Validating an AI-enhanced remote patient monitoring platform for orthostatic vital signs

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MassAITC Aging Focus Pilot Care

Background
Orthostatic Hypotension
- Orthostatic Hypotension (OH) affects nearly 1 in 3 older adults and increases the risk for falls by 2.5X
- Common side effect of BP medications
- Previous home methods fail to detect myriad forms of orthostatic intolerance, leading to poor management of OH

Existing Methods
- Inexpensive ($50)
- Doesn’t capture real-time hemodynamics
- Measures central BP, not cerebral perfusion

Supine
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Pilot Objectives
SA1: Validate TRACE in home-like laboratory
8-hour monitoring study
- Active Standup Test (ASt)
- Intrady Variables
  - 5 m
  - 5 m
- Evaluate orthostatic vitals with multiple ASs throughout the day
- Evaluate intrady changes in orthostatic vitals due to hydration, meals, bedrest, physical activity

SA2: Physician Guide
- Physician guide on utilizing TRACE metrics for diagnosis
- Collaboration with autonomic specialist Prof. Dong-In Sim (Stanford)

SA3: FDA Presubmission
- Early engagement with FDA is recommended as first step for FDA approval
- Presubmission packet
- Presubmission meeting to obtain feedback from FDA regarding future clinical test

Supine

Future Implications: Fall prevention
- This work is significant because it seeks to prevent fall-related injuries, which impact nearly 40% of adults over 65 and costs the US healthcare system >$50B annually.
- Preliminary data shows that TRACE can quantitatively measure loss in blood volume during standing, the root cause of lightheadedness upon standing.
- Remote monitoring of OH can help physicians better manage and treat OH

TRACE Product Concept
- TRACE is a patented wearable that measures orthostatic vitals due to its unique atrial-fiber form factor
- TRACE provides 4 Orthostatic Vital Signs: Orthostatic Hypotension (OHV), Postural Orthostatic Tachycardia (POT), Orthostatic Time Constant (OTC), and several others

Acknowledgements
TRACE technology has been developed and validated with funding from the following sources:
- MassAITC funding from National Institute on Aging grant P30AG021307
- Michigan Technology Research and Commercialization Fund (MTReC), from the Michigan Economic Development Corporation (MEDC)
- Michigan Health Endowment Fund (MHEF)
- NIH ACHIEVE GREATER from National Institute of Minority Health Disparities (NIMHD)
- Wayne State University
Let's Talk Tech
- the first tool to empower shared decision making about technologies to support dementia care

Clara Berndt PhD, MSW, Natalie Turner, LMSW, School of Social Work, William Lober MD, MS, School of Nursing

Technologies to support dementia care at home have outpaced our understanding of how to help people learn about and think about using them. The digital divide will not be bridged if we leave families to navigate this complex landscape alone. Let’s Talk Tech helps care partners (CPs) and people living with dementia (PLWD) understand technologies and balance a desire for monitoring and safety with PLWDs’ dignity and wishes. Grounded in the Theory of Dyadic Illness Management (Lyons & Lee, 2018), it is designed to help dyads negotiate digital technology use in an informed way.

LET’S TALK TECH is self-administered, completed in ~45 min. by a PLWD and one or more care partner. It facilitates:

1. A research-based education about data-diverse technologies:
   - Location tracking
   - Home activity sensing
   - In-home web cameras
   - Video (AI) companions
2. Dyadic communication about technologies
3. Documentation of the PLWD’s preferences

There are many reasons families require support to make personalized technology use decisions:
- Preferences are diverse and relatively embedded.

Next:
- Uniformity in PLWD support is critical to realistically embed preferences.
- Technologies that collect visual, activity, location, or audio data may cause conflict due to their surveillance nature.
- Uniform decision making is a stressful burden for care partners.

NIH STAGE 1A PILOT ESTABLISHED PRELIMINARY FEASIBILITY & EFFICACY
- mTAP 29 mild Alzheimer’s disease care dyads
- Age CPs: 55-83, 46-69, PLWD: 56-82, 46-70
- 100% completion (8/453 total questions skipped)
- Most reported LTT has the right amount of information (~84%), presented in a balanced way (~100%)

Preliminary efficacy:
- Improved CP preparedness to make technology use decisions (p = .002)
- 83.9% accuracy in CPs’ knowledge of PLWD’s technology preferences
- CPs’ technology understanding of all 4 categories
- PLWDs’ technology understanding for 2 of 4 categories
- CP perception of PLWD’s technology understanding
  - p < .001 for all categories (with involvement implications)
- CPs’ feelings of alignment (p < .001)

PENNAITech Work
Barriers to preferred technology use extend beyond education, awareness, and decision-making difficulty. Could sharing the technology preferences documented in Let’s Talk Tech achieve the dyads’ larger care networks to support them to use technology how they want to?

Every dyad who completes Let’s Talk Tech has a summary document of the PLWD’s technology use preferences. Pilot participants reported a desire to share their documented choices with other families and with providers to (1) obtain technology support from their care networks and (2) prevent family conflict.

1. ENABLE PERSON-CONTROLLED SHARING USING STANDARDS:
   SMARTHEALTH LINKS & FHIR
   - Implement user-controlled, standards-based sharing of preferences using FHIR and the SMART Health
   Links protocol to share clinical information
   - Express patient-authored goals & preferences using the FHIR standard
   - Test new sharing capabilities with dyads users

2. EHR INTEGRATION
   - Implement standards-based EHR integration using SMART on FHIR technology for provider access to patient preferences
   - Assess AD/ADRD clinic need and preferences for EHR documentation using test instance

3. BROADEN RELEVANCE & ACCESS
   - Enhance LTT for wider relevance and access by adding new features:
     - Capture preferences for future scenarios
     - Allow users to edit the summary of their choices to reflect their wishes more accurately
     - Further optimize the experience to achieve wider, equitable access through smartphones


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Intelligent Cognitive Assistant for Word Retrieval Support for Older Adults with Incipient ADRD

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IHMC, UCI, Northeastern University
MassAITC AD/ADRD Focus Pilot Core

MyWords quickly finds the word a user needs at a particular moment and optionally trains the user to better recall the word in the future.

Commercial and Translational Impact
- MyWords App: Utilizes NLP to create an intelligent Cognitive Assistant tailored for ADRD word retrieval.
- Adaptive Learning: Tailors support by learning from user interactions, easing word retrieval challenges.
- Broad Application: Viable for both home and healthcare settings.
- Scientific Impact: Offers insights into ADRD through associative semantic network monitoring, aiding research and treatment.

Key Features
- User-centric
- Interdisciplinary approach
- Adaptive design
- Data-driven insights

Pilot Project Highlights

Data Entry Mode
- Assistance Mode
- Update and Feedback Options

- Data Entry
- Assistance
- Feedback Options

Participant Information
- Target Demographics/Criteria: Older individuals including those with ADRD
- Recruitment Status: Initiated usability testing

Next Steps
- Complete Usability Testing: Engage healthy individuals and those with MCI/ADRD
- Expansion: Add features based on user feedback to improve the app.
- Longitudinal Study: Evaluate app’s response and appropriateness to users’ queries.
- Funding: Seek further grants for research and app enhancement
- Commercialization: Develop strategy for commercialization.

Takeaways
- Data Insights: Tracks memory patterns for personalized support
- Usability Feedback: Drives refinements in app design and efficiency, particularly for older users with ADRD
- Longitudinal Study: Arms to rigorously assess and tailor long-term efficacy
- Transformational Potential: Posed as a communication aid for ADRD
- Commercialization: Plans to broaden access and contribute to the discourse on ADRD care

References
- MyWords Github: https://github.com/MyWords-ap/a

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Advancing diagnostic excellence for older adults through collective intelligence and imitation learning

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PennAItech Aging Focus Pilot Core

Background

- Diagnostic error in primary care is a widespread and critical threat to the safety of older adults.
- Despite having been identified as a top research priority by national experts, no differential diagnosis clinical decision support system (CDSS) exists tailored for this population.
- Older adults have unique needs that should guide the development of a diagnostic AI CDSS.

![Figure 1: Conceptual model of a CDSS to support the diagnostic process by facilitating communication and history-taking among patients, caregivers, and clinicians. This system provides diagnosis and testing suggestions based on the collective intelligence of peer clinicians.](image)

Objectives

- Train deep learning models to predict the consensus diagnostic and testing behaviors of primary care clinicians.
- Develop and pilot an interactive electronic interface to deliver the predicted information that is acceptable and feasible for patients, caregivers, and clinicians (Figure 1).

![Figure 2: Performance of the prediction models demonstrating excellent calibration for identifying the most common suggested diagnoses (top panel) and tests (bottom panel) in primary care encounters for older adults.](image)

Project Achievements

- Trained and validated a preliminary version of the prediction model (Figure 2, right):
  - extracted and processed training and validation data sets based on four years of EHR patient data, including clinical notes, medications, and lab test results;
  - developed an extended list of relevant diagnoses, including a “do not miss list,” and manually mapped over 1,600 ICD-10 codes to clinically meaningful diagnostic categories;
  - Trained deep learning models to predict the average clinician treatment and diagnosis for each encounter.

- Developed a front-end, web-based, interactive cloud interface to display the outputs of the prediction models (Figure 3, below):
  - Models updated predictions as patients, caregivers, and clinicians enter additional information.
  - Updated outputs displayed to users in real-time.

![Figure 3: The interactive Interface of the prediction models. Patient information is displayed at the top. A list of potential symptoms is on the left side and can be modified in real-time. A list of the predicted diagnoses and their probabilities is in the center. A list of the predicted testing plans and their probabilities is at the right. The predicted treatments change based on the symptoms that are identified as present (YES), absent (NO), or unconsidered (SKIP).](image)

Future Directions

- This tool would be the first fully documented, open-source, diagnostic CDSS appropriate for the broad scope of primary care, in general, and for older adults, in particular.
- Our methodology has applications outside of primary care and would create a roadmap for developing AI CDSS in other settings with high clinical uncertainty.
- The proposed tool is well suited to several commercial opportunities and is likely to be appealing to health system operational leaders to improve documentation and clinical workflows.

