TochTech Sleepsense Trial

Bruyère Research Institute and Carleton University

AGE-WELL SAM[3] NIH

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AGE-WELL National Innovation Hub
Centre national d'innovation d'AGE-WELL

Sensors and Analytics for Monitoring Mobility and Memory
Capteurs et analytique de suivi mobilité-mémoire

Bruyère

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Carleton UNIVERSITY

Executive Summary

The TochTech Sleepsense bed occupancy sensing technology was installed into 15 rooms for a period of five months, within the Ottawa-based Courtyards on Eagleson, All Seniors Care retirement community for dementia care. The research and coordination of the project was run and administered by researchers at the Bruyère Research Institute and in collaboration with the AGE-WELL SAM3 National Innovation Hub.

The TochTech Sleepsense bed occupancy sensor is a puck-like sensor that is placed under the leg/foot of the resident's bed. It is paired with a matching placebo puck on the other side to ensure the bed stability is not compromised.

Participants were recruited with the assistance from the staff and Director of Care at Courtyards home. Participants were identified based on their risk of falling at night or other risks associated with overnight exit such as leaving their room. The family members and/or Substitute Decision Makers (SDM) for potential participants were approached through the Courtyards staff to discuss the possible interest of having their loved one (Person Living with Dementia) participate in the study. The research team obtained consent after discussing the study with the SDMs.

Once installed and connected, the sensors would send "out-of-bed" alerts to the nighttime-care staff to provide insight about who was out of bed. These alerts were either sent immediately after the bed sensor reported lack of occupancy or sent after a pre-determined and custom time delay. This accounts for the residents who are considered a high-fall risk compared to those who are more independent and able to use their bathroom during the night.

Over the course of the study, the research team visited the care home for technical maintenance and ensured all sensors remained connected and functioning per staff member's needs.

One night in December, the staff received no alerts. There was no mention if any of the residents were found out of bed, but the unusual event of receiving no alerts caused the staff to reach out to the research team. This issue had to be pushed to the TochTech support team as it appeared the Vericare application (installed on the phone used by staff) required an update. The TochTech team updated the application, and the issue were resolved.

Overall, the technology functioned and provided “out-of-bed” alerts to the night staff with 10 errors across the months of October to December, included. Staff were asked to reach out to the research team in the event of a false alert or lack of alert, in which case the issue was investigated. Staff were also asked to answer a short Likert scale questionnaire about their overall impression of the system. The results were positive.

Report Details

Overview

The research protocol was approved by the Bruyère and Carleton Research Ethics Boards and executed under the SAM3 National Innovation Hub. Staff members under All Seniors Care at the Courtyards location in Kanata provided potential participant SDMs with information on the study so that they could indicate their interest in participation and subsequently provide their informed consent, on behalf of their loved one prior to starting the study to the research team. The sensors were deployed in the rooms for five months.

The Care Setting

Courtyards on Eagleson is a retirement community for people living with dementia (PLWD). This community is partitioned into four separate quadrants (or blocks) with locked internal doors between the blocks and has a total of 71 suites (See Figure 1). This facility offers 24-hour care and provides all forms of care from mid-stage dementia care to end-of-life and palliative care. This facility is not an assisted living-home, and hence does not provide nursing care. As a result, there is no need for beside electronic patient records and the or the supporting network infrastructure.

Each block is square and has resident rooms on the outer perimeter with an enclosed outdoor courtyard inside. To allow for natural light and a bright environment, the hallway across from the resident rooms is mostly large windows looking into the block's courtyard. Each block has their own network and router, primarily used to connect the TV in the shared common area / living space to the Internet, but this was not designed or intended to reach all resident rooms. If family members wish to bring internet into their loved one's room, they can use an ethernet port in their rooms. Also, they must bring their own router to create a local Wi-Fi. staff do not use Wi-Fi as part of care delivery or record keeping.

Figure 1. Aerial view of the Courtyards home layout.

The Staff

The nursing staff members at Courtyards on Eagleson consist of Registered Practical Nurses (RPNs), and Personal Support Workers (PSWs). During the night shift, there is one RPN for the entire facility and four PSWs located one per block. The night shift PSWs perform several regular duties, including hourly checks on each resident room to ensure the resident is sleeping and does not require any assistance.

The night-shift staff identified two particular nighttime challenges. Some residents may wander at night leaving their rooms, possibly enter other resident rooms, or just remain up in the common area. Staff will guide them back to their suite. Others are at risk of falls during the night and require assistance with toileting quickly once they arise from bed.

