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Telerehabilitation

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Abstract

Objective. COVID-19 has widely affected delivery of health care. In response, telerehabilitation (TR) has emerged as alternative care model. Aims were: (1) describe baseline patient characteristics and available unadjusted outcomes for episodes of care administered during COVID-19 using TR vs. traditional in-person care, (2) describe TR frequency levels by condition and telecommunication modes.

Methods. A descriptive retrospective observational design was used to report patient variables and outcomes including physical function, number of visits, and patient satisfaction, by TR frequency (few, most, or all visits) and telecommunication modes. Standardized differences were used to compare baseline characteristics between episodes with and without TR.

Results. Sample consisted of 222,680 patients [59% female; mean age (SD) = 55(18)]. Overall TR rate was 6% decreasing from 10% to 5% between 2nd and 3rd quarters of 2020. Outcome measures were available for 90% to 100% of episodes. Thirty-seven percent of clinicians administered care via TR. Patients treated using TR compared to in-person care were more likely to be younger, and live in large metropolitan areas. From those with TR, 55%, 20%, and 25% had TR during few, most, or all visits, respectively. TR care was administered equally across

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orthopedic body parts, with lower use for non-orthopedic conditions such as stroke, edema, and vestibular dysfunction. TR was primarily administered using synchronous (video or audio) modes. The rate of patients reported being very satisfied with their treatment results was 3% higher for no TR compared to TR.

Conclusions. These results provide new knowledge about to whom and how TR is being administered during the pandemic in outpatient rehabilitation practices throughout the USA. The database assessed was found to be suitable for conducting studies on associations between TR and diverse outcome measures, controlling for a comprehensive set of patient characteristics, to advance best TR care models, and promote high quality care.

Impact. This study provided detailed and robust descriptive information using an existing national patient database containing patient health and demographic characteristics, outcome measures, and TR administration data. Findings support the feasibility to conduct future studies on associations between TR care and patient outcomes, adjusting for a wide range of patient characteristics and clinical setting factors that may be associated with the probability of receiving TR. Finding of limited and decreasing use of TR over the study period calls for studies aimed to better understand facilitators and inhibitors of TR use by rehabilitation therapists during everyday practice to promote its use when clinically appropriate.

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Telerehabilitation

Introduction

The coronavirus pandemic (COVID-19) has widely affected all aspects of society and impacted delivery of physical therapy and other health care services internationally as well as in the United States.[1-4] In response, telerehabilitation (TR) has emerged as a promising alternative model to traditional in-person clinical visits. TR refers to clinical services administered at a distance using telecommunication.[5] TR can be delivered using a variety of telecommunication media technologies with either real time (synchronous) 2-way interactive mediums such as video and/or audio calls, or asynchronous E-visits not in real time, eg, virtual check-ins, remote evaluations of recorded videos or applications/links to exercises and educational materials.[4, 6]

Evidence exists on benefits and patient acceptance of TR care for patients with a wide variety of conditions including orthopedic (eg, low back, total joint arthroplasty),[5-8] neurological (eg, stroke, multiple sclerosis),[9-11] and wide spread chronic pain syndromes (eg, fibromyalgia, rheumatoid arthritis).[12-14] Preliminary findings indicate that care delivered via TR in addition to or as replacement of in-person clinic visits was generally either equivalent to or yielded slightly better outcomes compared to usual in-person physical therapy care alone.[5, 15] However, many authors recommend caution to avoid generalization and overestimation of these findings given methodological weaknesses in available studies, heterogeneous nature of patient characteristics, variability in clinical conditions, and small sample sizes.[6,12,16,17]

Evidence supporting the benefits and effectiveness of TR was mainly published prior to COVID-19. Since the onset of COVID-19, many state and federal regulatory and reimbursement policies

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were implemented to enhance the administration of TR care by rehabilitation therapy specialists.[18, 19] No studies of TR using established large national patient databases that examine the actual implementation and administration of TR care in typical outpatient hospital and private practice physical therapy clinics across the USA were identified. Of interest, Miller et al evaluated telehealth physical therapy implementation at the beginning of the pandemic (March 16 to May 16, 2020) and found that implementation of telehealth physical therapy during COVID-19 was feasible and acceptable by patients and physical therapists.[2] However, the study was conducted within one large urban academic medical center and results may not be generalizable.