Acknowledgements: This study was supported by funding from the Penn Artificial Intelligence and Technology (PennAItech) Collaboratory for Healthy Aging, National Institute on Aging (P30AG073105).
**Clinical Background**

- **Delirium**: is a frequent complication in critically ill, older ICU patients, affecting up to 80% of those on ventilators. It leads to higher mortality, longer hospital stays, increased dementia risk, and over $200B in annual U.S. healthcare costs.
- **ICU delirium** has significant long-term effects, extending beyond discharge, including cognitive decline and an increased risk of dementia. While effective communication and reorientation interventions have shown promise in managing delirium, implementation challenges persist due to barriers such as limited resources and nursing bandwidth.

**Project Background**

- **EyeControl-Med (EC-M)**: is an innovative AI-powered wearable communication solution designed not only to manage delirium in the ICU but also to address its long-term effects post-discharge. By facilitating communication and reorientation interventions, EC-M aims to improve patient outcomes and reduce the risk of cognitive decline and dementia in the geriatric ICU population.
- **Features**: audio streaming, family messages, remote monitoring, & reorientation.
- **Prior work**: promising results in adult ICU populations on EC-M’s efficacy for delirium reduction.
- **Objective**: Evaluate the feasibility and efficacy of EC-M intervention in geriatric ICU patients focusing on addressing long-term outcomes such as post-ICU syndrome.

**Pilot Project Highlights**

| Duration | 52 weeks |
| Location | ICU |
| Cohort   | 30 patients |

**Figure 1: EyeControl-Med Headset**

**Table 1: Study Overview**

**Study Aims**

1. Assess how EC-M impacts duration and fluctuation of delirium-free days in patients using EC-M compared to conventional treatment.
2. Evaluate delirium detection accuracy of EC-M’s automated Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) compared to manual assessments.
3. Track longitudinal effect of delirium on cognition and dementia at admission and 6 months post-discharge, comparing EC-M to control group, utilizing the IQCODE and the QDRS assessments.

**Secondary Aims**

1. Refine workflow integration for EC-M implementation
2. Collect feedback and observational data from healthcare staff and families.

**Study Design**

- 52-week randomized controlled trial at Johns Hopkins, enrolling 30 ventilated ICU patients over 55 years old
- **Methods**: CAM-ICU, Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE), Quick Dementia Rating System (QDRS), MoCA assessment; alongside AI-powered EyeControl-Med for communication, reorientation, music, family engagement
- **Results**: Our hypothesis suggests reduced delirium duration/fluctuation, improved detection accuracy, lower cognitive decline
- **Next steps**: Potential commercialization and wider implementation plans

**Implications**

- **EyeControl-Med** offers an innovative AI-based approach to improve ICU patient communication, delirium management, and clinical workflows.
- **Potential impacts** include reduced delirium, shorter hospital stays, lower costs, improved patient/family experience, and reduced dementia risk.
- **This study highlights** the importance of effective communication interventions and potential for EyeControl-Med to establish a new standard of care.

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Real-Time Remote Monitoring of Confirmed Medication Adherence

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PennAITech Aging Focus Pilot Core

Abstract

The FDA-Cleared ID-Cap™ System is a seamless, end-to-end solution for remotely monitoring, tracking and improving medication adherence in real time. Using the world’s first and only off-body ingestion event monitor, along with Alexa integration, enables real-time medication adherence monitoring and encouragement to assist with aging in place.

Emily, it’s time to take your medication.

Milestones

✓ Design gathering and acceptability study completed
✓ Several software solutions with design informed by the completed study are in the verification phase
✓ Reader design completed with UCD also enables real-time incontinence monitoring at home and in assisted living facilities

Pilot Project Highlights

Key Participant Metrics

- 15 Participants Enrolled
- 14 Patients Enrolled
- 1 Care Provider Enrolled
- 7 Male Participants
- 8 Female Participants
- Mean Participant Age 76.6

Identified Themes

- 93% Have smartphones, predominantly iOS
- 80% Can download apps by themselves from app stores
- 2-15 Meds per day, 93% take all meds at one time
- 87% Take meds each day at the same time
- 93% Have heard of Alexa and 20% are actively using Alexa
- 33% Actively use some type of voice assistant
- 73% Use pill boxes to help with medication management and believe it helps, but are concerned about effectiveness in the future
- 93% State they are independently managing their meds
- 87% Have Wi-Fi at home

Key Design Takeaways

- 93% Think reminders would be helpful
- 33% Would also like reminders on their phone
- 60% Think secondary reminders would also be helpful
- 60% Would allow caregiver to help with setup
- 33% Stated they would setup device
- 67% Believe a visual display of ingestion history would be helpful
- 53% Would like device to identify you before making reminder announcement

Conclusions

- Of subjects expressed concern about devices “listening” and security of devices like the Echo – Maybe consider speaker instead?
- Believed that they would need help eventually with medication management beyond that which is provided by a pill box
- The vast majority believed a home reminder system would be helpful but would need help making adjustments to the device
- Strong consensus that caregiver should receive notification regarding medication non-compliance
- Verbiage consensus from reminder: <Name>, <Medication>, time to take or some variant. (John, please take your XXX at 8am)

Acknowledgements

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National Institute on Aging Grant 1R43AG073011-01A1
Improving Mobility for Dementia Alleviation in Older Adults via AI-Powered Affordable Exosuits
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Johns Hopkins University, Picasso Intelligence, North Carolina State University
JH AITC AD/ADRD Focus Pilot Core

Motivation
- Increased physical activity can lower blood glucose levels and the likelihood of dementia.
- Current solutions are tethered (only accessible in clinics) and restrict movement.
- Cognitive decline ultimately leading to AD/ADRD.
- Joint degradation & pain increased fatigue.

Objectives
- Learning-based personalized control for walking assistance via lightweight exosuits.
- Evaluate mobility biomechanics benefits of exosuit-assisted walking in the field.
- Revenue model and cost analysis for product translation from clinical to home use.

Pilot Project Highlights

![Image of highlights](image)

Figure 4: New actuator paradigm for exosuits that facilitates high compliance, bandwidth, and efficiency.

Conclusions

![Image of conclusions](image)

Figure 7: Deep neural network reinforcement learning based controller uses offline musculoskeletal agent simulation via imitation learning to produce assistive torque for multiple activities.

References

Acknowledgements
National Institute on Aging grant F30AG0373104
Device-Free Wi-Fi Sensing Technology to Assess Daily Activities and Mobility in Low-Income Older Adults

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BACKGROUND

- Low-income, minority older adults are at an increased risk of cognitive impairment and dementia.
- Cognitive impairment affects the ability to perform and manage daily activities and mobility behaviors.
- Assessing the ability to perform daily activities and detecting the changes in these abilities early is crucial, but often difficult in this population due to limited resources.
- Traditional activity and mobility assessment tools are primarily self-report, subjective, and episodic.
- Existing smart home sensors show limited ability to detect different types of human behaviors (e.g., eating, preparing meals).
- Sensing devices are not readily available to older adults with health disparities due to cost and information barriers.
- There is a need to develop new sensing technology that can characterize and quantify daily activities while also being discreet, affordable, and requiring minimal user engagement.

PILOT PROJECT HIGHLIGHTS

- Device-Free Wi-Fi Sensing
- CSI (Channel State Information) as the basis for activity recognition
- Machine learning for hyperparameter selection
- Edge model for real-time analysis

 TECHNOLOGY DESCRIPTION:
We leverage existing Wi-Fi infrastructure or use low-cost devices to transmit Wi-Fi signals in the home environment. The CSI of Wi-Fi signals in all subcarriers are used for communication between Transmitter and Receiver devices. We employ ML algorithms to process the CSI data and extract different activity features, such as sitting, meal preparation, kitchen sink use, watching TV, phone use, and entering/exiting a room.

Participants: Individuals living in low-income senior housing (aged 60 and older) with and without mild cognitive impairment.

Preliminary Results: Seven participants have been enrolled in the study. The following images show a participant's floor map with our setup and the spectrogram images obtained from 6 different activities of the participant. We are developing a Convolutional Neural Networks (CNN) model to establish the accuracy of activity detection based on the preprocessed raw data. Our CNN model based on a single participant was 68.8% accuracy. We will use data with more variations to fine-tune the model.

CONCLUSIONS & IMPLICATIONS

- The ability to identify and differentiate human activities will be improved when algorithms to disambiguate the data are fully available.
- This initiative aims to empower low-income older adults by harnessing the power of Wi-Fi sensing technology and ML to detect functional decline early that signals cognitive impairment. By providing an accessible and cost-effective solution, we can improve the lives of older adults with health disparities and enhance their brain health.
- Wi-Fi sensing system facilitates passive monitoring, which does not require user involvement. Our target population has limited digital technology experience and low IT literacy. This technology may provide a more effective sensing solution to older adults with cognitive decline, functional impairment (e.g., visual or hearing impairment), limited technology experience, low literacy, and/or lack of technology support, potentially achieving digital health equity.

PROJECT GOAL

To develop a Channel State Information (CSI)-based device-free Wi-Fi sensing system using ML classification to localize and recognize different in-home daily activities and mobility. Our ultimate goal is to create an affordable cutting-edge system that uses Wi-Fi signals for assessing physical function in low-income older adults.

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IN-home Cognitive Improvement Training using EEG-NFB

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Introduction:
- Alzheimer’s disease places an enormous psychological and emotional burden on patients and caregivers. It also places tremendous financial strain on families and healthcare systems.
- In 2023, Alzheimer’s and other dementias cost the nation $345 billion — not including the value of unpaid caregiving.
- EEG neurofeedback is applied to mitigate cognitive impairments and behavioral alterations in dementia and various neurological conditions. This method trains individuals to modify their brain waves through operant conditioning.
- Deep learning techniques are increasingly utilized in analyzing EEG data to identify and capture instances of peak working memory performance. By leveraging complex neural networks, these methods can discern intricate patterns in brain activity that correspond with optimal cognitive function.