When it comes to reporting on events, staff report only on exceptional events with respect to the normal for each resident. Courtyards is not a nursing home or Long-term care facility and therefore does not maintain detailed nursing-related patient records, which would typically store

all patient events. For this facility, they report in the patient record events that are out of the ordinary should there be a medically related issue. If a resident regularly wanders, their wandering will not be reported. In the case of a resident who doesn't wander, and then is found one night wandering, this event will be recorded. All falls all reported on.

The Residents

For this study, the goal was to obtain interest and consent from two of the four blocks, reaching around 50% of the Courtyard residents. After beginning the consent process, this goal was deemed challenging and adjusted to around 20 participants in total. This would include the five participants from the previous pilot MITACS study (see *Results* section for more details) using the same sensor at the same retirement community that would continue into the new trial.

During the study, we obtained consent from an additional 10 residents, with the included five from the previous study, bringing the total data count to 15 participants (F=11, M=4). These participants range in age and mobility capabilities, but all were labelled with concerns for their nightly activities around falls and/or wandering by the Courtyards care staff.

The Device

The TochTech SleepSense device is a coaster-sized sensor placed under the bed leg, similar to the one shown in Figure 2. It is paired with a second placebo coaster to balance the bed. The sensor can detect when someone gets into bed and when they leave. The sensor also collects heart rate, breath rate, motion (toss and turn) and sleep stage (light, REM, deep), and whether the sensor is online (i.e., connected to the network). This information is gathered and presented into a graphical view for each night, similar to the graph in Figure 3.

Figure 2: TochTech Sleepsense device under a bed leg.

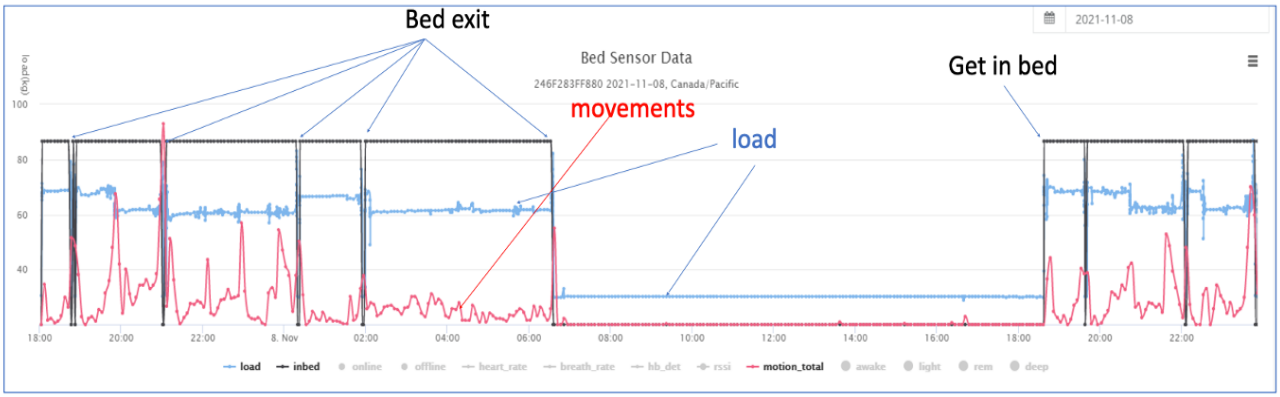

Figure 3. Sensor collected data illustrating bed exits and other biomarkers.

Deployment

The TochTech sensors were deployed in three of the four building pods based on where the participants rooms were located. One sensor was in the A pod, eight in the B pod and six in the C pod. With the pre-existing internet challenges found during MITACS study, initial sensor installation also included the installation of 3 Bell ZTE routers to replace the equipment previously used. Two routers were placed in the B pod (with the most sensors and based on the room spread in that pod) and one router in the C pod. A smaller portable router was brought to the A pod.

Shortly after the sensor and ZTE installation, the ZTE routers appeared to disconnect from the LTE network. The research team went to Courtyards and re-connected the devices, but after a few days, they disconnected again. After some research, it was discovered that the ZTE router is no longer a technology supported by the current LTE network infrastructure. These routers were quickly replaced with newer Huawei LTE routers and were all placed in the facility hallways, out of sight, to limit the risk of residents or staff disconnecting the router's power. Figure 4 illustrates one of the routers hiding locations.

Figure 4. Router hiding location to limit residents and/or staff from tampering.

Results and Discussion

Phone Alerts

The night staff nurse was given a cell phone with the TochTech Vericare application installed. This application received notifications (such as when a resident is out bed or off their sensor) from the TochTech Sensors and cloud system t presented to the nurse on the cell phone. This allowed the staff to check on residents sooner than their usual hourly rounds.