TR services are likely to remain a standard mode for administration of care and represent a new normal for rehabilitation therapy practice during and after COVID-19.[4] Therefore, continued TR research is required to explore how delivery of care has evolved in rehabilitation therapy practices in the USA as a result of COVID-19 and to inform future TR rehabilitation practices. Descriptive studies are needed to identify to whom and how TR care is being administered. To address these needs, Prvu Bettger and Resnik recently recommended rapid-cycle research, using large and existing patient database systems, to provide timely clinical insights about how TR care has affected rehabilitation therapy practice.[4] Examining TR data documented by clinicians working in everyday clinical practice is recommended to best understand how COVID-19 has impacted rehabilitation therapy care models and to translate findings to identify best clinical practices utilizing TR.[4,20]

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Our aims were to: (1) describe baseline patient demographic and health characteristics, and available unadjusted outcomes, for episodes of care administered using TR vs. traditional in-person care documented during COVID-19, (2) describe the TR frequency levels by conditions and by TR telecommunication modes.

[H1] Methods

[H2] Design and Data collection

This was a descriptive study using retrospective, observational data from a large national patient database system collected routinely in outpatient rehabilitation therapy clinics in the United States. Data included diverse patient characteristics and standardized documentation of TR use in outpatient clinics throughout all 50 states. TR use documentation was standardized. The study was approved by Solutions Internal Review Board, a private institutional review board located in Yarnell, Arizona. Participating clinics routinely collect patient demographics, health characteristics, and outcomes using the Patient Inquiry software developed by Focus on Therapeutic Outcomes (FOTO),[21] a Net Health company that provides outcomes management software solutions for rehabilitation therapists. Patients aged 14 to 89 years were included if their episode of care started no earlier than the 4th quarter 2019 and they were discharged from rehabilitation therapy care during the 2nd quarter, 2020 (May 1st to June 30th) or 3rd quarter, 2020 (July 1st to September 30th).

[H2] Telerehabilitation

TR data were collected using the following survey question *("How many of your current therapy visits have taken place over the internet or by phone (telehealth) instead of in the clinic.")*.

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Patient response categories were: none, few, most, or all. Response categories were defined as: none when no visits used TR during the episode of care, few as less than ½ of the total episode visits with TR, most half or more of total episode of visits with TR but not all visits, and all when all visits during the episode of care were administered using TR. In order for patients to accurately document the TR frequency used during his or her episode of care, the TR frequency data used for analyses were obtained from the patient's discharge survey. This question was administered starting April 30th, 2020. Subsequently on August 4th, 2020 if the patient responded that TR was administered during the episode of care, a second patient-facing TR question was added to each follow up FOTO survey *[“Which of these was used in your telehealth care? (select all that apply.)*”] Patient responses were: video call, audio call (without video), text or email messaging, links to video materials (like YouTube clips), and other. Patients were subsequently classified into 3 communication modes: 1) synchronous for patient responses video and/or audio call, 2) asynchronous for patient responses text or email messaging, links to video materials (like YouTube clips), and other, but no use of video and/or audio modes, and 3) mixed if the episode of care included both synchronous and asynchronous telecommunication modes.

[H2] Outcomes

The outcomes described were physical function (PF) change, number of treatment visits during the episode of care from intake to discharge, and patient satisfaction with treatment results at discharge. PF was assessed at intake and discharge using a set of patient-reported outcome measures (PROMs) developed using item response theory (IRT).[22-25] Measure administration mode was through computerized adaptive tests (CATs) described previously in detail.[26-31] The IRT model calibrated the PF scores into a linear metric from 0 (low) to 100 (high) functioning.

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Number of visits were used as a proxy to describe direct costs and health care usage incurred by TR use as recommended in a recent systematic review by van der Meij.[32] Patient satisfaction with treatment results data were collected using a question that was administered on every follow-up patient survey *(“How satisfied were you with overall results of your treatment at this facility?”*). Patient response categories were: very satisfied, somewhat satisfied, neither satisfied or dissatisfied, somewhat dissatisfied, or very dissatisfied.

[H2] Data Analyses

To address the first aim, standardized difference analytical methods were used to determine differences in baseline characteristics between those episodes with TR and those without TR. Standardized differences were calculated to compare means of continuous variables and prevalence of dichotomous variables as recommended by Austin.[33] Briefly for continuous variables the standardized difference was defined as:

$$Standardized\ Difference = \frac{|\bar{x}_{group\ 1} - \bar{x}_{group\ 2}|}{SD_{pooled}}$$

Where $\bar{x}_{group\ 1}$ denote the mean of the covariate in each group, and SD_{pooled} denote the full sample standard deviation.

