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Comparison of telemedicine versus in-person visits for persons with multiple sclerosis: A randomized crossover study of feasibility, cost, and satisfaction

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ABSTRACT

Background: Telemedicine, the remote delivery of health care services, increases access to care for patients with mobility or geographic limitations. Virtual house calls (VHCs) are one type of telemedicine in which clinical visits are conducted remotely using an audio-visual connection with the patient at home. Use of VHCs is more established in other neurologic disorders but is only recently being formally evaluated in multiple sclerosis (MS). This randomized crossover study systematically assessed VHCs compared with in-clinic visits in persons with MS.
Methods: Recruitment occurred in a university based MS clinic. Each subject completed one VHC and one in-clinic follow-up visit. A 1:1 randomization determined whether the VHC or in-clinic follow-up visit occurred first. Baseline surveys included demographics and MS history; post-visit surveys elicited subject responses regarding each visit type to assess feasibility, satisfaction, and cost differences. Outcomes were compared using *t*-tests for continuous variables and Fisher's exact test for proportions.
Results: Thirty-six participants completed both study visits and both post-visit surveys. VHC feasibility was demonstrated by a lack of statistically significant difference in the number of completed VHCs as compared with in-clinic visits. VHCs provided both cost and time savings to participants. The majority of participants reported that they would recommend telemedicine visits to others (97.1%) and rated it easy to connect via telemedicine (94.3%). In qualitative comments, participants expressed appreciation for VHCs due to convenience and similarity to in-clinic visits.
Conclusions: VHCs were found to be feasible, cost-effective, and appealing to persons with MS and physicians, supporting their utility as a care delivery method for MS.

1. Background

Access to neurologic care is often limited for persons with MS (PwMS). One large epidemiologic study found that nearly 30% of PwMS do not receive care from a neurologist or other neurologic clinician. Patients who live in rural areas or have low socioeconomic status or mobility limitations have decreased likelihood of receiving neurologic care. PwMS who receive neurologic care have an increased likelihood of being treated with disease modifying therapies and obtaining other specialized care from physical therapy, occupational therapy and urology (Minden et al., 2008).

Telemedicine is emerging as a tool that can increase access to medical care, particularly for people with geographic or mobility limitations. Telemedicine is broadly defined as the provision of healthcare via an audio-visual connection; the range of applications includes virtual house calls, specialists consulting remotely on patient care in healthcare facilities, and specialists remotely reviewing previously recorded patient encounters. This study focuses specifically on the virtual house call (VHC). In VHCs, patients have clinical visits while at home, interacting remotely with clinicians through web-based audio-visual connections.

This study was designed to address the gap in the formal assessment of the use of VHCs with PwMS. It builds on previously conducted clinical trials of VHCs used for patients with other neurologic disorders including Parkinson's disease (Dorsey et al., 2013). Although telemedicine has been used to conduct physical therapy interventions remotely in PwMS, the use of VHCs for PwMS has only recently been evaluated more systematically (Amatya et al., 2015; Finkelstein et al., 2008; Frevel et al., 2015; Bove et al., 2018). This randomized controlled clinical trial uses a crossover design to assess VHCs versus traditional in-person visits for routine follow up care in PwMS.

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2. Methods

A randomized crossover study was conducted to assess feasibility, participant satisfaction, and cost associated with the use of web-based videoconferencing for specialty MS care visits as compared with standard in-person clinic visits. The study protocol and consent forms were approved by the University of Rochester (UR) institutional review board.

2.1. Study participants

Participants were recruited from the UR MS Center on designated clinic days in an attempt to balance the number of participants seen by each of the two MS neurologists acting as investigators. Inclusion criteria included age > 18 and a diagnosis of MS (relapsing or progressive). Participants were initially required to have an internet-connected device with a webcam, but the latter restriction was lifted partway through the study as webcams were made available to participants if needed. Participants were required to reside within New York State because the MS neurologists were only licensed to see patients in this state. Exclusion criteria included lack of proficiency in written or spoken English or lack of coordination (or caregiver assistance) to manipulate the internet-connected device.