Aims:
Purpose: developing a unique method for ameliorating the progression of cognitive impairment in persons with Alzheimer’s Disease and other dementias.

Aim 1. Design a machine learning algorithm to capture EEG patterns associated with peak working memory performance in near real-time. Fine-tune the machine learning model based on individual patient EEG characteristics and feedback thresholds.

Aim 2. Develop hardware/software integrating EEG recording, evaluation of EEG components defined in Aim 1, and module music volume contingent on the presence of EEG components associated with peak working memory performance.

Methods:
- A CNN pipeline algorithm trained on a publicly accessible database consisting of EEG data recorded from 36 subjects performing mental arithmetic tasks.

Data preprocessing:
- Denoising:
  - Independent Component Analysis (ICA) to eliminate the artifacts (eyes, muscle, and cardiac overlapping of the cardiac pulsation).
  - Band pass filter with the cut-off frequency 0.5-45 Hz to remove baseline noise
  - Notch filters (50-60 Hz) to remove line noise

  Specific 10-20 system sites:
  - F3, F4, Fz, P3, P4, Pz; focused on frontoparietal axis dynamics.

  Data segmentation:
  - Segments of 2 seconds with 50% overlap.

  Scalogram:
  Compute the scalograms (heat maps) of each EEG signal segment using the Continuous Wavelet Transform (CWT) with a ‘Morlet’ wavelet at a scale of 128.

CNN Architecture:
Three convolutional layers followed by 2x2 max-pooling layers.

Classification:
Three fully connected layers with a dropout probability of 25%.

Accomplishments:
- Developed an AI model for classifying cognitive tasks using publicly available data.
- Designed a hardware/software infrastructure for collecting data, utilizing wearable dry EEG electrodes and BCI technology.
- Established individualization assessment protocol for personalization of the AI model.

Results:
- The initial model (Aim 1) achieves a 79% F1-score overall and is 84% sensitive to detecting working memory peaks.

<table>
<thead>
<tr>
<th></th>
<th>Train</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>85.05%</td>
<td>67.59%</td>
</tr>
<tr>
<td>Precision</td>
<td>0.67</td>
<td>0.75</td>
</tr>
<tr>
<td>Recall</td>
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<td>0.84</td>
</tr>
<tr>
<td>F1_Score</td>
<td>0.90</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Establishment of Individualization Assessment:
- Recording EEG during the performance of a task modeled on the WAIS-IV Letter-Number Sequencing task.
- String length increases until failure of 2 sequential strings of the same length, then length reduces by 1. Then, it continues to increase until failure repeats. The process repeats until the threshold is reached (~20-minute duration).
- This procedure is then used to identify features of the EEG activity associated with peak performance vs. working memory failure.

Next Steps:
- Refine our deep learning model using experimental data. This involves updating the model’s parameters with the new information and applying a fine-tuning technique.

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Introducing Sleep Sensors and Devices in Older Adults

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Introduction

- Good sleep is critical to health, and poor sleep often precedes the onset of Mild Cognitive Impairment (MCI).1,2
- Early detection of poor sleep may provide an opportunity to identify MCI earlier, and may provide avenues to reduce the onset and severity of MCI.
- Many commercial devices can track sleep non-invasively at home, which could be monitored long-term by caregivers or clinicians offline.3
- While several studies have examined the accuracy of commercial sleep monitoring devices in young adults, more studies are needed to examine the accuracy of these devices in older adults with and without MCI.4

Study Objectives

- To evaluate the sleep monitoring performance, compliance, and usability of commercial devices compared to polysomnography (PSG) and self-reported sleep in 30 older adults, 30 older adults with MCI, and 30 young adults.
- To develop a database of physiological signals, sleep measures, and questionnaires to facilitate research evaluating the accuracy of commercial sleep monitoring devices, and potentially the identification of novel biomarkers for the early detection of MCI.
- Here, we preliminarily compared total sleep time reported by the Dreamhead band and Sleep Profiler, to self-reported total sleep time in older adults and young adults.

Full Study Protocol

1. Daily Sleep Tracking with 4 Commercial Devices and Polysomnography (PSG)
   - Screening
   - Participants apply PSG
   - Researchers setup devices

2. 4 Commercial Devices
   - Each device, every day
   - Fill out Sleep Diary
   - Sleep Profiler
   - Emblicita MPR

3. 3 PSG Measurements
   - Study 1: PSG, Study 2: PSG

Preliminary Results for Dream and Sleep Profiler

Device vs Self-Reported Total Sleep Time

- Dream Headband: Older Adults
  - Total Sleep Time (minutes): (201)
  - Mean Total Sleep Time (minutes): (300)
- Sleep Profiler: Older Adults
  - Total Sleep Time (minutes): (105)
  - Mean Total Sleep Time (minutes): (280)

- Dream Headband: Young Adults
  - Total Sleep Time (minutes): (53.9)
  - Mean Total Sleep Time (minutes): (60)
- Sleep Profiler: Young Adults
  - Total Sleep Time (minutes): (162)
  - Mean Total Sleep Time (minutes): (170)

Future Directions

- Our objective is to compare sleep measures reported by all of the commercial devices to corresponding measures collected by self-report, the Dreamhead band, the Sleep Profiler, and the Emblitica MPR.
- We will continue to diversify our sample, and recruit participants who indicate Mild Cognitive Impairment based on their scores from the Telephone Interview for Cognitive Status.
- We will develop a public database of the physiological signals, sleep measures, and all data collected by each of the 4 devices, 3 types of PSG, and all of the questionnaires. Data will be provided at the highest resolution possible.

Participant Sample Characteristics and Cognitive Assessment Scores

Conclusions

- In both older adults and young adults, the Dream headband tended to report total sleep times that were similar to self-report. The Sleep Profiler tended to underestimate total sleep time in both groups.
- For the Dream headband, the limits of agreement were wider in older adults than in young adults. Limits of agreement were wide in both older adult and young adult groups for the Sleep Profiler.
- Overall, total sleep time reported by the Dream headband was more consistent with self-report than total sleep time reported by the Sleep Profiler.
A novel insole solution used in daily life to identify and mitigate falls and frailty.

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JH AITC [AD/ADRD or Aging] Focus Pilot Core

Background

• Falls are leading cause of injury and hospitalization in people >65
• Balance difficulties in walking is a risk factor for falls
• Remote, in-home monitoring of gait and balance may improve ability to track and treat fall-prone people.
• An instrumented insole was developed to provide real-time balance and gait metrics to patients and/or clinicians.
• This tool could assist in mitigating falls and relieve economic burden.
• However, validity of insole mobility outcomes and potential usability in the clinic must be assessed.

Objectives

• Validate insole walking and standing balance to gold-standard
• Validate if walking and balance patterns are relevant to prospective fall history
• Validate usability of insoles by end-users

Methods and Results

Figure 1: Path Feel instrumented insole
Figure 2: GaitRite mat

Methods

• 31 participants (≥ 50 y.o.) completed a single data collection
• 11 walking & balance assessments were completed, including:
  • Walking at normal pace with/without a distracting task
  • Data collected via GaitRite mat (gold standard) and insoles
  • Insole and mat synchronization was completed via visual first contact time. Algorithms for pressure and acceleration and additional methods such as python, numpy and pandas

Results

Table 1: Step to step comparison insole to GaitRite mat (“sample size” = number of steps included in analysis)

<table>
<thead>
<tr>
<th>Gait Parameter</th>
<th>Sample Size</th>
<th>Mean Absolute Error (1 standard deviation)</th>
<th>Accuracy (100% - MAE)</th>
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</thead>
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<td>6.70 ± 4.73%</td>
<td>93.24 ± 4.73%</td>
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<tr>
<td>Stride duration</td>
<td>639</td>
<td>2.34 ± 1.21%</td>
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<td>91.67 ± 4.46%</td>
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<tr>
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<td>642</td>
<td>8.99 ± 5.47%</td>
<td>91.61 ± 5.47%</td>
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</table>

Conclusions

• Insoles provide accurate gait parameters compared to gold standard (collection ongoing)
• Next steps
  • Relate outcomes to fall history
  • Conduct focus groups
• Collaboration with Carey Business School for marketing
• Target stakeholders:
  • Individuals at risk for falls
  • Healthcare professionals including physicians, nurses, social workers, physical therapists and occupational therapists

Acknowledgements

JH AITC funding via National Institute on Aging grant P30AG073104.
Passive measures of physical activity as an early biomarker for cognitive impairment
Hui tong Ding, David Paquette, Biqi Wang, Nicole Spartano, Honghuang Lin
Boston University Chobanian & Avedisian School of Medicine; UMass Amherst;
UMass Chan Medical School
MassAITC AD/ADRO Focus Pilot Core

Introduction

A growing body of research indicates that regular physical activity can mitigate the risk of cognitive decline among older adults.

The advent of digital technology facilitates the collection of passive measures of physical activity.

The objective of this study is to examine the association between physical activity measures and the neuropsychological (NP) tests across multiple cognitive domains and evaluate the added predictive power of physical activity measures for the prediction of dementia.

Methods

Study population

This study included participants from the Framingham Heart Study, a community-based cohort with longitudinal surveillance for incidental dementia.

Physical activity assessment

All participants were instructed to wear an omnidirectional accelerometer (Actical model no. 198-0208-00; Philips Respironics Inc., Murrysville, PA) around their hip during waking hours, excluding any times spent bathing.

Activity levels per minute were defined by intensity thresholds: ≥1535 counts for moderate to vigorous physical activity (MVPA) and ≤110 counts for sedentary time.

Sedentary time was normalized to wear time, calculating it as a proportion of an 18-hour day.

The average daily steps were computed across all valid days, with a cap at 20,000 steps to address outliers.

42 physical activity measures were included in this study.

NP assessment

18 NP tests measuring multiple cognitive functions including verbal and visual memory, verbal fluency, attention and concentration, executive functioning, abstract reasoning, visuospatial perception, and language.

Ascertainment of dementia

Dementia diagnosis at FHS was made by a review committee, including at least one neurologist and neuropsychologist. Diagnosis criteria followed the DSM-IV standards.