For dichotomous variables the standardized difference was defined as:

$$Standardized\ Difference = \frac{|\hat{p}_{group\ 1} - \hat{p}_{group\ 2}|}{\sqrt{\frac{\hat{p}_{group\ 1}(1-\hat{p}_{group\ 1}) + \hat{p}_{group\ 2}(1-\hat{p}_{group\ 2})}{2}}}$$

where $\hat{p}_{group}$ denote the prevalence or mean of the dichotomous variable in each group.

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Unlike p-values, standardized difference analyses are not influenced by sample size, and can be interpreted as an effect size, with values of 0.2, 0.5, and 0.8 proposed previously to represent thresholds of small, medium, and large effect sizes, respectively.[34] Standardized difference values <0.1 were suggested to represent clinically negligible differences.[33]

For our second aim, we calculated the standardized difference between 2 orthopedic body parts that had the highest and lowest rates of TR use, allowing us to infer if TR was equally administered between all orthopedic body parts. Additionally, we calculated percentages for telerehabilitation frequency levels ie, few, most or all, by telecommunication technology modes ie, synchronous, asynchronous, and both (mixed) modes.

[H1] Results

[H2] Patient Sample

Our sample consisted of 222,680 episodes of care [59% female; mean age (SD)25th,75th percentile= 55(18)43,69; age range 14-89]. Of those, 13,059 (6%) episodes incorporated some level of TR. Of interest, when percentage of episodes involving TR were compared between 2nd quarter (May - June 2020) vs. 3rd quarter (July-September 2020), a higher percent of episodes involving TR was observed during the 2nd quarter (10%) vs 3rd quarter (5%). Data were contributed by 13,240 clinicians working in 3,045 outpatient rehabilitation clinics located in all 50 states (USA). Of those, 37% of clinicians and 69% of clinics located in 49 states implemented and administered care using TR.

[H2] Patients with and without TR

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Baseline patient characteristics were compared between episodes with and without TR (Table 1). The standardized difference values suggest that many of the patient variable differences between the TR and no TR subgroups are not meaningful, ie, standardized difference <0.1. However, the standardized differences for 10 patient variables were considered important with values >0.1. For examples, for those patients treated using TR compared to traditional in-person visit care: mean age was 4 years lower (standardized difference = 0.21), the rate of patients treated in private practice settings was 7% higher (standardized difference = 0.16), the rate of metropolitan core, a Rural-Urban Commuting Area (RUCA) classification [35, 36] category, was 10% higher (standardized difference = 0.25), Medicare B Age 65 or above was 8% lower (standardized difference = 0.19), exercise 3x/week was 5% higher (standardized difference = 0.10), arthritis was 7% lower (standardized difference = 0.14), high blood pressure was 7% lower (standardized difference = 0.14), and obesity was 6% lower (standardized difference = 0.12).

[H2] Outcomes

Unadjusted patient outcomes at discharge for the full sample and the samples using or not using TR for PF change, number of visits, and patient satisfaction are presented in Table 2. Briefly, PF change varied depending on condition and TR use, ranging between 2 and 23 points. Of interest patients experiencing thoracic, vertigo, stroke upper extremity, and upper and lower extremity edema conditions who received TR reported 2.2, 2.9, 3.9, 6.5, and 9 unadjusted PF points less at discharge from those not receiving TR. Number of visits at discharge had a mean of 13 (SD=9, median =11). Patient satisfaction ratings were available for 90% of the sample. The rate of patients reported being very satisfied with their treatment results was 3% higher for no TR compared to TR.

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[H2] TR frequency and mode

Percentages of TR use by frequency levels and body part or care type are presented in Table 3. From those patients that received TR, 55%, 20%, and 25% had TR during few, most, or all visits, respectively. To determine if TR was equally administered between all orthopedic body parts, we calculated the standardized difference comparing the rate of no TR between hip that had the highest rate of no TR (94.5%) and thoracic that had the lowest percent of no TR (93.4%). The standardized difference was trivial (0.05), inferring TR was equally administered between all orthopedic body parts. We also observed TR administration for vestibular, stroke, edema, and other conditions, however this sample was small (n = 638) compared to the orthopedic sample that received TR (n = 12,421). TR was used less frequently for non-orthopedic conditions.

There were 2634 episodes of care that included the 2nd TR survey question regarding type of telecommunication technology modes. Most episodes with TR included a video call communication mode (71%), followed by 18%, 15%, 14%, and 12%, for text messaging, educational links, other modes, and audio call, respectively. The percentages per TR modes groups were 60%, 21%, and 19% for synchronous, asynchronous, and mixed respectively (Table 4). The interaction between TR mode and TR intensity levels varied. For few TR frequency level, synchronous mode was used more frequently (69%) compared to most (53%) or all (46%) TR frequency levels, yet asynchronous mode was used more frequently for all and most (26-27%) vs few (16%) TR frequency levels.

