Handouts to accompany Poster Paper 214, Session 7680
'Comparison of Sensor Based Continuous ADL Assessment to Care-Giver ADCS-ADL Survey Results'

This handout is intended to provide contextual information on the study and details on the data derivation from the sensors for the results presented in the poster paper.

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Abstract:

This paper presents preliminary correlation analysis results between the Birkeland Current Sovrin IoT in-home sensing system and monthly ADCS-ADL survey data for 117 CareRecipient/CareGiver (CR/CG) pairs as part of a Phase II NIA SBIR study (R44AG065118) conducted from 2021 to 2023. The analysis provides correlation analysis between overall BC ADL Scores and ADCS/ADL Scores as well as comparisons to two-factor IADL/BADL scores and to the four-factor Kahle-Wrobleski ADL scores (W1-W4). The CR population was screened to represent mild to mid-level cognitive decline utilizing the MMSE tool with the expectation that most of the change in ADL scores would be based on IADL groupings. Utilizing percent change from monthly ADL survey scores and associated subscores, the BC system demonstrates significant correlation with the ADCS-ADL score at the level of sensitivity of the ADCS survey and subfactor results. For modest change, the BC system shows significant sensitivity to two factor IADL change (10-20%) with the two-factor BADL sensitivity dominating for 30-40% change. The BC system shows little or no sensitivity to the W3 (communications and engagement) and W4 (outside activities) scores as these are items not directly measurable by the BC system. The correlation with the W2 (Household Activities) provides the highest subfactor correlation at low change levels and most closely represents the BC system approach which is dominated by household activity measures. Utilizing the correlation approach, the BC system is able to demonstrate sensitivity to a single point change in the two factor BADL score and a one-point change in the two factor IADL score which matches the consensus sensitivity of the ADL survey. All data presented is statistically significant at an alpha value of 0.05.

Study Introduction and BC system Overview:

With global aging, it is important to establish the daily functioning and associated care needs of older adults living at home or in congregate independent living environments. Typical functional and cognitive assessments are

carried out in a clinical environment at relatively sparce timing (semi-annual to annual). The results of these assessments are critical in establishing annual care plans and care reimbursement strategies especially under CMS and LTC insurance requirements. Most often, these assessments are accomplished based on Care Giver subjective observational retroactive surveys. In the case of Alzheimer's and Dementia populations, an accepted standard survey tool is the ADCS-ADL method developed in the 1980's. These survey methodologies suffer from a variety of limitations such as: self or third-party assessment biases, non-continuous assessments, discrete versus continuous domain indicators, use of indirect domain measures, and reliance on a small number of domains and indicators. As such there is a recognized need for better assessment tools, especially during early AD/ADRD stages when the rate of progression is not as acute, or individuals maintain sufficient cognitive function to effectively mask the decline and their care needs. The 2015 NIH AD Research Summit, included a variety of recommendations specifically addressing the desired goal of developing improved measurement tools for monitoring and assessing AD/ADRD populations. As sensor technologies, wireless communications, edge computing, and big data analysis techniques have matured, we are now in a position to provide low-cost, ubiquitous, non-invasive sensing in homes and facilities to improve upon prior assessment techniques conducted by home health care professionals. This sensed data provides the ability to identify individual patterns of behavior, changes to those patterns, and required and delivered assistance levels with unprecedented fidelity.

With this background need, Birkeland Current developed the Sovrin IoT sensing system which utilizes smart home technologies to monitor device utilizations in the home and combines that with real-time location of the care recipient and care giver to attribute specific activities to a care recipient and establish the level of assistance provided by the care giver. This data is therefore able to provide an ADL equivalent score on a continuous basis. Under NIA SBIR Phase II grant R44AG065118, Birkeland Current outfitted 117 CR/CG homes or assisted living locations with the BC Sovrint IoT sensing system and monitored individual BC ADL Scores continuously for up to 18 months. During the monitoring period, ADCS-ADL surveys were conducted with the CG's on a monthly basis. Inclusion of individuals for the study was conducted under IRB approved criteria and utilized the MMSE as a screening tool to include individuals over 65 years of age with mild to mid-level cognitive decline (MMSE < 26 and MMSE > 11). CG inclusion required the CG to be present and providing CR assistance a minimum of 6 hours per week. The overall AIM of the research was to demonstrate improved sensitivity to identifying decline in AD/ADRD populations.