Incident dementia cases were participants initially cognitively intact but diagnosed with dementia during follow-up.

Statistical analyses

Linear regression models evaluated the association between physical activity measures and NP tests, adjusting for age, sex, and time interval between NP and physical activity examine dates.

Cox proportional hazards model assessed the association between incident dementia and physical activity measures, also adjusting for age and sex.

Investigated the predictive improvement of physical activity measures for incident dementia using ROC analysis and the CatBoost model.

Model 1 used predictors such as age, sex, and education.

Model 2 included these predictors plus 42 physical activity indicators.

Model 3 added age, sex, education, and specific physical activity measures with significant association to NP tests.

Results

Our study included 1569 participants from the FHS Offspring cohort (mean age: 70.8 years; 54.0% women). There are 53 participants with incident dementia with mean follow up time of 9 years.

Min/day (average) of medium movement (80-99 steps/min) on adherent days was associated with incident dementia with nominal significance (HR: 0.8, 95% CI: 0.20-0.86, P=0.018).

24 physical activity measures were associated with at least one NP test after Bonferroni correction for multiple testing. min/day (average) of sedentary activity (≥ 100 counts/minute) on adherent days was significantly associated with 6 NP tests.

The physical activity measures can increase the AUC of the baseline model for dementia prediction from 0.66 to 0.70.

Conclusion

We identified multiple associations between NP tests and physical activity measures suggesting the potential of using passive measures of physical activity as an early biomarker for cognitive impairment.

Additional research, especially with external cohorts, is needed to validate these findings further.

Acknowledgement

Our study was supported by National Institute on Aging grant P03AG073107.
Creation of a Technology-Ready Cohort of Patients with Alzheimer’s Disease and Related Dementias and Their Caregivers

Mark C. Eldaief, MD1, Baeta-Gabriela Simpson1 and Sudeshna Das, PhD1
1Massachusetts Alzheimer’s Disease Research Center, Massachusetts General Hospital and Harvard Medical School. Boston, MA

Background/Introduction

- Patients with Alzheimer’s disease and related dementias (ADRD) are evaluated at infrequent clinical or research visits in artificial settings.
- This hinders the ability to granularly and accurately characterize disease progression in ADRD.
- Digital technologies such as digital phenotyping, AI, and machine learning can track cognition, behavior, activity, socialization, and sleep quality in ADRD.
- Such assessments have the advantage of repeated (or continuous) data sampling unobtrusively in real-life, ecologically valid contexts.

Objectives

Aim 1: To create a cohort of technology-ready older adults, ADRD patients, and their caregivers.
Aim 2: To use digital assessments to predict cognitive and behavioral declines in ADRD patients.
Aim 3: To assess the ability of these measures to engage ADRD/caregivers and to troubleshoot issues.

Methods

- 75 participants: 25 cognitively normal or subjective cognitive decline, 25 with Mild Cognitive Impairment (MCI) and 25 with mild dementia, aged 55-90 years, and their co-participants will be recruited from our MADRC Longitudinal Cohort. Active and passive data assessments will be collected over 1 year (Fig. 1).
- Participants will be instructed on how to use devices/programs through telephone/video support calls and technical issues will be troubleshooted iteratively.
- Passive assessments will be collected through the Apple Watch™ (series 9).
  - This will be worn continuously (as tolerated) and will record heart rate, ECG, skin temp, motor activity & sleep.
- Active assessments will be done monthly and will include:
  - Voice recordings on participants’ personal smartphones using the Sonde One app.
  - Online subjective cognitive concern questionnaires (SCD-Q).
  - Online caregiver distress questionnaires (study partners).
  - Online study adherence questionnaires (study partners).
  - Online mood questionnaires (PHQ-9, NPI, QIDS, HAM-D).
- Subjects will undergo extended cognitive testing through the NIH toolbox at baseline and at 6 and 12 months.
- Subjects can play games (e.g., Solitaire, Tetris) on their personal smartphone by using the Game Pack app.

Outcome measures

- Comparison of ratings on digital assessments to progression to cognitive and behavioral endpoints, e.g., changes on the Clinical Dementia Rating (CDR) scale or on the Neuropsychiatric Inventory (NPI).
- Assessments of barriers to technology adherence (e.g., ease of use).
- Assessment of ability of refinements to resolve barriers to technology use.

Opportunities

Technology development in ADRD: Other MADRC/MAITC investigators will be able to use the technology-ready cohort to test novel technologies & methods.
Data Sharing: Data from this work will be made available via open access data sharing with other MADRC/MAITC investigators, with NACC and NACDA.
Research applications: The programs tested may be used as biomarkers in clinical trials in ADRD.

Acknowledgements

This work is supported by an MAITC pilot grant through the National Institute on Aging grant P30AG073107.
Implementation of the digital HART assessment requires integrating the scoring algorithm into the report generation process.

**Health App Review Tool (HART)**
- Designed to characterize the features of apps and then match these features to the needs and abilities of those affected by Alzheimer’s Disease and Related Dementias (ADRD).
- The HART is intended to be a low-burden tool that aids those affected by ADRD who are experiencing barriers to initial adoption or sustained health app use.
- Anticipated to impact the clinical recommendation, selection, uptake, and use of health and function supporting apps within ADRD and ADRD caregiver community.

**Objective:** To develop a refined HART interface (mobile and web-based), finalize the matching algorithm, and incorporate the algorithm into a seamless back-end integration.

**Setting:**
- Web-based portal (mobile screens compatible); community setting

**Design**
- Human centered design approach

**Methods**
The digital HART system consists of three parts: 1) Web Portal (mobile screens compatible) for the user interface; 2) Data Server for facilitating communication between the interface and the database; and 3) Database for storing assessment and report data.

**Methods Continued…**
The prototype design and implementation process includes:
- Designed and implemented user interfaces
  - Configuration and account authorization
  - Assessment pages (User, App)
  - Report
- Translated the HART scoring algorithm from SAS into web programming
- Programmed the system workflow to generate the HART reports

**Expected Deliverables**
This development aim will result in a dedicated HART interface curated by a co-design process with a stakeholder advisory group. The scoring algorithm will be integrated such that the match score is displayed upon completion of the HART. Availability of the HART is anticipated to maximize the utilization of impactful health technologies, enabling better disease management and higher quality of life for those with ADRD and their caregivers.

**Next Steps**
Our team is preparing to conduct 4 to 6 co-design workshops with our stakeholder advisory panel, comprising individuals experiencing ADRD or those providing care to a family member with ADRD. Starting with our preliminary webapp interface, our goal is to refine the HART interface through a dynamic process of ‘ideation—design—evaluation.’ This approach will lead to a refined design prototype, establishing a solid foundation for the development of the HART WebApp within a concentrated 4-week development sprint.

**References**
Speck: A Sensor For Healthier Lighting
William Huang, Erik Page, Hank Ibser, Dave Harris
Blue Iris Labs
MassAITC AD/ADR Focus Pilot Core

Does getting “bright days and dark nights” result in a measurable improvement in sleep quality?

Background
Circadian disruptions and sleep irregularity are associated with increased mortality, dementia, and a host of other health issues. As we age, so does our circadian system, and studies indicate that 40-70% of the elderly population suffers from chronic sleep disturbances. Light is the primary regulator of our circadian rhythm, regulating the secretion of melatonin. The ways light interacts with our circadian system is affected by the full spectrum of light throughout the day.

Goals
Our goal is to help people better understand their lighting exposure and how to use that data to better regulate their circadian rhythms and improve their sleep quality.

Speck: A Circadian Lighting Sensing System
The Speck sensor is a compact full spectrum lighting sensor. Traditional compact lighting sensors typically only measure brightness or RGB lighting. Full spectrum sensing allows the Speck to measure circadian lighting metrics such as circadian stimulus (CS) and melanopic equivalent daylight illuminance (mEDl). Unlike traditional lighting metrics which measure our visual perception of light, CS and mEDl measure how lighting affects our circadian system. The Speck sensor is accompanied by an iPhone app and web portal, and we have both a BLE version and an openThread mesh networking version depending on user needs.

Our system has been used by researchers as both wearable and stationary sensors. Most recently Pacific Northwest National Laboratory (PNNL) published a study using our sensor to track Well Building Standard compliance in office and factory settings.

Milestones and User Study
Our pilot study will be validating a study design to use Specks to measure light exposure, and surveys and Apple watches to measure sleep and other relevant factors. Our IRB approval is pending, and we plan to do the study in the next few months with 15-20 participants.

We have been doing internal testing with the Speck and iPhone App to validate our system stability.

We thank the NIH and MassAITC for the National Institute on Aging grant P30AG073107. Previous development on the Speck has also been funded in part by NIA grant SR44AG060857-06.
DECREASING RISK OF FALLS VIA COMPUTER VISION & AI DRIVEN FUNCTIONAL ASSESSMENTS
David Keeley, PhD, Michael Busa, PhD, Corrina Serviente, PhD, Marissa Graham, Bailey Henderson
Electronic Caregiver Inc.
MassITC AD/ADRD Focus Pilot Core

Background
- The prevalence of falls is over 25% among Americans aged 65+, with Alzheimer’s Disease (AD) and Alzheimer’s Disease-Related Dementia (ADRD) patients facing double to threefold higher risks (1). This leads to 3 million hospital treatments for fall-related injuries, premature deaths, and exceeds $50 billion in healthcare costs annually, underscoring the need for frequent and accessible in-home assessments (2).
- Addison, is a 3D avatar experience delivered on RGB camera equipped tablet hardware capable of real-world delivery needed fall risk screening.
- Electronic Caregiver has 10 years of human subject research experience around deploying algorithms for human motion.
- Leverages Addison, coupled with Intel’s pose estimation technology to perform at-home physical assessments.
- To be delivered via developing feature, called Functional Assessment in the Home (FAITH), aims to detect fall risks early and enhance care for Alzheimer’s and related dementia patients.

Inclusion Criteria:
- 20 participants with AD/ADRD capable of on-campus visits and qualifying TICS and MOCA scores.