[H1] Discussion

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Our study examined a very large patient cohort contributed by multitudes of front-line clinicians across 50 states in the USA investigating rehabilitation care models administering TR compared to in-person visits during the COVID-19 pandemic. The national database included hundreds of thousands of complete episodes of rehabilitation care across a breadth of RUCA classification categories[35, 36] representing diverse and robust patient demographics, conditions treated, as well as medical and other health-related variables.

[H2] Major findings

The study's major findings were: 1) only 6% of episodes of care in our sample incorporated some level of TR provided by 37% of clinicians; 2) TR was more likely to be administered during the 2nd quarter, 2020 (10%) compared to the 3rd quarter 2020 (5%); 3) meaningful differences in some patient health and demographic characteristics were observed between TR and no TR subgroups; 4) TR frequency levels varied from 55%, 20%, and 25% for few, most, or all visits, respectively; 5) any TR use was equally administered across orthopedic body parts, with lower use for conditions of stroke, upper or lower quadrant edema, and vestibular dysfunction; and 6) percentages per TR technology modes were 60%, 21%, and 19% for synchronous, asynchronous, and both or mixed modes respectively.

[H2] Implication for practice

The low TR administration rate by service providers in our study contrasts with recent studies consistently recommending a rapid adoption and implementation of TR in replacement of or in addition to in-person rehabilitation clinic visits since the start of the COVID-19 pandemic.[2, 4, 20, 37, 38] The recommendations supporting TR's outcome effectiveness, reduction in patient in-direct

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costs, and acceptability by providers and patients were based on evidence published prior to COVID-19 pandemic. Since the pandemic onset, we are aware of only 2 studies examining actual TR feasibility and outcomes.[2, 39] For instance, Negrini et al demonstrated that a complete shift from traditional in-person clinic care to telehealth was feasible and acceptable during COVID-19.[39] In another recent study, the authors observed 4548 physical therapy sessions provided by 40 therapists, of which 85% were administered using telehealth and all participating physical therapists conducted at least one telehealth session indicating 100% adoption.[2] Both of these studies, however, were limited to one medical setting and their results may not be generalizable to other medical contexts.

Many of the patient health and demographic characteristics between the TR and no TR subgroups were meaningfully different which is consistent with previous research suggesting that clinicians prefer to use TR for certain patients but not others. Previous research however did not use standardized difference analyses to determine if reported inequalities or differences observed between patient variables in TR and comparison groups were clinically meaningful.[2, 40] For example, Miller et al using P value statistics reported that during their study's TR implementation phase a greater proportion of patients were younger, primarily English speaking, and had fewer medical comorbidities vs. the comparison phase.[2] As previously reported, we also observed important differences in patient characteristics between those receiving and not receiving TR. For instance, patients receiving TR were younger, more likely to be commercially insured vs. Medicare, and to reside in large metropolitan areas. The standardized differences for these variables were > 0.1 suggesting groups were not similar enough to allow comparisons of outcome of care that would take into account the probability of different patients to receive TR.

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Therefore, when interpreting associations between patients receiving TR vs. no TR and health outcomes, rigorous statistical methods have been recommended.[4,32] For instance, propensity score matching has been identified as an important analytic approach to balance or control for differences between the comparison groups (eg, with or without TR) that may be a result of their different probabilities of receiving the treatment under investigation (eg, TR), which may confound the outcome of interest.[4, 41] Future studies applying such adjustments are needed to identify the treatment effect of TR and specific subgroups of patients that might or might not benefit from specific technology modes, dosage, and frequency levels of TR administration.

We also observed that clinicians administered TR across different frequency levels for either a few, most, or all visits during the episode of care. Some level of TR was used in addition to or replacement of in-person clinic visits in 75% and 25% of episodes, respectively. This suggests that TR use is not a one size fits all approach, but delivery of TR is flexible and can be tailored to individual patients' needs.

Prior studies investigating TR use in clinical practice examined patient samples with specific orthopedic conditions mainly low back, knee or hip complaints[12, 17] and to a lesser extent upper limb and ankle foot impairments. [5, 15, 42] It is not known if clinicians during routine practice administer TR to all patients referred to physical therapy outpatient services regardless of condition type. Some authors speculate that only specific patient populations, eg, acute vs chronic spinal pain, benefit from TR services.[8] Our findings suggest that TR was administered equally across a wide variety of typical orthopedic conditions commonly managed by clinicians in outpatient rehabilitation settings. In addition, we also observed that TR was administered to

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other care types such as vertigo, stroke, and edema, but these sample sizes were small, thereby, limiting our interpretations regarding the descriptive results for non-orthopedic impairments. Our findings support the feasibility to administer at least some level of TR during everyday outpatient services to patients treated with conditions assessed in this study.