2.2. Study design

Each participant signed written consent at a routine clinic visit and subsequently received two follow-up visits over 6 months (months 3 and 6). One follow-up was a typical in-person visit at the clinic while the other was a telemedicine visit conducted with the same MS neurologist through web-based videoconferencing software. The participant's regular neurologist conducted both the in-person and telemedicine visits to avoid potential bias related to the care provider. Participants were randomized using a random number chart (1:1 allocation) at the time of consent to determine which type of visit (in-person versus telemedicine) would occur first, primarily to avoid bias related to winter weather-related travel. The software, Zoom, was selected based on ease of use and compliance with the Health Insurance Portability and Accountability Act (HIPAA). For the telemedicine visits, participants received e-mail links prior to the visit which automatically downloaded Zoom and allowed them to connect to their specialist at the scheduled time. The e-mail also provided participants with a phone number to contact their MS neurologist directly if there were difficulties establishing a connection. The neurologist had the ability to involve support from information technology staff as needed. For the telemedicine visits, participants completed a "test connection"—a brief scheduled check of the video/audio connection with the specialist a few days prior to the subject's telemedicine visit. Patients and insurance were not charged for the telemedicine visits; they were viewed as study visits. It was uncertain whether insurance would cover telemedicine visits due to the lack of billing infrastructure between the study institution and the local insurance providers.

At each visit, participants provided interval clinical history and underwent a focused neurological examination. The exam included brief mental status assessment, evaluation of eye movements and facial motor symmetry, pronator drift, coordination testing (finger-to-nose and finger tapping), and casual and tandem gaits. The exam was modified by having participants use their own finger to guide eye movements and also as a target with finger-to-nose testing. The former was done to compensate for the limited range of eye movement required to watch the examiner's finger move on the screen. Pertinent imaging and bloodwork results were reviewed if indicated, and treatment recommendations were given. Following randomization, participants completed two electronic surveys pertaining to clinical history and demographics. After each visit, participants were emailed surveys that were specific to the visit type. The surveys addressed topics including appointment duration, ease of appointment, and overall subject satisfaction. Survey distribution and subject data were managed through Redcap. The neurologists conducting the telemedicine visits were also the principle investigators, and their satisfaction with the telemedicine visits was not formally assessed, but their perspective is outlined in the discussion.

The sample size estimation was adapted from a pilot telemedicine study in Parkinson's disease; this study doubled the sample size due to fewer planned study visits.

2.3. Outcome measures/statistical analysis

The primary outcome measure for the study was feasibility, which was measured by the percentage of visits completed within the scheduled time window (3 months post-randomization +/− 30 days for visit 1 and 3 months from the first visit +/− 30 days for visit 2). Telemedicine visits were pre-defined as feasible if there was no more than 15% difference between the percent of telemedicine visits completed as scheduled as compared with the in-person visits. The definition for feasibility was modeled after a similar study of virtual house calls in Parkinson's disease (Dorsey et al., 2013). Secondary outcome measures included assessment of participant satisfaction, visit quality and cost-effectiveness. Similar to feasibility, satisfaction was pre-defined; it was considered a positive outcome if > 75% of participants were "likely" or "very likely" to choose a telemedicine visit in the future or recommend a telemedicine visit to a friend. Quality and cost-effectiveness outcome measures for the visits included audiovisual quality rating of telemedicine visits, distance traveled for in-person visits, rating of communication with physician, total time of study visits (including travel time, time in waiting room, time with physician), proportion of study visits spent with the physician, and associated costs of study visits (parking, gas, tolls, wages lost). Quantitative times and costs as well as qualitative measures were collected from subject responses to both types of visits on the post-visit surveys. Outcomes were compared using t-tests for continuous variables and Fisher's exact test for proportions. All statistical analyses were completed with R software. Participants' qualitative responses about the two types of clinical visits were collated, then analyzed for themes. Representative comments were then selected for each theme.

3. Results

3.1. Subject participation

Participants were recruited over 9 months, and a total of 43 participants signed the initial informed consent. Study visits were conducted over a 14 month interval. As summarized in Fig. 1, 40 participants completed at least 1 survey (2 changed their mind and withdrew consent, 1 moved out of state). At least 1 study visit was completed by 38 participants (1 withdrew consent prior to any visits, 1 moved out of state), and 37 participants completed both study visits (2nd visit not completed by 1 subject due to unrelated medical complications). Overall, 36 participants completed both visits and both surveys, though not all participants completed every survey question.

