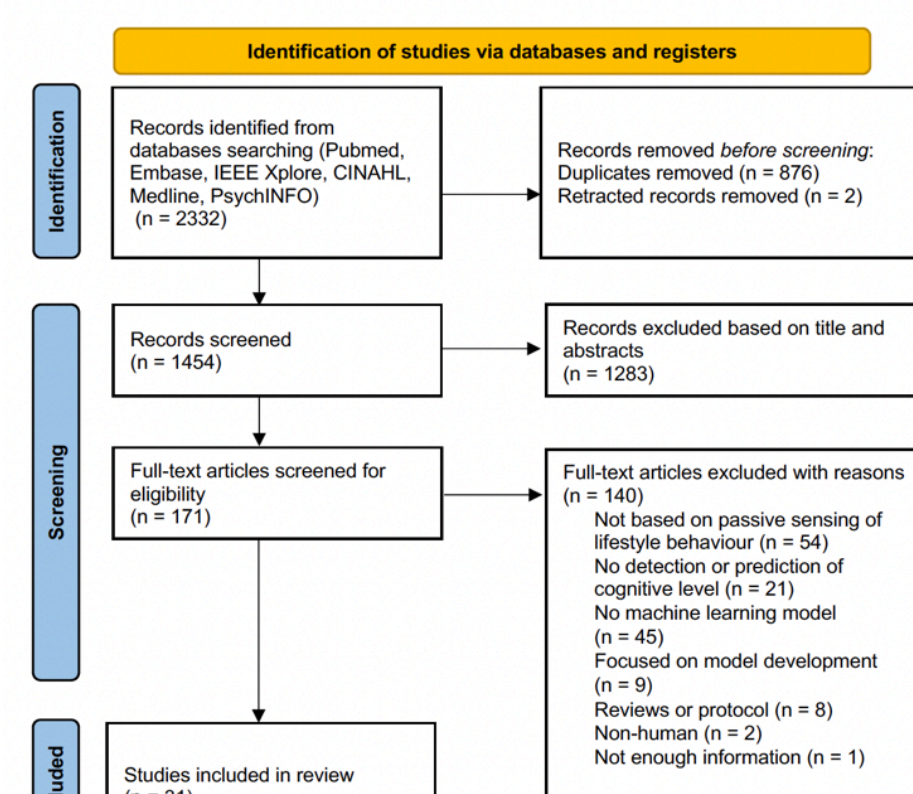
Mobility Patterns
Activity levels
Sleep
Outdoor mobility
Driving
Routine consistency
Social behaviour
Language
Physiological signals

Analysis

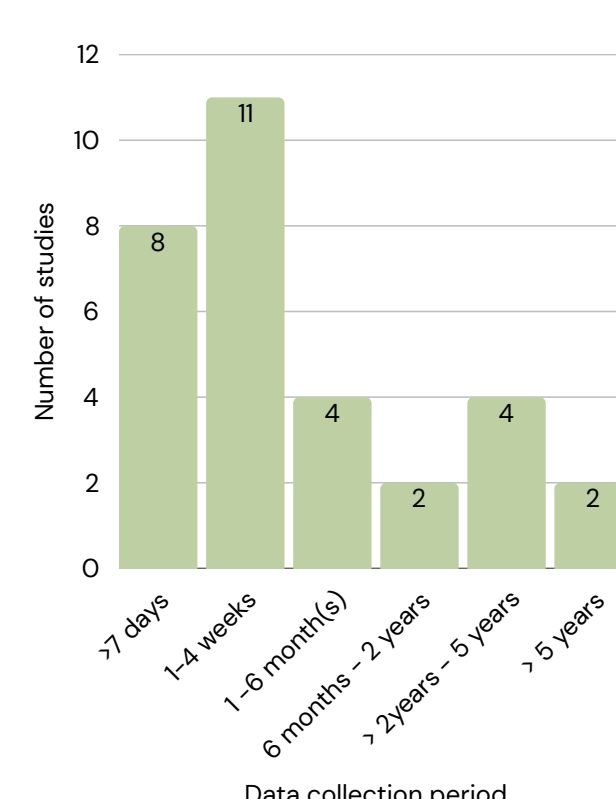
Study design
Sample size
Data collection
Screening methods
Key features
ML models
Validation methods
Performance metrics