We observed that synchronous modes (2-way real time communication) were used in 60% of episodes with TR, 21% administered TR asynchronously (one-way E-visit communication not in real time) and 19% using both modes during the episode of care. Although clinicians primarily used synchronous TR modes, asynchronous mode was utilized by many physical therapists during the patient's episode of care. Medicare B as well as certain private payers pay clinicians for TR care administered using either mode separately or together.[43] Although the percentage of asynchronous use was lower compared to the synchronous mode, asynchronous TR modes were reported useful for clinicians to follow up with patients via recorded videos, secure messages, or with written materials to maximize efficiency and outcomes.[44] There is also some evidence that asynchronous mode can be effective for patients status-post total joint replacement surgery.[45]

For synchronous mode, video call (71%) was the preferred communication medium. This is consistent with previous findings reporting physical therapists favored video technologies rather than other mediums such as the telephone to deliver care.[46, 47] Despite the preference for communication using video mediums to deliver TR, prior studies reported that audio modes such as telephone supported or telephone coaching programs may be a more practical alternative to real-time video telecommunication.[40, 45] Recent evidence showed little differences between these two modalities in terms of patient outcomes, and more research was recommended to determine

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the circumstances under which video medium is superior to telephone as a telehealth modality.[48] In another recent study, the authors reported that 75% of patients aged 65+ operated TR telecommunication mediums independently and concluded TR was feasible in adults of all ages.[38] We recommend selecting TR communication technologies which are most user-friendly and capable of expanding access of rehabilitation services to all of our patients. We recommend future studies examining the optimal interactions between TR delivery modes and frequency levels to achieve best patient outcomes.

We did not anticipate the low adoption and implementation of TR by providers and the sharp reduction in TR administration between the 2nd and 3rd quarters 2020 given recent reports that telehealth is rapidly being implemented in light of the COVID-19 pandemic.[44] We speculate that the reduction in TR use observed may be primarily explained by 1) the easing of stay-at-home and mandatory restrictions during the 3rd quarter, 2020 and 2) subsequently, lightening of pandemic restrictions decreased some of the motivation of both patients and providers to continue using alternative TR care services, favoring the familiarity of an in-person approach. One possible explanation for the decrease in TR administration may be patient dissatisfaction with TR compared to in-person care. The unadjusted results indicate that it is plausible that patients were less likely to be very satisfied with TR and that patients with specific conditions may have had less improvement than those treated in-person. However, due to the nature of this descriptive study and no adjustment as to the probability of being treated using TR, further research is needed to study associations between TR use and patient satisfaction or other patient outcomes while controlling for potential confounders of the outcomes assessed. Implementation of TR faces many challenges which may also explain the overall low TR adoption by clinicians

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in our study.[17, 49] For instance, findings suggest that clinicians have been reluctant to consider TR because of the impossibility of using palpation as well as certain manual techniques and diagnostic tests, and the lack of rehabilitation equipment commonly used in outpatient clinics.[17]

Recent research is providing clear clinical guidance on best strategies necessary to successfully implement TR.[4, 37, 44, 49] Emerging implementation strategies include a well-designed administrative plan within the organization backed with financial and technological support, provider education on choice of platform, legal and ethical considerations, implications for best treatment and examination choices, management processes, and timely recognition and feedback on adoption and implementation progress.[44, 49, 50] A systematic review and a qualitative study identified that the organization of the care model was the most important strategy in determining the value and implementation of TR service.[51, 52] This organizational strategy was supported by 2 recent papers touting that the smooth transition to TR care observed within their facility followed a rigorous administrative and clinical TR plan of care, which we speculate accounted for their successful TR implementation.[2, 39]. Continued research exploring best methods and strategies to enhance widespread implementation of TR care across a broad spectrum of outpatient rehabilitation clinics from rural to metropolitan areas within the US is warranted.