Protocol Overview:
- Use of a single tablet-based Addison unit for data collection.
- Collaborative data collection by ECG and UMass leveraging Addison Care and motion capture technology.

Assessments for Data Collection:
- Johns Hopkins Fall Risk Assessment Tool (JHFRAT).
- Short Physical Performance Battery Assessment (SPPB-A).

Data Analysis:
- Analyze patient responses and clinician entries from JHFRAT.
- Assess \([x,y,z]\) and \([x,y,z]\) spatiotemporal data for patient movements during SPPB-A assessments from both the Addison unit and UMass MoCap lab.

Expected Outcomes and Anticipated Impacts
- Outcomes from this pilot are to validate and tune an algorithm to be used to measure functional assessments from the deployed Addison Care RGB camera technology.
- By evaluating and enhancing the algorithm of FAITH, this initiative is set to enhance patient safety and potentially decrease healthcare costs related to fall injuries in the elderly and AD/ADRD patients.

Acknowledgements: This work is funded in part by National Institute on Aging grant P30AG073107

References
**EZ-Aware**: Digital Twin for wearable-enabled, AI-supported assessment of cognitive impairment

Kunal Mankodiya’, Nicholas Constant’, Geoff Tremont”, Laura Korthauer”, Charley Denby”, Alyssa De Vito”**, Brian Ott”**

’ EchoWear LLC, Pawtucket, RI
” Rhode Island Hospital, Providence, RI
** Brown University, Providence, RI
JH AITC [AD/ADR or Aging] Focus Pilot Core

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**Problem**

13.8M diagnosed with Alzheimer’s Disease (AD) by year 2050 [1]

51T cost to care for AD and related dementia [2]

15% of MCI patients progress to dementia in 1 year [1]

Lack of data and efficient tools to collect and detect cognitive impairment in diverse populations at a large scale

---

**Aim**

To design a digital health application, EZ-Aware that can bring cognitive assessments into everyday environments and offer following values to end-users:

- Reliable and engaging health experience
- Clinically proven, comprehensive tests
- Deployable at clinics, community, and homes
- Multiple language support for cultural diversity

---

**Digital Cognitive Screening**

NIH/NIA STTR Phase I

The STTR phase I project (2021-23) developed and tested a digital cognitive screening tool designed to accurately identify mild cognitive impairment in older adults.

- 99 participants (Healthy Controls [HC] n=49; Cognitively Impaired [CI] n=50) completed the cognitive screening twice (one month span).
- The data analysis demonstrated strong test-retest reliability/inter-rater consistency, and evidence of concurrent/construct validity.

---

**Passive Monitoring**

NSF SBIR Phase I

The SBIR phase I project (2021-23) focused on developing and testing EZ-Aware, a digital health platform designed to support individuals with Parkinson's Disease (PD) and caregivers.

- We conducted a feasibility study to verify the usability and robustness of the EZ-Aware app in the daily lives of people with PD (n=31) and caregivers (n=14).
- All the participants liked EZ-Aware, with an average usability rating of 4.75/5.

---

**Current Focus**

EZ-Aware is currently under developments to bring cognitive assessments into everyday environments.

It incorporates age-friendly, digital interfaces for smartphones (and tablets) delivering periodic micro-assessments (span across several weeks) for various cognitive domains. This provides a robust estimate of cognitive functions.

The EZ-Aware app will be piloted for feasibility in a 6-week in-home study in which 30 participants (15 healthy old adults and 15 with mild cognitive impairment [MCI]) will complete brief cognitive screening assessments, periodic micro-assessments, and collection of daily life functions via smartwatch.

---

**Project Timeline**

1. Cognitive Micro-Assessment Design
2. In-Home Pilot Study (N=30)
3. 3 Digital Twin & Public Datasets

**Citations**


**Acknowledgements**

This work is supported by various grant funds including NIA/NIH and NSF/NIH grants (P2012020151), National Institute on Aging STTR Phase I grant (R4422462126), and National Science Foundation (STTR Phase I grant 2011-90593).
Utilizing the Druid® Impairment App to Assess and Enhance Senior Adults’ Driving Performance

Michael Milburn, PhD, * and William DeLong, PhD, Impairment Science, Inc.
Anuj Pradhan, PhD, Apoorva Hungund, and Melissa Paciulli
Human Performance Lab, UMass/Amherst
MassAITC Aging Focus Pilot Core

Study Background
Aging adults face multiple difficulties that can impact their driving performance, ranging from stiff joints and slower reaction times to prescription medications and dementia. In a meta-analysis of research on older drivers’ self-perceived driving ability, Huang et al. (2020) observed, “As people age, some can recognize and identify these sensory, cognitive, and physical changes by themselves, while others cannot.” In addition, they found that “Overall, the majority of studies report that older adults self-perceive their driving abilities to be better/higher than themselves at a younger age, their cohorts, and all other drivers, as well as better/higher than their objective driving ability evaluation.”

Study Overview
GOAL: To determine whether the Druid impairment app can predict driving performance and assist with healthy aging.

SAMPLE: Recruiting 40 participants aged 65-84

Two aspects of the proposed research:

--- Performance on Driving Simulator at UMass/Amherst Human Performance Lab (HPL)

--- Performance on Druid impairment measurement app from Impairment Science, Inc.

Human Performance Lab

Multiple published, peer-reviewed validation studies show Druid’s sensitivity in measuring cognitive-motor performance after consuming alcohol or cannabis

Frequent cannabis users (UC Boulder)

Infrequent cannabis users (Johns Hopkins)

Conclusions
--- Druid is a reliable and highly sensitive measure of cognitive-motor performance and impairment

--- We anticipate that this study will demonstrate that Druid can predict driving performance and a variety of errors made while using the HPL driving simulator in a senior population

This research is supported by National Institute on Aging grant P3004073107.
Prevention of Patch Poisoning in Elderly Alzheimer’s Patients

Sandeep Patil* MD PhD, William Z Potter MD PhD, Sean Harrison MPH ACE-CPT (Penn), Tushar Patil, Ted Zipoy, Patrick Mercier PhD
Vaaji LLC, Los Angeles, CA

Developing a smart transdermal therapeutic patch and AI-enabled monitoring platform to improve safety of patients with Alzheimer’s disease

The Need:
Transdermal medicine patch application errors are common and are associated with serious consequences.
- Per the Federal Adverse Event Reporting System, >7000 serious events (including fatalities) have been reported with transdermal rivastigmine patches used in the treatment of Alzheimer’s Disease (AD).
- Similar reports of serious incidents or fatalities involve fentanyl, clonidine, scopalamine, and other patches. (Institute of Safe Medicine Practices, 2021)

The Opportunity:
- No method currently exists to monitor therapeutic patch use.
- Early detection and intervention can prevent adverse outcomes.

Key Benefits:
- Reduce morbidity and mortality.
- Increase caregiver support.
- Facilitate healthy aging at home.

Project Overview

Background

Objectives and Methodology

Primary Study Outcome:
The primary outcome variable will be the degree to which the information derived from the remote monitoring portal accurately reflects the number of patches on a participant in the Home Health Lab as noted by the site research personnel.

Clinical Study Design:
50 Healthy volunteers
Up to 3 placebo patches per volunteer
In-home-like environment
Real-time monitoring via cloud data platform
Compare remote monitor data with site observations

Exploratory Hardware Research
Clinical Study Protocol Development and IRB Application
Clinical Study Hardware Selection
Data Platform and Infrastructure Development
Clinical Study
Data Analysis and Reporting

Progress and Ongoing Activities

Hardware:
- Ongoing exploration of active and passive RFID and Bluetooth tags
  - Core requirements: size < 2x2”, signaling distance while on body < 1 ft
  - Three different types of tags met the core requirements after testing
  - Selected a disposable, low-cost, BLE signaling tag with non-toxic battery
- The chosen tag surpasses size, range, battery life, ease of integration, and data consistency requirements

Data and Infrastructure:
- Remote monitoring capabilities and data collection for study purposes
  - Site feasibility assessment

Key Milestones
- Study protocol approved by IRB - January 2024
- Recruitment materials have been finalized
- Data collection protocol and instruments moved to production

Conclusion
A successful study will provide a strong proof-of-concept for developing a pioneering, FDA approved smart transdermal therapeutic(s) aiming to substantially enhance the safety of patients with Alzheimer’s and facilitate healthy aging at home.

The project described is supported by the National Institute on Aging of the National Institutes of Health under Award Number 7R01AG073103. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Contact: tushar@vaaji.io
Predicting Fall Risk in Older Adults Using Machine Learning
RM Patterson*, J Knebl, KG Fulda, K Camp, F Zhang, M Albert
JH AITC [Aging] Focus Pilot Core

Purpose
Use point of care data to create an algorithm to predict falls and provide real time feedback to clinicians.

Background
Falls are a significant health problem
• 684,000 fall-related deaths in older adults, annually
• 80% are in low to middle income countries,
• Results in more years lived with disability and a decrease in life expectancy

The cause is complex
• Health conditions
• Body structure/function
• Environment
• Personal factors

Pilot Project Highlights
Methods:
Balance data with eyes open and closed is collected while performing intake vitals in the HSC clinic for older adults on all patients (2-minute protocol using a Bertec Force plate).

Milestones:
• Clinical - Collect 1000 encounters
• Update the Power Bi dashboard for viewing
• ML – Use unsupervised autoencoder network to learn statistical relationships in patient demographics, medical comorbidities, balance variables, and falls.

Conclusions
• Managing data from dashboard & EMR
• Integrating data into clinical workflow
• Correlating sway data with individual EMR data (i.e. health conditions, demographics)
• Developing advanced algorithms for prediction

Acknowledgements
Funds to support this AITC study were provided by the Johns Hopkins University AITC under award number P30AG073104.

Balance is an ability to maintain the line of gravity (vertical line from center of mass) of a body within the base of support with minimal postural sway.
Sway is the movement of the center of gravity even when a person is standing still.