This application also allowed the staff to take note of any discrepancies with the sensors and the application and report back to the research team. During the first pilot of the study, with only five sensors, the staff were asked to manually report on all phone alerts. Each alert indicated a bed exit, and the staff were asked to verify if the alert indicated a true exit or a false exit. In a few cases, if the resident was found outside of their room or out of bed with no phone alert, this was also recorded. The staff performed this for a two-week period, and the research team manually tabulated the following results, displayed in Table 1.

Table 1. Summary of phone alerts across a two- week period.

	Total Alerts	Total Correct Alerts	Total False Alerts	Total Missing Alerts
TOTALS	61	48	13	8

A total of 61 alerts were sent to the staff phone, of which 48 were correctly reporting the situation at hand (i.e., the alert read “resident out of bed” and the staff would find the resident out of bed) representing around 78% accuracy. Thirteen of the alerts were noted as discrepancies, and in eight instances, the staff noted missed alerts where the resident was found out of bed with

no alert. This is a total of 21 cases in which the staff experienced a discrepancy with the technology. Of the 21 discrepancies, six of those cases were times at which a duplicate alert was received by the cellphone, this occurred only one night so an out-of-bed was reported twice with a delay on the second report. This could have been the result of a network error as the cellphone may have had Wi-Fi connection issues (as this was a known area of weakness in the pilot trial).

Using the Vericare Field Tool web portal, the research team examined other cases of false alerts to determine what the sensor data indicated at the time of the alert (false positive: out-of-bed alert was sent, but resident was not observed by staff out of bed). This was analyzed to determine if the resident managed to get back into their bed before staff could respond to the alert. In one case, there were many device triggers around the time of the alert. The reason for the device triggers (many changes between on and off bed) is unknown but could explain why a false alert was noted.

In four noted discrepancies, no data was found in the Vericare Field Tool web application as the device was offline and not providing data. This indicated that the sensor was not working or at least not online which could be related to network issues. This leaves 10 instances where the alert or lack of alert remains unknown. For these instances, the device network status (online or offline) was analyzed. In all cases, the device reconnects online within a matter of minutes if it drops its network connection, and these drops were not noted around the time of concern (noted by the staff) eliminating network issues as a plausible cause. Another possible explanation could be from the cellphone Wi-Fi connection if it was moved around the building, out of range of the known Wi-Fi signals. This remains unknown but a likely cause for delayed and duplicate alerts (which were noted nine times). This process was manual for both the staff and the research team, and therefore could include human errors and not be 100% accurate to the technology results.

These were previous fundings from the pilot trial at this location. To avoid further network complications, the research team provided a more robust solution by bringing in LTE routers so that the TochTech sensors did not have to rely on the internet provided by Courtyards. ZTE routers with data SIM cards were used at the start, however after a couple weeks, the routers would disconnect from their internet connection. Research found that this was common in ZTE routers, and they were quickly replaced with portable Huawei routers using the same data SIM

cards. Once the Huawei routers were installed, the network connection for both the sensors and the phone was more stable and reliable.

Staff and Feedback

During the challenges and solutions around the network connection, there were also challenges experienced around staffing. The deployment of the sensors was delayed due to the facility undergoing waves of COVID-19 outbreaks among staff and residents. This caused the facility to operate under short/minimal staffing for most of the summer months. During this time, the facility also closed their doors to visitors, which included the research team. This delayed the project start, not only because visitation was not permitted, but also adding a new task for research while operating under short-staffed working conditions resulting in more staff stress during an already stressful time. This would have limited staff engagement. Once the COVID-19 situation resolved, the research team was able to deploy the sensors.

After solving the network issue by installing newest LTE portable routers, the staff were asked to only take note of false events. This would be related to the cases where the phone received an alert, and the resident was not out of bed, or the staff found a resident out of bed, but no alert was sent. This was a tactic to help reduce the added work that comes with a research study, as the staff and facility were already experiencing external stressors. By only reporting on false positive error events, the research team achieved a higher study compliance and engagement from the staff over the duration of the project.

Both the Director of Care and the night nurse were asked to fill out a quick and simple questionnaire (see Figure 5) bi-weekly about their perception of the technology. The goal of this questionnaire was to provide insight on staff acceptance and enjoyment of the system, without being a point of stress for workers who already had their workload full. Results from their responses can be found in the table below with the first and last responses bolded.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When the technology is online/functioning:					
This technology has made my working hours more efficient?	1	2	3	4	5
This technology supports the work I do daily.	1	2	3	4	5
I can provide better care to my residents with this technology.	1	2	3	4	5
I trust the notifications from the technology.	1	2	3	4	5
I wish more residents under my care had this technology.	1	2	3	4	5
This technology provides information on nightly patterns that was not accessible before	1	2	3	4	5
This technology works most of the time.	1	2	3	4	5
I trust the notifications from the technology.	1	2	3	4	5

Figure 5. Questionnaire provided to the staff on three occasions during the study.