[H2] Limitations

Caution is recommended to avoid over-interpretation of our findings. First, due to the nature of this descriptive design and no risk-adjustment, interpretation of PF, visits, and patient satisfaction outcome results for TR and no TR subgroups are limited. The focus of future

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research is required to 1) study associations between TR use and patient satisfaction and improvement in physical function outcomes while controlling for potential confounders of the outcomes assessed and 2) determine the value of TR care in physical therapy. Second, our descriptive data may not be generalizable to the overall outpatient rehabilitation population in the US. Although this was not the purpose of this study, testing for the generalizability of the national database analyzed merits attention. Third, TR frequency level was based on patient's recall at discharge. Validating patient-reported TR frequency levels using billing data, which were not available to us, are recommended for future research. Fourth, we analyzed data only from clinicians using FOTO to collect treatment outcomes, with no comparison to clinicians who either did not document treatment outcomes or did not use FOTO for outcome documentation. Therefore, we cannot rule out a potential selection bias.

[H2] Conclusion

Our results provide new knowledge regarding to whom and how TR is being administered during COVID-19 in outpatient rehabilitation practices included in our study. The database assessed was found to be suitable for future studies on associations between TR use during the episode of care, and diverse outcome measures documented during routine rehabilitation outpatient practice, while controlling for a comprehensive set of patient characteristics. Studies on the generalizability of these findings into the "real-world" settings where telerehabilitation is yet to be adopted are needed to advance best TR care models and promote patient outcomes during and after the COVID-19 pandemic.

Author contributions

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Concept/idea/research design: M.W. Werneke, D. Deutscher, D. Hayes
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Ethics

This study was approved by the institutional review board of IRB Solutions, a private institutional review board located in Yarnell, Arizona and given exempt status based on federal guidelines (IRB #: IORG0007116).

Disclosures

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other affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article.

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Table 1: Baseline Health and Demographic Patient Characteristics for the Full Sample and the Samples Not Using or Using Telerehabilitation (TR)[a]

Baseline Characteristics	**Total Sample n = 222,680**	**Sample Not Using TR n = 209,621**	**Sample Using TR n = 13,059**	**[b]Standardized Difference**
Number of providers				
Clinicians	13,240	12,878	4,943	-
Clinics	3,045	3,012	2,096	
States	50	50	49	
Physical function score at intake				
Mean (SD)	48.5 (15.5)	48.6 (15.5)	48.0 (16.0)	0.04
Median (25th;75th percentiles)	49.0 (39.0; 58.6)	49.0 (39.1; 58.6)	48.5 (38.0; 58.6)	
Age (y)				
Mean (SD)	54.9 (18.2)	55.1 (18.2)	51.3 (18.1)	**0.21**
Median (25th; 75th percentiles)	58 (43; 69)	58 (43; 69)	53 (37; 66)	
Age Groups (column%)				
14 to <18	3.2	3.2	4.0	0.04
18 to <45	23.9	23.5	30.8	**0.16**
45 to <65	36.6	36.5	37.2	0.01
65 to <75	23.4	23.7	19.4	**0.11**
75 to 89	12.8	13.1	8.7	**0.14**
Sex: Female (%)	59	58	62	0.07
Practice type (column %)				
Hospital Outpatient Dept	28.3	28.8	21.5	**0.17**
PT private Practice	70.6	70.2	77.3	**0.16**
Other	1.1	1.1	1.2	0.01
Rural-Urban Commuting Area (RUCA) (column %)				
Metropolitan core (primary flow within an urbanized area; population density > 50,000)	80.0	79.4	88.6	**0.25**
Metropolitan (primary flow to an urbanized area)	5.3	5.4	3.2	**0.11**

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Micropolitan (primary flow within or to a large urban cluster: population density 10,000-50,000)	9.0	9.2	5.4	**0.15**
Small town (primary flow within or to a small urban cluster: population density 2500-9999)	4.2	4.3	2.0	**0.13**
Rural areas	1.6	1.7	0.7	0.09
Acuity (column %)				
0-7 days	5.4	5.5	5.2	0.01
8-14 days	6.5	6.5	6.7	0.01
15-21 days	8.7	8.7	8.4	0.01
22-90 days	27.7	27.5	29.5	0.04
91 days to 6 months	15.7	15.7	16.0	0.01
Over 6 months	36.0	36.1	34.2	0.04
Payer (column %)				
HMO, Preferred Provider	46.5	46.2	50.9	0.09
Medicare B Age 65 or above	22.6	23.0	15.4	**0.19**
Workers compensation	6.9	6.8	8.3	0.06
Medicaid	4.9	4.9	4.6	0.01
Indemnity insurance	3.7	3.8	3.6	0.01
Medicare B Under Age 65	2.4	2.5	2.2	0.02
Medicare A	1.3	1.3	1.2	0.01
No fault, Auto insurance	1.1	1.1	1.6	0.04
Patient	0.6	0.6	0.6	0.00
Other (Litigation, Medicare C, School, No charge, Early Intervention, Commercial Insurance)	9.9	9.8	11.6	0.06
Surgical history (column %)				
No related surgery	69.7	69.8	68.6	0.03
1 related surgery	23.0	23.0	24.1	0.03
2 related surgeries	4.6	4.6	4.8	0.01
3 or more related surgeries	2.6	2.6	2.5	0.01
Post-surgical procedures (%)	15.3	15.3	15.8	0.01
Exercise history: (column %)				
At least 3x/week	42.1	41.8	46.8	**0.10**
1-2x/week	23.7	23.7	24.3	0.01
Seldom or Never	34.1	34.5	28.9	**0.12**
Medication use at intake (%)	58.8	58.7	60.4	0.04