3.2. Demographics

Table 1 summarizes the characteristics of the 38 study participants who completed at least one study visit. The mean subject age was 50.6 with the female predominance expected based on the prevalence of MS. Sixty-seven percent of participants had relapsing MS. Approximately 50% of the participants lived farther than a 30-minute drive from the clinic, with 18% living more than 2 h away. Over half of the participants had received a college degree.

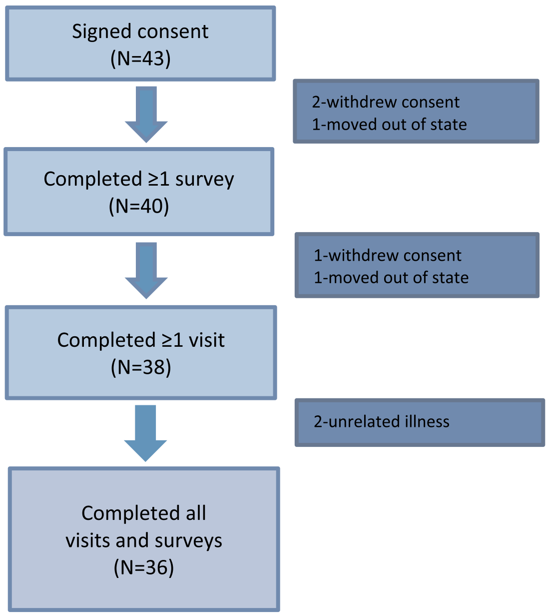

Fig. 1. Subject participation.

Table 1
Study subject characteristics.

Participant characteristics	n = 38*
Age, mean years (SD)	50.6
Sex, female	23 (61%)
Race	
Caucasian	36 (95%)
African American	1 (3%)
Other	1 (3%)
MS Type	
Relapsing remitting	27 (71%)
Secondary progressive	11 (29%)
Disease duration	
< 10 years	16 (42%)
≥10 and ≤20	13 (34%)
> 20 years	9 (24%)
Disease modifying therapy	
Injectable	15 (39%)
Oral	9 (24%)
IV	7 (18%)
None	5 (13%)
Education	
High school graduate	15 (39%)
College graduate	13 (34%)
Higher degree	10 (26%)
Income	
< 25,000	1 (2%)
25,000–49,999	7 (18%)
50,000–99,999	12 (32%)
> 100,000	12 (32%)
Declined	6 (16%)
Employed	18 (49%)
Drive distance, mean miles	58
Drive time	
0–30 min	19 (50%)
31–60 min	3 (8%)
61–120 min	9 (24%)
> 120 min	7 (18%)

* Not all participants answered every question.

3.3. *Feasibility/Satisfaction*

Table 2 summarizes the feasibility outcomes from the study. There was no statistically significant difference in the number of completed telemedicine visits as compared with in-person visits: 25 of the 37 (67.6%) telemedicine visits were completed within the specified time frame versus 28 of 38 (73.7%) in-person visits ($p = 0.62$). This difference of 6.1% was within the pre-specified feasibility goal of < 15%. Overall, 97.1% of participants reported that they were very likely or likely to recommend telemedicine visits to others as compared with 97.4% who would very likely or likely recommend an in-person clinic visit ($p = 1$). Similarly, 91.4% of participants noted that they would very likely or likely return for a telemedicine visit as compared with 100% for an in-person visit ($p = 0.11$). When the responses were stratified by subject distance from clinic, the participants who lived closer to clinic were less likely to return for a telemedicine visit compared with those who lived > 30 min from clinic, but this difference did not reach statistical significance ($p = 0.11$). However, the number of participants in this subgroup analysis is relatively small.

3.4. *Quality/cost effectiveness*

The majority of participants (94.3%) reported that connecting via telemedicine was easy, with 97.1% of participants rating the audiovisual quality as good or very good. 100% of participants reported good or very good communication with the physician (equivalent to in-person results).

The average total visit time was 39 min for telemedicine visits compared with 126 min for in-person visits ($p < 0.001$), with an average of 26 min spent with the physician via telemedicine versus 32 min in-person. Additionally, participants reported an average additional cost of $49 for parking, gas, and tolls associated with in-person visits that were not incurred during the telemedicine visits (Table 3).