Quiet standing sway plot

Current Sway Dashboard filtered for patients 65 and older
Towards Objective Detection of Neuropsychiatric Symptoms using Ambient Intelligence
Narayan Schütz*, Christine E. Gould, Silvia Tee, Feng Yankee Lin, Ehsan Adeli
Stanford University
JH AITC AD/ADRD Focus Pilot Core

MOTIVATION
- Neuropsychiatric Symptoms (NPS), such as agitation or depression, are commonly overlooked in older adults.
- NPS are common early manifestations of neurodegeneration (prevalence of up to 90% in mild cognitive impairment).
- NPS negatively affect the quality of life of both older adults themselves as well as their caregivers.
- Current assessment is based on clinician and caregiver-reported outcomes, thus often subjective, lacking detail, and limited in frequency.

OBJECTIVES
I. Collect clinical and at-home ambient sensing data from patients with NPS
II. Detect select NPS indicators using state-of-the-art computer vision (CV) algorithms
III. Build a clinician interface to let them succinctly access key NPS indicators

METHODS
(1) Collect Data
Study Population
20 Participants, Aged 65+ 10 with reported agitation 10 with reported mood disorders

Study Design
Observational Pilot Study
3-Month Duration
Audio-Visual Ambient Sensor in participant’s kitchen and dining area

Clinical Assessments of NPS and cognition

Outcomes
Clinical Assessments:
- MMSE Behavioral Impairment Checklist (M-BIC)
  Schedule: Beginning - End
- Neuropsychiatric Inventory (NPI-Q)
  Schedule: Beginning - End
- Cognition (based on existing health records)

Ambient Sensors:
- Video
- 16 wall sensors
- PDMs

(2) Detect NPS
Exemplary NPS Indicators
Motor
- Wandering
- Fidgeting
- Shaking/Tremors
- Physical Activity

Emotion
- Anger (towards self, others, or objects)
- Sadness

Evaluation
- Correlate NPS Indicators with MMSE and NPI-Q
- Indicators Differentiate Participants with Agitation vs Mood Disturbances

(3) Build Clinician Interface
Survey Clinicians
- Identify Most Useful Extracted NPS Information
- Develop a possibly Large Multimodal Model/Powered, Physician interface

CV for detecting ADL/NPS
Few-shot detection of activities that correlate with NPS.

CONCLUSION
- IRB is approved; recruitment has started; identified 6 participants so far.
- Immediate next steps include (1) data collection, (2) running a clinician survey on what items to include in the clinician survey. (3) Implementing a prototype.
- This system may lead to the discovery of novel digital biomarkers that can be continuously tracked through time.

ACKNOWLEDGEMENT
- JH AITC: National Institute on Aging grant P30AG073104.
- Stanford School of Medicine, Department of Psychiatry and Behavioral Sciences, Jaswa Innovator Award.
Fairness and Robust Interpretability of Prediction Approaches for Aging and Alzheimer’s Disease

Li Shen1,*, Kazi Noshir2, Victoria Lu2, Bojian Hou1, Weiqing He1, Mary Regina Boland3, Carol Manning2, Aidong Zhang2
1Univ. of Pennsylvania, 2Univ. of Virginia, 3Saint Vincent College
PennAiTech AD/ADRD Focus Pilot Core

Introduction

- Opportunity of EHRs to diagnose AD/ADRD
- EHR-based ML methods that are fair, robust and interpretable solutions for current diagnosis and prediction of the AD/ADRD risk in future

Objective

- Leveraging EHR data in predicting and classifying AD/ADRD
- Defense against Racial / Ethnic Disparities
- Clinical Interpretability via trustworthy AI/ML Methods

- We will take this clinical data and build fair / interpretable models to predict AD severity

Method

- Integration of Debiasing Techniques
- Development of Explainable ML Methods
- Improvement of Human-Centered AI Technologies

Method

- Fairness learning: bilevel optimization to remove bias.
- Train global / local models in upper / lower levels, respectively.
- Lower level: train local models for each group using KL divergence as regularization to restrict the local models close to the global model.
- Upper level, train a global model on the entire data and use KL divergence to make it close to all the local models.
- KL divergence bw models: Bayesian method to transform model parameters into distributions + MC sampling to create specific models.

Timeline and Milestones

Table 1. Timeline and Milestones

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<th>Timeframe</th>
<th>Milestone</th>
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<tr>
<td>Week 1</td>
<td>Aim 1: Enhance Fairness through De-biasing</td>
</tr>
<tr>
<td>Week 2</td>
<td>Post-Test Interpretation</td>
</tr>
<tr>
<td>Week 3</td>
<td>Aim 2: Explainable Model Evaluation</td>
</tr>
<tr>
<td>Week 4</td>
<td>Evaluate methods, submit papers, disseminate code &amp; results</td>
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</table>

Participation Information

- Our preliminary PennMedicine data demonstrate that EHRs can be used to identify cohorts of ADRD patients.

- Participation Information

  - Participation Information

    - Sex: Male/Female
    - Age range: [min, max] 63 [9, 95]
    - Race: Asian 9%, Hispanic 2%
    - Ethnicity: White 65%, Black/African American 23%
    - Unknown/Other 16%

    - Participation Information

Anticipated Outcomes

- Algorithms & tools: De-bias EHR datasets → more trustworthy and generalizable for AD/ADRD prediction
- Algorithms & tools: Interpret prediction models → help inform decision making for AD/ADRD.

Acknowledgements. This work is supported by National Institute on Aging grant P30AG073105 (PennAiTech)
AI-Supported In-Home Brain Assessments for Older Adults and Persons with Alzheimer’s Disease

Jian Shi, MD*, Jacqueline Gong, BA*, Gary Strangman, PhD, Deborah Blacker, MD, PhD, Quan Zhang, PhD
Neural Systems Group Biomedical Engineering Lab | Massachusetts General Hospital / Harvard Medical School
MassAITC AD/ADRD Focus Pilot Core

Background/Introduction/Motivation

- Early and accurate AD diagnosis could save up to $7.9 trillion in medical and care costs, but it can be onerous for older adults to go to the hospital or clinic for regular assessments
- Current clinical AD diagnosis tools—including PET, MRI, cerebrospinal fluid biomarkers—are cumbersome, expensive, or invasive
- What if a self-deployable ‘mobile clinic’ device could support AD-relevant, brain-based assessments at home?

Our Process

1. **NINscan Optimization for In-Home Assessment**
   - Integrate multiple sensing capabilities into one single, easy-to-wear headband

2. **Human Subjects Data Collection**
   - Recruit n=15 AD patients, n=15 cognitively healthy controls
   - Collect multivariate neurophysiological data and cognitive status at home

3. **AI Model for Current AD/Cognitive Prediction**
   - Develop cross-attention based, multi-modal deep learning prediction model

Our NINscan Technology

**Key requirements for application in older adults:**
- Easy-to-use
- Meaningful
- Cost-effective

- Our self-developed NINscan is a battery-powered wearable neuroimaging and vital sign monitoring device
- NINscan simultaneously measures numerous neural and vascular physiological features during rest and daily activities
- We expect to provide comprehensive brain assessments and AD related diagnosis at home

Future Directions

Recruitment & Home Monitoring
- 15 AD and 15 controls from the Longitudinal Cohort within MGH’s Massachusetts Alzheimer’s Disease Research Center’s (MADRC)
- Develop an AI model
  - Transformer-based predictor: data from NINscan systems as inputs
  - Extract high-level semantic knowledge
  - Establish correlations between different data types in the cross-attention-based decoder
  - Combine different data types in the decoder by gated mechanism
  - Simultaneously predict the target AD status/cognitive test scores/plasma Tau using multitask fully connected layers

Additional Applications
- Cardiovascular disease (CVD) - NINscan can also monitor numerous parameters relevant to CVD (continuous blood pressure, vasomotion and pulsatility/diastensibility, cerebral autoregulation).
- Sleep assessment – Sleep is critical to health, but often disrupted in aging populations. NINscan has been demonstrated for self-deployed polysomnography use with NASA.

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Expanding a Multimodal VR Fitness Platform to Remotely Assess, Monitor, and Report Cognitive and Physical Function for Older Adults

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MassAITC/AD/ADRD or Aging Focus Pilot Core

Background

Surgery General 2023 Advisory on the "public health crisis of loneliness, isolation, and lack of connection" 1
- Social isolation: 30% increase in mortality rates, 50% increase in risk of dementia, and 30% increase in stroke and cardiovascular disease - 3 major causes of loss of function for older adults.
- National Academy of Sciences 2017 summary report on the data to delay or prevent cognitive decline in aging found encouraging results for blood pressure medication and two interventions: Exercise + Cognitive training 2
  - Exercise= effective strategy for maintaining independence preventing/reducing cognitive & physical disability reducing healthcare burden of aging population
  - BUT... it's not fun. Low compliance limits its a widespread strategy.

RenederFit is the first VR exergaming platform that combines physical, cognitive, and social stimulation. Research in VR exergaming has demonstrated the potential efficacy of improving physical and cognitive function and suggest potential as a digital diagnostic biomarker.

RenederFit Results from initial pilot study with FrontPorch and USC.3
- 2 sessions (30 min/4k, 4 weeks, 18 participants, avg age: 76.3
- Significant improvements in all physical function assessments:
  - 78% of participants improved the TUG test: (p<0.01), 94% of participants improved TUG Manual: (p<0.01)
  - 89% of participants achieved faster times on the TUG test: (p<0.01), 74% of participants achieved faster times on the TUG Manual: (p<0.01)
  - 5% average increase in movement speed.
- Physical Health, Abilities, and Mobility Index (a = 0.56) increased, p = 0.01
- 48% decrease in fall anxiety
- 44% decrease in pain interfering in daily life
- 32% decrease in loneliness
- 36% increase in how much of others they exercised with in RenederFit.
- 10% of users thought RenederFit was fun.
  - 91% of users had a positive composite of user experience ratings: 4.3/5 average rating for how much they had exercising with RenederFit scale 0/10, 95/10 (most pleasure/least of their entire lives)

Objective

To develop accurate, unbiased ML algorithms using the passively collected data from RenederFit to assess and remotely monitor cognitive and physical function of older adults at home.

