

Next-day Prediction Of Agitation In Dementia Using Passive In-home Sensors: Analysis Of The TIHM For Dementia Dataset

P1-10

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KEY FINDING: Passive PIR sensors predicted next-day agitation (AUROC 0.848, PRAUC 6.1× chance).
No wearables. No active patient participation.

INTRODUCTION

Background & Clinical Burden
Agitation is among the most clinically significant behavioral and psychological symptoms of dementia (BPSD). It is associated with patient distress, caregiver burnout, emergency department visits, hospitalizations, and escalating pharmacological management. Timely identification remains a major gap in real-world dementia care.

Limitations of Current Approaches

- Intermittent clinical assessments — low temporal resolution
- Self-managed wearables — adherence challenges in dementia
- Retrospective monitoring — no prospective early warning
- Most studies lack cross-patient validation designs

The TIHM Dataset
Technology Integrated Health Management — a naturalistic UK remote monitoring cohort (2019–2021) of community-dwelling adults with dementia. Passive in-home PIR motion sensors, door sensors, and under-mattress sleep staging. Agitation events clinically verified by nursing staff via structured caregiver report — yielding deployment-ready labeled outcomes.

Ethics: NHS HRA (IRAS 224526). Secondary analysis exempt: IRB No. WKUH 2026-03-052.

Gaps in Prior TIHM Research

- Monitoring/anomaly-detection framing without explicit next-day prediction targets
- Multimodal sensor gaps limiting systematic feature evaluation
- Insufficient cohort size for reliable cross-patient validation

Study Objective
Evaluate feasibility of NEXT-DAY agitation prediction using passive PIR sensing and identify behavioral digital biomarkers of agitation risk — validated via leave-one-patient-out cross-validation (LOPO-CV) for deployment-realistic cross-patient generalizability.

Passive sensing advantage: no active patient participation, no wearables — suitable for cognitively impaired populations requiring zero-burden continuous monitoring.

METHODS

Analytical Cohort (TIHM Dataset)

56
Patients
with dementia

2,610
Patient-
days analyzed

114
Agitation
events (27 pts)

Study Design

- TIHM dataset
- 56 participants
- 2,610 patient-days
- Next-day prediction

Feature Engineering

- Activity volume
- Evening activity ratio
- Location entropy
- Low-stimulation room ratio
- Self-loop ratio (SLR)

Statistical Analysis

- GEE
- GLMM
- LOPO-CV

Primary endpoint:

- PRAUC

LOPO-CV (Leave-One-Patient-Out)
Train on N–1 patients → Test on unseen patient

RESULTS

GEE Associations with Next-Day Agitation

Feature	OR (95% CI)	P
Activity Volume ↑	2.16 (1.44–3.24)	< .001 ***
Evening Activity Ratio ↑	1.54 (1.11–2.15)	.010 *
Self-Loop Ratio ↓	0.25 (0.18–0.33)	< .001 ***

AUROC 0.848
Model B · 95% CI 0.776–0.901

6.1× Chance
PRAUC · 95% CI 0.090–0.395

LOPO-CV: Cross-Patient Predictive Performance

Model	AUROC	PRAUC	×Chance	Brier
Model A (PIR only)	0.762	0.207	4.8×	0.195
★ Model B (PIR+SLR)	0.848	0.263	6.1×	0.161
Model C (SLR-dev)	0.716	0.090	2.1×	0.216
Subgroup (n=27)	—	—	—	—
Model B (agit-present)	0.780	0.273	3.7×	0.229

Sleep subgroup
"Sleep features did not improve prediction."

CONCLUSIONS

- Passive PIR sensing accurately predicted next-day agitation (AUROC 0.848).
- Activity volume, evening activity, and SLR were the strongest behavioral predictors.
- Sleep features provided limited additional predictive value.
- Passive home sensing may support scalable early intervention in dementia care.

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Publicly available TIHM dataset (Palermo et al., *Sci Data* 2023); IRB No. WKUH 2026-03-052.

LIMITATIONS

- Single UK cohort — external validation essential
- Modest events (n=114) — wide bootstrap confidence intervals
- Heterogeneous dementia etiologies — subtypes not analyzed
- Sleep data available in only 30% (n=17, 31 events)
- Binary outcome — agitation severity not modeled
- No sociodemographic fairness analysis possible (limited TIHM metadata)
- Observational design — no causal inference
- Concomitant medications unavailable as covariates

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