3.5. *Qualitative data*

The primary positive themes highlighted by participants included convenience and cost-effectiveness of telemedicine visits as outlined in Table 4a. Participants also commented on the equivalence to in-person visits and expressed the value of having the option of telemedicine as an alternate visit type. Themes raised by the participants related to areas for improvement primarily included technology and connection difficulties and are outlined in Table 4b.

4. Discussion

VHCs were found to be feasible, with a high percentage of visits completed within a pre-specified time window and no statistically significant difference in completion compared with in-person visits. In addition, participants found VHCs appealing, with the vast majority of participants reporting that they would opt for VHCs in the future and also recommend VHCs to peers. VHCs were appreciated due to convenience, ease of communication with providers, and both cost and time savings. VHCs allowed participants to spend less time to complete their clinical encounters, in comparison to in-person visits. As one might expect, the participants who lived farther away from the MS clinic had higher satisfaction responses for VHCs compared with those who lived closer.

From a physician perspective, the VHCs were reassuringly informative for follow up visits. Although some neurological exam modifications or substitutions were utilized, the VHCs provided similar information compared with in-person visits. Review of imaging data with participants was satisfactory. For physicians, there was added value from observation of the participants' home environment. The ease of connectivity was appealing for physicians as well as participants. The physicians determined that higher web camera resolution (i.e. desktop versus tablet) aided in certain exam components such as tracking eye movements and observing rapid alternating movements (Table 5).

To the best of our knowledge, this is the first randomized clinical trial assessing VHCs in PwMS. Telemedicine has been found to be feasible in other uses with PwMS, including assessing cognitive and walking function. A recent study compared patients completing in-

Table 2
Feasibility, satisfaction, and quality outcomes for telemedicine versus in-person visits.

Outcome	Telemedicine (%)	In-person (%)	*p*-value	95% CI
Scheduled visits completed within window (*n* = 37, 38)	67.6	73.7	0.62	[0.24, 2.26]
Would return for same visit type (*n* = 35, 38)	91.4	100	0.11	[0, 2.18]
*Near (*n* = 18, 19)	83.3	100	0.11	[0, 2.21]
Far (*n* = 17, 19)	100	100	1	[0, inf]
Would recommend visit type to others (*n* = 34, 38)	97.1	97.4	1	[0.01, 72.1]
*Near (*n* = 18, 19)	94.4	100	0.49	[0, 36.9]
Far (*n* = 16, 19)	100	94.7	1	[0, inf]
Reported good/very good communication with MD (*n* = 35, 38)	100	100	1	[0, inf]
Found telemedicine connection easy (*n* = 35)	94.3	–	–	–
Thought AV quality was good (*n* = 34)	97.1	–	–	–

*"Near" defined as within 30 min from clinic. "Far" defined as > 30 min from clinic.
**Differences in *n* for each outcome reflects variability of response rate for each question.

Table 3
Cost effectiveness (monetary & time) outcomes for telemedicine versus in-person visits.

Outcome	Telemedicine	In-person	*p*-value	95% CI
Mean costs in dollars–parking, gas, tolls, wages lost(range, SD), *n* = 27, 38	$5.56 (0–150, 28.9)	$54.48 (0–734, 123.5)	0.02	[7.0, 90.9]
Mean time spent with MD in min (range, SD), *n* = 34, 37	25.9 (15–45, 9.3)	32.2 (15–80, 12.4)	0.02	[1.1, 11.5]
Mean total appointment time in min (range, SD), *n* = 34, 37	39.2 (16–95, 21.1)	125.8 (50–287, 64.3)	< 0.001	[64.0, 109.0]
Proportion of visit spent with MD (%)	66.1	25.6	< 0.001	[0.22, 0.58]

*Differences in n for each outcome reflects variability of response rate for each question.