Table 2. Results of the questionnaire from figure 5.

	Response 1		**Response 2**		**Response 3**	
When the technology is online/functioning:	Staff 1	Staff 2	Staff 1	Staff 2	Staff 1	Staff 2
This technology has made my working hours more efficient.	**4**	3	4	3	**4**	N/A*
This technology supports the work I do daily.	**4**	4	3	4	**4**	N/A
I can provide better care to my residents with this technology.	**4**	4	4	4	**4**	N/A
I trust the notifications from the technology.	**4**	2	3	2	**3**	N/A
I wish more residents under my care had this technology.	**4**	3	4	3	**5**	N/A
This technology provides information on nightly patterns that was not accessible before	**4**	5	5	4	**5**	N/A
This technology works most of the time.	**3**	3	3	3	**4**	N/A
I trust the notifications from the technology.	**4**	3	3	2	**4**	N/A

*During the last month of the trial, Staff 2 left their role at Courtyards, and it was not filled before the project ended. Thus, they did not complete their response to the final questionnaire.

Between response 1 and response 2, the technology experienced some connection issues. This was related to a sensor being unplugged, presumably by the resident. Another device was offline, which was determined to be a network issue, where restarting the router solved the error.

Table 3. Results for the trial showing identified errors and likely cause.

Month	# Sensor Experienced Issues	Network Related	Staff/Resident Tampered	Other/ Unknown	Notes
Oct.	5	3	2		Sensors were found unplugged and removed from their under-bed leg location. These are noted in the results under the discussion of assent. A router was also unplugged, and this led to it being reinstalled in a more hidden location.
Nov.	1			1	Resident was moved to a mattress on the floor as they were experiencing frequent falls. This move was made prior to the issue being resolved but not related to sensor behaviour. Sensor challenges experienced prior to the move to floor due to sensor sensitivity as this resident was petite and the roll to side issue identified in the objective study for smaller subjects likely applies.
Dec.	4	2	1	1	Vericare Phone Application needed to be updated, which caused one night when no alerts were produced.
Jan.	N/A	N/A	N/A	N/A	N/A*

*During the last month of the trial, Staff 2 left their role at Courtyards, and it was not filled before the project ended. Thus, they did not complete their response to the final questionnaire.

Staff Usage

After the network issue was resolved in the fall and the sensor system appeared stable, the night staff were asked to report only if there were false alerts. This resulted in emails regarding sensors that "misbehaved" the night previous. This started in October as September was spent replacing the ZTE routers with new portable LTE routers. The research also needed to wait for the regular night nurse to return from vacation as they were most familiar with the project and their role within the project.

During these months, there were cases where residents removed or unplugged the sensors. This happened in two rooms multiple times . In another sensor case, the sensor was placed under a queen-sized bed, under the leg at the head of the bed closest to the wall, rather than the side that the resident used for entry/exit. Since the resident was quite petite and their bed was considerably heavy, this resulted in some false alerts with the sensor and phone as shown in the objective testing report. This case was also tested during our objective testing cases in a controlled lab setting, and the outcome observed was similar to that seen at the study location. Moving the sensor to the head of the bed on the side of entry/exit solved the issue.

In January, the night nurse left their job, and their position was sporadically filled with day nurses. This resulted in a non-consistent staff member monitoring the facility, in which case the phone was not in use as the Director of Care preferred only to have their regular night nurse involved with the research.

Consent and Assent

The staff at the home contacted each potential participant Power of Attorney's (POA) to ask if they would be interested in joining the study and to ensure that they consented to being contacted by the research staff. Once the POAs consented to being contacted by research staff, their contact information was shared with the research assistant. The research assistant

proceeded to contact the POAs to discuss the participation of their loved one in the study. If the POA agreed, they signed the consent form on behalf of their loved one, and occasionally would mention the study to their loved one during visits. Once consent was provided, the research assistant installed the technology in the resident's suites.

During installation, the research assistant would go into the resident's room, place the sensor under the bed, ensure the sensor was connected to the network and exit. In some cases, the resident would enter the room during installation and become agitated at the stranger (research assistant) in their room. During these events, the research assistant would exit politely, and ask one of the staff members on the unit to escort the resident out of their room. This tactic only worked for a short period of time, if it worked at all. In a few cases, the sensors could not be installed during the first visit and would be handed off to staff for their installation when the resident was not present.