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Previous treatment (%)	62.1	62.2	60.5	0.03
Number of comorbidities				
Mean (SD)	4.4 (3.2)	4.4 (3.2)	4.1 (3.1)	**0.11**
Median (25th; 75th percentiles)	4 (2; 6)	4 (2; 6)	3 (2; 6)	
Specific comorbidities (%)				
Allergy	26.2	26.1	27.6	0.03
Angina	0.9	0.9	0.8	0.02
Anxiety or Panic Disorders	16.3	16.2	18.0	0.05
Arthritis	42.6	43.0	36.1	**0.14**
Asthma	10.7	10.6	11.9	0.04
Back pain (neck pain, low back pain, degenerative disc disease)	52.9	53.0	51.4	0.03
Cancer	8.5	8.6	7.3	0.05
Chronic Obstructive Pulmonary Disease (COPD)	3.3	3.4	2.5	0.05
Congestive Heart Failure	4.5	4.6	3.4	0.06
Depression	16.2	16.2	17.1	0.03
Diabetes Type I or II	13.4	13.5	11.4	0.06
Gastrointestinal	14.8	14.8	14.0	0.02
Headaches	19.8	19.7	21.4	0.04
Hearing	5.7	5.8	4.1	0.08
Hepatitis / HIV-AIDS	0.8	0.8	0.8	0.00
High Blood Pressure	36.4	36.8	30.2	**0.14**
Heart Attack (Myocardial Infarction)	2.5	2.5	1.9	0.04
Incontinence	5.5	5.5	5.1	0.02
Kidney, Bladder, Prostate or Urination Problems	9.2	9.3	7.9	0.05
Neurological Disease	1.7	1.7	1.7	0.00
Obesity (BMI>=30)	40.7	41.0	35.4	**0.12**
Osteoporosis	8.2	8.3	7.6	0.02
Other disorders	3.0	3.0	3.3	0.02
Peripheral Vascular Disease (or claudication)	1.5	1.5	1.1	0.03
Previous accidents (Motor vehicle, work, or other accident)	11.6	11.6	12.6	0.03
Previous Surgery	39.9	40.2	36.1	0.08
Prosthesis / Implants	8.8	8.9	6.7	0.08
Sleep dysfunction	15.6	15.6	15.8	0.00
Stroke or Transient Ischemic Attack	3.9	4.0	3.0	0.06
Visual Impairment	8.8	8.9	6.8	0.08

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Pacemaker	1.5	1.5	1.2	0.03
Seizures	1.4	1.4	1.4	0.00
Condition type (column %)				
Low Back	21.1	21.1	21.0	0.00
Shoulder	18.1	18.0	20.0	0.05
Knee	17.8	17.8	17.0	0.02
Foot & Ankle	9.6	9.6	9.7	0.00
Hip	8.8	8.9	8.3	0.02
Neck	8.5	8.6	8.2	0.01
Elbow, Wrist, Hand	8.2	8.1	9.0	0.03
Thoracic	1.7	1.7	2.0	0.02
Vestibular[c]	1.7	1.8	1.1	0.05
Other	4.3	4.4	3.7	0.00

[a]Values are percent unless noted otherwise. Column % sum may not be exactly 100% due to rounding. BMI = body mass index; HMO = health maintenance organization.

[b]Standardized differences between those with or without TR; values highlighted in bold represent an important difference. Variables were included for those variables that had a frequency or TR use of at least 1%.

[c]Vestibular is the only non-orthopedic condition included due to $\geq$ 1% threshold, Other includes neurological and lymphedema conditions with < 1% frequency, eg, stroke, edema.