Table 4
Participants' Comments.

a) Best Parts of Telemedicine Visit

Convenience
"No drive time, parking fees or lost wages from my husband bringing me to the appointment"
"Not having to drive 6 h round trip to see a specialist"
"Time saving"
"The convenience of meeting with my doctor from my home"
Equivalence to in-clinic visits
"How similar it actually is to an office visit"
Importance
"I believe it is a great alternative to an office visit."
"I was happy with the virtual house call and hope it is something that will be used more in the future."
"I can see this being a revolutionary step in medicine!"

b) Areas for Improvement of Virtual House Calls

Technology Issues
"I need a better web cam."
"The patient, if necessary, needs to have plenty of space to move with a camera that is adjustable."
"I need to prop up my Notebook [and] made sure it's 100% charged prior to the call."
Connection Difficulties
"We had a slight problem connecting, but I just called [the neurologist] directly and we connected within minutes."
Non-Replacement of In-Clinic Visits
"While useful for "off-schedule" visits, I don't think this type of interaction can replace the live, one on one visit with the doctor on an annual basis for a proper and thorough MS evaluation."

Table 5
Investigators' observations.

- Remote exams required modifications but overall provided similar information compared with in-person exams.
- Visits were enriched by the ability to view patients' home environment.
- Higher web camera resolution (i.e. desktop versus tablet) aided in certain exam components such as eye movement.
- Ease and utility of VHCs from the clinician perspective makes them an appealing option for future visits.

home telemedicine visits with a convenience sample of in-clinic visit patients and demonstrated similar high rates of satisfaction with telemedicine visits and associated cost and time savings. Our study reinforces those findings in addition to formally measuring feasibility. The crossover design ensured that participants answering our surveys had the opportunity to experience both types of visits, allowing for more informed responses and likely reducing bias. Our study's findings combine with recent work to support a broader use of telemedicine in PwMS to include VHCs for MS patient follow-up visits with clinicians.

Limitations of this study include a modest sample size and the relatively high average educational level of participants. The latter was also noted in Bove, et al., suggesting that future studies assessing in-home telemedicine visits may need to focus on recruitment of greater numbers of participants with lower educations levels. Additionally, the study relied on subject report of cost and time savings, instead of using potentially more verifiable methods for measurement. There may also have been some degree of response bias, with participants possibly providing high ratings to the visits in order to please their care provider. The study was limited to follow up visits; further assessment would be needed to determine feasibility and satisfaction for new patient evaluations given the increased complexity.

Given that VHCs were found to be feasible, cost-effective, and appealing to PwMS and physicians, they may be considered a useful care delivery method for MS. Advocacy focused on increasing payer coverage for telemedicine visits could expand the availability of this useful technology to improve access to care for PwMS, particularly those with geographic or mobility limitations.

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References

Amatya, B., Galea, M.P., Kesselring, J., Khan, F., 2015. Effectiveness of telerehabilitation interventions in persons with multiple sclerosis: a systematic review. Mult. Scler. Related Disord. 4 (4), 358–369. https://doi.org/10.1016/j.msard.2015.06.011.

Bove, R., Garcha, P., Bevan, C.J., Crabtree-Hartman, E., Green, A.J., Gelfand, J.M., 2018. Neurol. Neuroimmunol. Neuroinflamm. 5, e505. https://doi.org/10.1212/NXI.000000000000505.

Dorsey, E.R., Venkataraman, V., Grana, M.J., Bull, M.T., George, B.P., Boyd, C.M., Beck, C.A., Rajan, B., Seidmann, A., Biglan, K.M., 2013. Randomized, controlled trial of "virtual housecalls" for Parkinson disease. JAMA Neurol. 70 (5), 565–570. https://doi.org/10.1001/jamaneurol.2013.123.

Finkelstein, J., Lapshin, O., Castro, H., Cha, E., Provance, P.G., 2008. Home-based physical telerehabilitation in patients with multiple sclerosis: a pilot study. J. Rehabil. Res. Dev. 45, 1361–1373. https://doi.org/10.1682/JRRD.2008.01.0001.

Frevel, D., Maurer, M., 2015. Internet-based home training is capable to improve balance in multiple sclerosis: a randomized controlled trial. Eur. J. Phys. Rehabil. Med. 51, 23–30.

Minden, S.L., Hoaglin, D.C., Hadden, L., Frankel, D., Robbins, T., Perloff, J., 2008. Access to and utilization of neurologists by people with multiple sclerosis. Neurology 70, 1141–1149. https://doi.org/10.1212/01.wnl.0000306411.46934.ef.