General Results

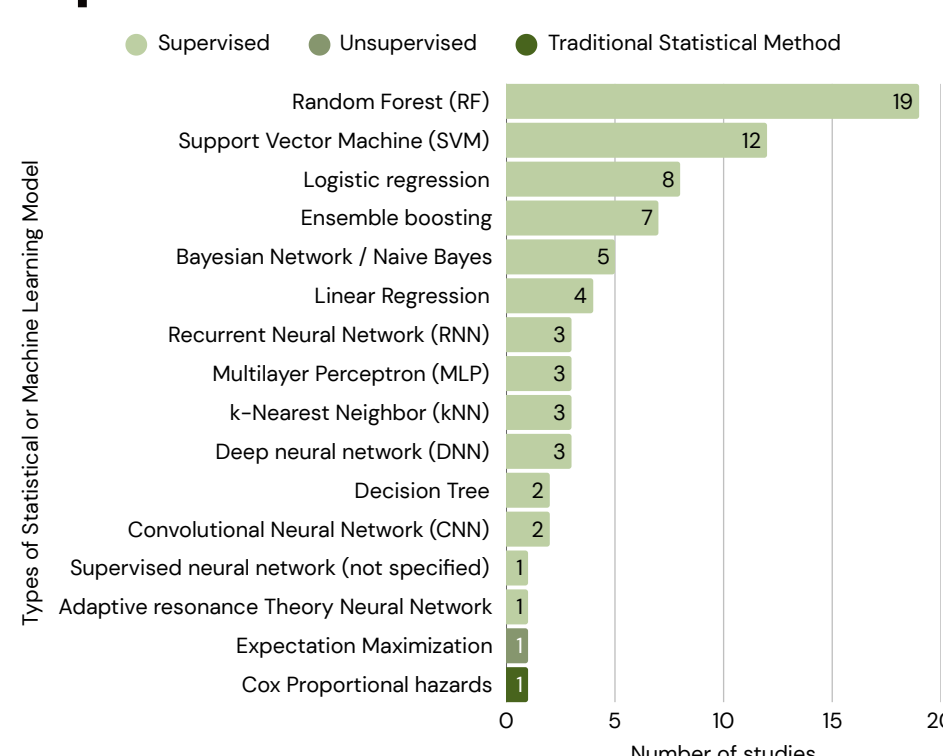
PRISMA Flowchart



Data Collection Period can be within 4 weeks

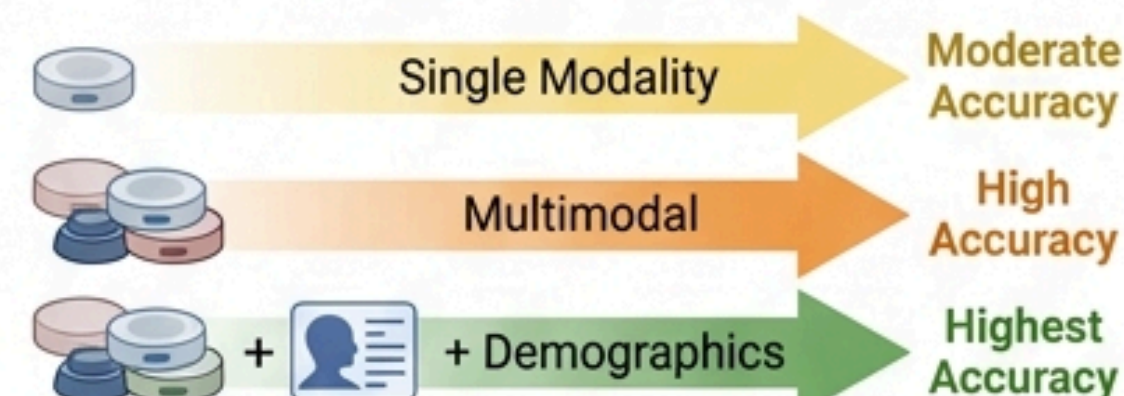


Supervised models predominates



No single type of machine learning model outperformed

Multi-modality increases accuracy



AUC significantly improves when adding age (e.g. 0.86 to 0.94)

Key Results – What we found interesting

Passive sensing modalities

Wearables Carry-on devices

- Accelerometer
- PPG, EDA
- Voice recorder
- GPS

Smart Home System

- Motions sensors
- Smart plugs, doors, mats

In-vehicle sensors

- GPS
- Telematics
- Reaction
- Ventilation

Key Predictive Features

Physiological signs

- Altered heart rate variability (HRV)
- Respiratory coupling
- Skin conductance

AUC: 0.62 – 1.0

Behaviour Feature

- Reduced walking speed
- Path complexity
- Activity variability

AUC: 0.72 – 0.99

Sleep

- Fragmented sleep
- Nighttime activity pattern
- Disrupted circadian
- Sleep time

AUC 0.88 – 1.0

Driving

- Restricted patterns
- Reduced nighttime trips
- Less aggressive velocity

AUC: 0.82 – 0.96

Conclusion

KEY PREDICTIVE FACTORS:

The **changes in patterns and variability** of mobility, sleep, and driving behaviors collected by passive sensing

performs best in detecting dementia

Future Directions

Early Detection Concept loop