Methods

- 30 older adults with cognitive impairment currently receiving physical therapy + 30 live-in family caregivers living with them - decentralized recruitment across US via Clinimas app
  - Use RenederFit for their PT-prescribed exercise for 6 months
    - Uncompleted dyads will be replaced with new recruited dyad
  - Collect daily, weekly, and quarterly standardized assessments of cognitive and physical function
    - Cognitive health: MoCA, Mini-cog, reaction time test
    - Physical function: Timed Up and Go (TUG), TUG Manual, TUG-cognitive, 4-stage balance test, functional reach test, fall anxiety, ADLs, Germin VivoSmart 5 watch data
    - Pain: acute pain, chronic pain inventory
    - Physical health: depression (PHQ-8), anxiety (GAD-7), QoL
    - Caregiver: Caregiver burden and stress (BakasCOS), Communal coping, relationship closeness
  - Collect daily Germin VivoSmart 5 watch data: HR, sleep, steps, etc

Outcome Measures

- Technology: acceptance system usability score, tech acceptance metric, RenederFit usage data
  - Novel outcomes from feature extraction from incoming data streams: ML build, for example
    - 6DoF Positional Tracking: balance, rigidity
    - Eye Tracking: target tracking and latency, horizontal and vertical saccades, attention
    - Face Tracking: mask-like face, appropriate emotional response, facial symmetry/depth
    - Hand Tracking: reach, tremor, cogwheel rigidity, dyskinesia, reaction time, range of motion
  - Performance Data:
    - Cycle: dual-task score, single-task score, baroelons pop accuracy, distance traveled, speed, cadence
    - Pong: accuracy, score, paddle collision speed, difficulty, off/on target hits, paddle distance
    - Traveling, swing depth, spin percentage, total hits
    - Paint: distance moved, range of motion, # brushstrokes, tools used, time spent, artwork created
  - ML Output Score: physical function measure cognitive function measure interpretable by all stakeholders

Implications

Offer a fun, social exercise option accessible for people
- Along the whole spectrum of cognitive and physical ability
- Develop digital biomarkers to remotely monitor the health of older adults while they are exercising at home or maintaining cognitive function.
- Enhance caregiver decision-making, support CG health
- Reduce time to treatment with remote monitoring
- Provide nonpharmacological solution for pain
- Provide digital therapeutic device for PT maintenance program

Acknowledgments

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References

[1] Surry, General 2023
[3] FrontPorch and USC
Non-Intrusive, Fine-Grained In-Home Daily Activity Transcription for Alzheimer’s Monitoring

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Abstract
• Background: Monitoring in-home activities of daily living (ADL) is essential for early detection of AD.
• Goal: Using on-body smartphone/smartwatch as an egocentric sensor hub to sense and transcribe a subject’s ADLs.
• Motivation
  • Self-reported assessment is time-consuming, error-prone, and requires strict patient compliance.
  • Cameras-based solutions are often prohibited due to privacy concerns.
• Key Hypothesis: non-visual multi-sensor fusion methods can be empowered by a data-driven model to achieve near-vision precision.

Challenges and Solutions Highlights
Fusing heterogeneous multi-modality sensors
• Audio: behaviors with unique sound events;
• Wireless Sensing: coarse-grained full-body behaviors and interactions with the ambient environment;
• Motion Sensor: ambulatory actions of single point

Data and annotation scarcity
• Overfitting problem
• Lack of generalization

Example multi-modal sensing data

Self-supervised multi-modal feature representation
• Self-Supervised Deep Clustering
• Knowledge distillation from external audio datasets

Semantic transcription of behaviors
• Refine the annotations to match the sensing capabilities of sensors
• Fine-tune the language model to learn the contextual reasoning

Results and Future Work
• Open-sourced dataset and benchmark
• 72.5% top-1 and 90.8% top-5 mAP for recognizing 105 human behaviors, 49 object interactions, and 54 actions.
• Significant improvement in generalization and extensibility for unseen environments users, and behaviors.
• Overall comparable performance with vision-based methods.

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GlucoCheck: Non-invasive AI-powered blood glucose monitoring device for older adults with diabetes

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Motivation
The US faces a metabolic disease epidemic in the older adult population, with more than 47% of people over age 65 diagnosed with metabolic syndrome and more than 30% of adults over 65 diagnosed with diabetes. To manage these conditions, monitoring blood glucose concentration (BG) and taking appropriate action when values stray from safe levels is imperative.

Unfortunately, BG monitoring involves either a cumbersome process of drawing blood several times daily, implanting needles under the skin, or relying on non-invasive devices that are expensive, inconvenient and/or inaccurate. Frequent finger-prick blood draws, and other invasive methods increase the risk of infection or tissue damage, particularly in seniors with reduced skin elasticity and delayed immune response. Thus, an accurate non-invasive device for BG monitoring would present a life-changing option for millions of elderly patients.

Product and Objectives
We developed GlucoCheck, a non-invasive AI-powered blood glucose monitoring device for older adults with diabetes.

The goals of this project are:
1. To improve the accuracy of GlucoCheck in older adults with MatchAlgo algorithm.
2. Test durability of GlucoCheck by older adults.

Methodology
Features Extraction: Each absorption image is converted into image tensors and individual arrays. Other image and pixel statistics are calculated in frequency and time domain.

Model Selection: In our model, we combine AdaBoost and KNMI as complementary strategies, employing AdaBoost for training the data and adding a weighted KNMI algorithm on the classifiers produced by AdaBoost to generate accurate results.

Data Collection
IRB-FY23-249 - 11/39 older adults
Protocol: Blood samples of the participants were taken using a flexible blood catheter always under supervision a certified phlebotomist. Images of fingers were taken with GlucoCheck glucose identification. Participants need to be in fasting mode and later were given an oral glucose tolerance test. Samples were performed at 10, 20, 30, 60, 90, and 120 minutes. Skin color, temperature and mousier of finger were taken.

Conclusion
GlucoCheck compared with YSI 2300 STAT has a statistical accuracy of 2.52 ± 0.09 with a wavelength of 850nm. It also achieves accuracy >90% in Zone A of the Clarke Grid Error. GlucoCheck also minimizes the outliers and increases the agreement with a wavelength of 850nm.

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Machine Learning to Predict Post-COVID-19 Cognitive Decline and Dementia

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Background and Objectives

Problem:
There is an urgent need to identify novel methods to evaluate the impact of COVID-19 on the dementia risk of older adults while facilitating access for those in low-resource settings.

- Cognitive deficits are frequently observed following COVID-19 illness, particularly in the domains of memory, executive functioning, processing speed and attention.
- COVID-19 may increase the risk for Alzheimer’s disease or potentiate the onset of symptoms in at-risk older adults.
- The COVID-19 pandemic widened disparities in health outcomes.
  - Older adults and members of underrepresented minority groups were disproportionally affected.
  - People living in underserved urban as well as rural communities face distinct challenges in accessing dementia care due to factors such as transportation limitations and scarcity of skilled providers.

Objective:
This project seeks to develop a more accurate, reliable, and accessible method to detect and predict cognitive dysfunction and risk of Alzheimer’s disease in older adults following COVID-19.

Approach:
- We will apply machine learning to:
  - the remote, longitudinal, app-based measurement of cognition
  - demographic characteristics
  - Features of the acute COVID-19 illness and related treatment

Pilot Project Highlights

Study Design & Participants:
- This prospective cohort study assesses cognition remotely on 6 occasions over 3 months using a smart-device application
- Participants are ≥ 60 years old, have a documented history of COVID-19, and have an Internet-connected smartphone or tablet
- Recruitment sources: the Johns Hopkins Post-Acute COVID-19 Clinic and the Hopkins Opportunities for Participant Engagement Registry.

DANA™ mobile application:
- The FDA-cleared DANA™ mobile application was developed and validated to detect subtle cognitive impairment
- 7 cognitive tests: Measure simple and procedural reaction time, processing speed, visual working memory, spatial processing, response inhibition, and memory
- Symptom inventories: Measure depression (PHQ), anxiety (GAD), subjective cognitive dysfunction (ASRS)
- Rich DANA™ data:
  - Accuracy, mean reaction time, and throughput
  - Trial-by-trial response data resulting in >200 data points per administration
  - Each data point is described by multiple parameters such as response time, inter-trial interval, and trial difficulty
  - Captures intra-individual and intra-task variability, which are risk factors for Alzheimer’s disease, while also measuring fine-grained changes over repeat assessments
  - Provides a performance-based measure of cognitive fatigue

Project Status

Enrollment:
- Current enrollment: N = 20
  - Mean age: 66 years
  - Mean education: 14.9 years
  - Race: 25% non-white
  - Mean MoCA: 18/22 (normal ≥ 19/22)
  - Mean DANA adherence: 89.4% completion of assigned assessments
- Goal: n = 120
  - 20% of participants residing in rural areas
  - Interim data analysis planned at n = 60

Future
We will expand the present study to employ longer follow up periods and dementia outcomes to further refine the algorithm, allowing for development of precision models of AD risk that exceed existing gold standard approaches and allow improved patient access.

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Detection of Falls and Other Health Events Using Sound, Activity monitoring and Machine Learning

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**Background**

Falls annually cause 32,000 deaths, 7 million injuries and over $50 billion in Medicare costs. Our research presents a novel approach to detect falls using audio and activity monitoring. The research will also study if the system can reduce an older adult’s fear of falling which may also decrease falls.

Livindi is used by thousands of older adults to stay healthy and safe using communication, monitoring and Medicare-covered virtual clinical services. The complete Livindi platform provides a tablet, call button, passive activity sensors, biometric sensors and enterprise tools.

Our research focuses on real-time detection of verbal requests for help as well as a model detecting changes in activity patterns to determine if someone has fallen. If a fall is detected, the system will engage the care team via an App on their phone.

**Objectives**

- Detect falls by listening for the phrase “Help Me”, on-device, and monitoring for changes in activity patterns using sensors.
- Reduce fear of falling based on changes in the Falls Efficacy Scale (FES).
- Allow listening for alternative phrases without re-training the audio model.