Data Set Derivation:

The BC ADL Score is derived from continuous sensor measurements of individual locations and device interactions in a home or facility location. Typically, the BC Sovrin IoT system provides measurements with 10 second resolution of sensored devices and individual locations. This raw data stream is converted into individual device events (start of flushing toilet, start/stop taking shower, opening/closing refrigerator door, etc.) These device events are combined based on BC developed algorithms to establish activities (bathrooming, bathing, meal preparation, etc.) When an event or activity is detected, the BC system utilizes the concurrent real time location information to attribute the event or activity to an individual (primary) and to identify if there are other individuals in the household that are assisting in the activity or event (secondary). Attribution and assistance levels are established as functions of proximity of individual(s) to the event or activity and relative timings of proximities to events or activities throughout the duration of the event or activity. Scoring of the individual events and activities mimic the ADCS-ADL approach where typically a 3 is assigned for no-assistance, 2 assigned for minimal or supervisory assistance, 1 assigned for functional assistance, and 0 assigned for full assistance in the task. For the

BC Score, a 3 is assigned if the CR accomplishes the activity without assistance from the CG, a 2 is provided if the CR is the primary attribution and the CG is secondary, a 1 is provided if the CG is primary and CR is secondary, and a 0 is provided if the CG is the primary attribution and the CR is not involved. The BC scoring is only accomplished on events and activities where the system is fully operational during the duration of the event and the individuals involved in the event are fully identifiable and locatable throughout the duration of the event or activity. In this way, individual BC activity scores are established for each event throughout the day. These scores are averaged over a desired time period (day, week, month) to provide an aggregate total BC ADL Score which is directly comparable to a total ADCS/ADL Score.

The comparator ADCS/ADL Score was derived from monthly CareGiver phone surveys from staff certified under Baylor Scott and White Hospital system requirements to perform the surveys. Survey responses were captured in a real time data management system and deidentified, scored and subscored according to ADCS-ADL two-factor subgroup and Wrobleski 4 factor subgroup scoring approaches. The ADCS/ADL approach represents a class of retroactive observational survey tools. In this case, the ADCS requests observed summaries of assistance levels for various activities during the previous 4 weeks from the time of the survey.

Based on the actual dates of the ADCS survey, BC ADL average scores were derived as described above for the preceding 28 days, 21 days, 14 days, and 7 days. The number of BC events combined for average scores is also provided to allow filtering for statistically representative data during correlation comparison. Each BC Score is accompanied by an N value of scored events that were used to compute the BC Score as described above. In some cases, a null value is assigned to the BC Score based on no BC scored events during the previous time period. This could be caused by an extended period of CR out of house, extended period of specific house or facility down time, or extended period of CR or CG not carrying their associated location devices and therefore not allowing BC scores to be established. These N values [events tally] are used for quality control during analysis described below. A total of 1356 independent interviews are accomplished with an average of 11.6 interviews spanning an average of 10.6 months in the study for CR/CG participants. Individual participation ranged from 1 month to 18 months in the study.

Conclusions

This initial analysis was intended to identify the ability of the BC system to detect change in functional assessment with a similar sensitivity to an accepted observational measurement technique. The comparison analysis between two fully independent measurements (home sensors versus care giver observational assessments) demonstrates good to excellent correlation for change observed by the accepted standard at the available precision (1 point) of the accepted standard. Additionally, the BC system demonstrates sensitivity to detect change at a threshold of the total ADCS-ADL score (~11%) and below the acceptable threshold of the two factor IDL score (13% versus 20%). The BC score in this analysis did not meet the threshold requirement of the two factor BADL score (approximately 5%). Additionally, the BC score in this analysis showed sensitivity to the Wrobleski Household items and was insensitive to the Wrobleski W3 and W4 factors as was anticipated based on BC sensor measurements. Additional review of the W1 BADL factor is warranted as the p-values computed were not significant while the two factor BADL changes were.