Once installed, the devices are small however often visible such that a few residents did notice them and removed or disconnected them from power. This meant asking staff to enter the room, locate the sensor and reconnect to power or find where the resident put the removed sensor and place it back under the bed leg. Sometimes the staff were able to do this, but in other cases this required a visit from the research assistant.

Case Study- Medication Change

The family of a resident had noticed that their loved one was tired during their daytime visits. This resulted in the family asking the staff about the residents sleep patterns and bringing the issue to the facility's physician, a specialist in dementia. In a normal scenario, tracking sleep patterns would be challenging without the use of a camera or hiring a PSW to watch the resident during the night. However, as it happened, this resident was already a part of the study, and the staff knew they could request sleep sensor data to get an overview of the resident's sleeping habits.

The physician prescribed a medication change to encourage more sleep during the night hours and allowed the resident to be more awake during the day. This resident, being part of the study, had a TochTech Sleepsense device installed under their bed; therefore, the data for nightly bed exits and sleep patterns could be seen both before and after the change in medication. After the medication change took place, the physician could compare sleep pattern data and confirm if the change was effective, or if more change was required. Figure 6 shows the sleep patterns across 1 month form November 22 to December 21.

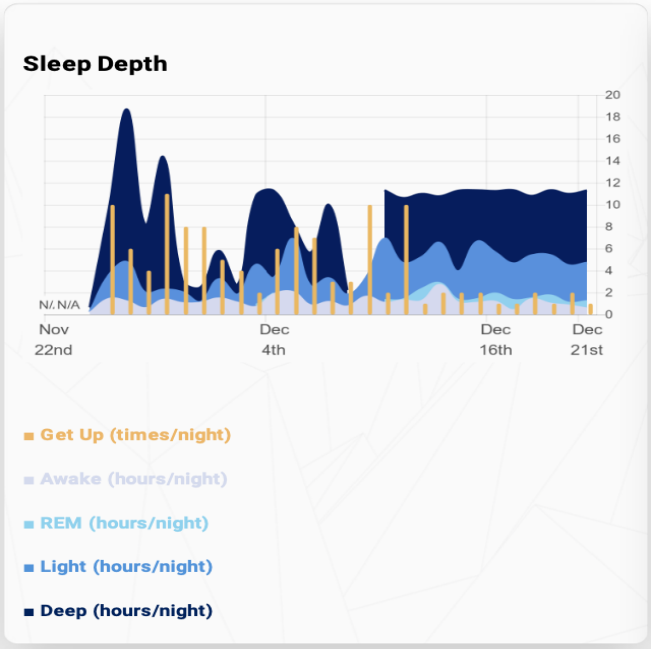

Figure 6. Sleep graph displaying number of bed exits in a night before and after a medication change.

As shown in Figure 6, the number of bed exits was around 6-10 times in a night prior to December 11. After, this number reduced to one or two times a night, which is considered normal in this demographic. On December 11, the sensor for that resident was moved. Previously, it was placed on the head of the bed on the far side (i.e. not the exit side). However, the staff noticed false alerts to their phone and so the sensor was moved to the other side, the exit side, still at the head

of the bed. This observation was also noticed during our objective testing, in the case of a larger bed (double or queen) and a smaller resident. Once the sensor was moved, the resident's sleep data appears far more normal and regulated.

The medication change took place on December 15. Since the resident themselves is not able to accurately report on sleep quality, and staff can only report on what they observed during hourly checks or from daytime alertness, this graph could be used to show sleep patterns, and assist in medication titration for the physician.

This graph could also be shown to the family members to show the effects of the new medication or provide comfort knowing their loved one id getting adequate sleep.

Conclusion

While many technical challenges were experienced, none of the issues were directly related to the TochTech Sleepsense device. The building and non-existent network infrastructure resulted in many technical difficulties that would not have been experienced if the building itself was equipped with a wi-fi network that reached across all resident rooms.

Other challenges experienced were related to resident/participant assent. It is easy for the family to approve participation in the study and allow their loved one to partake, but in some cases, the resident would see the device (after or during installation) and remove or disconnect from power. The research team often installed when the resident was not present, but in rare cases, this was not always possible.

On a positive note, Courtyards and their staff were very involved throughout the study. Emails would go back and forth if there was an issue, or even a suspected issue, in which case the research team could investigate remotely prior to scheduling a site visit. This made running the project much easier as communication was simple and frequent.