**Project Highlights**

- The tablet captures a constant audio stream
- Window Sampling
- Noise Reduction
- Voice Activity Detection
- Automatic Speech Recognition
- PIR sensors capture motion data
- Door sensors capture egress, bathroom and refrigerator activity
- False Positive Reduction and Triage Analysis
- Notification and Automated Calls
- Activity Analysis Model
- Button and Watch accelerometers capture activity and explicit requests for help
- Care Team Engagement

**Methods**

Several methods were used for ASR including training an RNN model on audio samples saying “Help Me”. This method was limiting and had a high error rate with background noise. We ultimately used a weak-supervision model with better noise reduction and dynamic triggering.

**Milestones and Commercialization**

The solution is commercialized and launched in Q3 2024 on the Livindi platform. We are currently fine-tuning the models and the False Positive Reduction. The study will show how accurately it detects falls and calls for help and if it can reduce fear of falling which studies show may also reduce falls.

**Participant Enrollment**

Recruitment begins Q2 2024. Participant criteria includes: age 65 or older, can move independently with or without walking devices, lives in a home with one egress door and may have cognitive impairment. Participants will be provided the Livindi system for the duration of the study and will have full use of its other features including video calling, picture sharing and caregiver support.

**Conclusions**

Our research addresses a critical healthcare issue by leveraging ASR and activity monitoring technology to detect falls, a leading cause of injury and high medical costs. By integrating audio detection of the phrase “Help Me” with an activity monitoring system, we have demonstrated a novel, proactive approach to enhance the safety and well-being of seniors.

In Q1 2024, we launched the technology on the Livindi platform. Once enrollees are in the study, we will also determine if the system can help reduce fear of falling by administering the Falls Efficacy Scale survey to enrollees before the study begins and after the study completes.

The research will also be used to provide proactive voice prompts used to confirm detection of other health issues based on sensor data for the in-home virtual care system.

**Acknowledgements**

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A Digital Biometric Approach to Reducing Hospital Admissions for Underserved Older Adults with COPD

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MassAITC Aging Focus Pilot Care

\section*{Background}

\begin{itemize}
  \item Chronic obstructive pulmonary disease (COPD) poses significant mortality and morbidity in elderly population with disproportionate under-diagnosis and management of individuals with ethnic and socioeconomic disparities.
  \item Significant comorbidities, challenges with accessing care, and infrequent clinic visits are barriers to detecting and managing COPD.
  \item Home management of COPD patients is crucial to reduce morbidity and mortality, decrease hospitalizations and ER visits, and improve overall quality of life in the aging population.
  \item Conventionally used for early detection of COPD exacerbations, home spirometry faces significant limitations in the elderly due to adherence as well as physical & cognitive challenges.
  \item An innovative solution involves passive assessment of acoustic data from cell phone recordings, as a surrogate for spirometry, to detect COPD exacerbations unobtrusively.
\end{itemize}

\section*{Objectives}

\begin{enumerate}
  \item Develop a COPD Care mobile app and integrate the audio-based COPD metrics, educational material, and messaging protocols into it.
  \item Complete usability testing of the COPD Care app prototype with older adults with COPD in a laboratory setting (2 rounds of testing with 5 subjects each).
  \item Conduct a feasibility pilot of the working COPD Care mobile app over an 8-week period in the homes of 20 older adults with COPD.
\end{enumerate}

\section*{Pilot Project Highlights}

\subsection*{Data collection}

1. \textbf{Demographics}: Age 65, of minority or low socioeconomic status, speak English, have a smart cellphone, and with at least moderate COPD.
2. \textbf{Static variables}: GOLD Stage, typical sleep time, typical waking time
3. \textbf{Dynamic variables}: Peak flow and FEV1 (from home spirometer), heart Rate, SpO2, activity steps, stress level, sleep length and quality (from smart watch).

\subsection*{Outcomes}

1. \textbf{Primary outcomes}
   a) \textit{App satisfaction and ease-of-use}: via single-item questionnaire (mean \pm SD)
   b) \textit{Satisfaction with overall clinical care}: within-subject t-test
2. \textbf{Secondary outcomes}
   a) \textit{Engagement}: via monitored system usage (mean \pm SD)
3. \textbf{Exploratory outcomes}
   a) \textit{FEV1}: within-subjects t-test.
   b) \textit{Q of L} — within-subjects t-test of CAT score (QR code for CAT score)
   c) \textit{Voice-based Pulmonary Function (VPF)}—correlate VPF to COPD symptoms, SpO2, and step counts.

\section*{Motivation & Innovation}

- Monitor underserved older adults with COPD at home using an unobtrusive metric derived from acoustic features collected during regular cell phone use to detect preventable exacerbations that would, otherwise, lead to hospitalization.
- AI-based metric was developed by Samsung Research America using deep learning algorithms trained on large COPD data sets.
- Speech recordings are processed using pre-trained YAMNet to obtain embeddings, serving as input features for a COPD classifier based on fully connected networks.
- The final output of the sigmoid classification is a probability value, with a value > 0.5 indicating the likelihood of the speech recording being from a pulmonary origin.

\section*{Conclusions}

If results support the outcome, data from this innovative pilot study could be used to inform a larger follow-on clinical trial with a larger sample of COPD patients towards commercialization and nation-wide use of COPD care App.

\section*{Acknowledgements}

National Institute on Aging grant P30AG073107
**BACKGROUND & OBJECTIVE**

- Overlapping symptoms in various forms of dementia highlight the urgent need for better diagnostic methods.
- The scarcity of neurologists, especially in remote and developing regions, intensifies the need for more accessible screening tools.
- Recent regulatory approvals of disease-modifying therapies for Alzheimer’s disease emphasize the importance of early risk detection.
- Reliance on in-depth clinical evaluations, cognitive testing, and MRI scans for diagnosis calls for specialist expertise, underscoring the demand for advanced, user-friendly diagnostic technologies in primary care and general neurology.

**Objectives:**

- To develop an AI model that harnesses a broad array of data, including demographics, person-level and family medical history, medication use, neuropsychological assessments, functional evaluations, and multimodal neuroimaging, to identify the etiologies contributing to dementia in individuals.

**METHODS**

**RESULTS**

- Development of a multimodal machine learning architecture integrating numerical, categorical, and imaging data.
- Model alignment with clinical dementia ratings.
- Comparison between model-predicted probability scores and the assessments provided by practicing neurologists.

**CONCLUSIONS**

- Our model differentiates various etiologies of dementia using diverse modalities, including individualized demographic, health status, neuropsychological test, and multivariate MRI parameters.
- The model demonstrates potential for early risk detection and diagnosis, facilitating personalized treatment strategies.

**REFERENCES**

A speech-processing algorithm for automatic screening of Black patients with mild cognitive impairment and early dementia in home healthcare setting

Maryam Z. Iztarzooi, Columbia University Medical Center, VNS Health, New York, NY

Background
Mild cognitive impairment (MCI), and early-stage dementia (ESD) are major public health concerns, affecting one in five older adults over 60. Despite notable efforts, more than 50% of MCI/ESD patients remain undiagnosed. Data from the National Institute on Aging (NIA) reveals that less than 1 in 10 MCI patients have a favorable rate of cognitive change compared to their White counterparts just two years later. The use of electronic health records (EHRs) have substantial performance in early detection of MCI/ESD. It is hypothesized that integrating audio-resonated home health patient-nurse verbal communication with EHR data use enhances screening algorithms, enabling timely identification of patients with cognitive impairment, particularly among Black patients.

Objectives
This study aimed to develop a natural intelligence-based pipeline for audio-recording home healthcare patient-nurse verbal communication, modeling the audio-recorded data using natural language processing (NLP), and developing machine learning models for timely identification of patients with mild cognitive impairment (MCI).

Method
The development of the pipeline consisted of four components:
Component 1: We created a novel procedure for audio-recording patient-nurse verbal communication in a home healthcare setting. As part of this procedure, we tested the viability of seven audio-recording devices in both laboratory and in-home settings. We also interviewed five nurses and select patients to understand the feasibility of this procedure. Component 2: We identified the specific features of interest, and a speech recognition (SR) system to extract the ASR system with high accuracy for automatic transcription of audio-recording verbal communications. Component 3: We developed machine learning classifiers for automatically differentiating patients' speech from the nurse's speech in the audio-recorded patient-nurse verbal communication. We choose this classifier because it maintains better retrieval performance when used with conventional feature processing (e.g., linear discriminant analysis) generated from patients' and nurses' utterances. Component 4: We developed a screening algorithm by training and evaluating several ML models on the combination of audio-recorded patient-nurse verbal communication, home healthcare clinical notes, and a set of clinical variables from EHR system, such as the list of medications and diagnosis for 10 Black patients, natural language processing techniques, and pattern of communications were used to identify the early detection of cognitive impairment. These algorithms were tested using advanced natural language processing methods such as Clinical BERT (Figure 1).

Results
Component 1: According to nurses' evaluations, Parametric Bink, a complete-recording audio-recording device, yielded the highest score for usability. Both nurses and patients found the audio-recording process satisfactory. Component 2: The natural language processing (NLP) using the ASR system, Speech-to-Text conversion for the automatic transcription of verbal communications due to the highest accuracy of transcription (Viterbi Error Rate < 0.2%). Component 3: The performance of the classifier for differentiating patient speech from nurse's speech has an F1 score of 95%. Component 4: The initial performance of the screening algorithm for cognitive impairment detection using only natural language processing (NLP) features was encouraging. The early detection of cognitive impairment using advanced algorithm using EHR data including clinical text) be 10%. Moreover, when EHR data were added to the patient-nurse verbal communication, the F1 score increased to 85%

Conclusions
The MCI/ESD screening algorithms developed using this pipeline for Black patients has strong potential to be integrated with home healthcare workflows, to automate detection of home healthcare patients with cognitive issues. Therefore, the home healthcare team can approach patients with appropriate interventions to mitigate risks.

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