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Table 2: Unadjusted Patient Outcomes at Discharge for the Full Sample and the Samples Not Using or Using Telerehabilitation (TR)

Impairment type	**Total Sample** **N = 222680**	**Sample Not Using TR** **N = 209621**	**Sample Using TR n = 13059**
Unadjusted Physical Function change: Mean (SD)			
Low Back	16.1 (15.9)	16.2 (15.8)	15.8 (16.6)
Shoulder	19.2 (17.5)	19.1 (17.5)	20.0 (18.2)
Knee	22.1 (17.8)	22.1 (17.7)	23.1 (18.4)
Foot & Ankle	19.5 (16.6)	19.5 (16.6)	20.7 (17.3)
Hip	17.8 (16.8)	17.8 (16.7)	17.9 (17.4)
Neck	14.0 (14.8)	14.0 (14.8)	14.1 (14.8)
EWH	19.4 (16.4)	19.4 (16.3)	19.7 (17.1)
Thoracic	15.9 (16.7)	16.0 (16.7)	13.8 (16.0)
Vertigo	19.6 (21.1)	19.7 (21.1)	16.8 (21.1)
Stroke Lower Extremity	12.9 (14.7)	13.0 (14.8)	9.1 (10.6)
Stroke Upper Extremity	12.3 (14.6)	12.0 (14.6)	19.1 (13.3)
Lower quadrant edema	8.7 (11.9)	8.8 (11.8)	2.3 (14.4)
Upper quadrant edema	13.8 (15.1)	13.9 (15.1)	4.9 (9.7)
Other	11.4 (15.1)	11.5 (15.2)	9.3 (13.6)
Number of visits: Mean (SD) Median (25th; 75th percentiles)	13.1 (8.5) 11 (7; 17)	13.0 (8.4) 11 (7; 17)	14.2 (10.1) 12 (6; 19)
[a]**Satisfaction data with overall results:** (column %)			
Very Satisfied	80.2	80.4	77.0

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Somewhat Satisfied	7.6	7.5	9.2
Neither Satisfied nor Dissatisfied	1.6	1.6	2.1
Somewhat Dissatisfied	0.3	0.3	0.5
Very Dissatisfied	0.1	0.1	0.1
Missing satisfaction data	10.1	10.1	11.1

[a]Patient satisfaction data were available for 89.9% (n=200,092) of the sample.

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Table 3: Telerehabilitation Frequency Levels by Body Part or Care Type[a]

Body Part or Care Type Conditions	None	Few	Most	All	Total n (100%)
Low Back	44,264 (94.2)	1,440 (3.1)	557 (1.2)	742 (1.6)	**47003**
Shoulder	37,793 (93.5)	1,501 (3.7)	520 (1.3)	589 (1.5)	**40403**
Knee	37,404 (94.4)	1,267 (3.2)	420 (1.1)	539 (1.4)	**39630**
Foot & Ankle	20,126 (94.1)	683 (3.2)	282 (1.3)	305 (1.4)	**21396**
Hip	18,557 (94.5)	592 (3.0)	212 (1.1)	281 (1.4)	**19642**
Neck	17,946 (94.4)	573 (3.0)	205 (1.1)	288 (1.5)	**19012**
EWH	17,081 (93.6)	592 (3.2)	249 (1.4)	328 (1.8)	**18250**
Thoracic	3,615 (93.4)	145 (3.7)	48 (1.2)	63 (1.6)	**3871**
Vertigo	3,693 (96.1)	85 (2.2)	30 (0.8)	35 (0.9)	**3843**
Stroke Lower Extremity	673 (96.4)	15 (2.1)	3 (0.4)	7 (1.0)	**698**
Stroke Upper Extremity	390 (95.6)	13 (3.2)	3 (0.7)	2 (0.5)	**408**
Lower quadrant edema	501 (97.9)	10 (2.0)	-	1 (0.2)	**512**
Upper quadrant edema	339 (98.5)	3 (0.9)	-	2 (0.6)	**344**
Other	7,239 (94.4)	240 (3.1)	90 (1.2)	99 (1.3)	**7668**
Total	**209,621 (94.1)**	**7,159 (3.2)**	**2,619 (1.2)**	**3,281 (1.5)**	**222680**

[a]Values are n (row %)

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Table 4: Telerehabilitation Frequency Levels by Telecommunication Delivery Modes [a]

TR telecommunication delivery modes	Few	Most	All	Total
[a]Synchronous mode (video or audio)	966 (69)	247 (53)	359 (46)	1572 (60)
[b]Asynchronous mode (no video or audio)	229 (16)	122 (26)	211 (27)	562 (21)
[d]Mixed modes	199 (14)	95 (20)	206 (27)	500 (19)
Total n (100%)	1394	464	776	2634

[a]Values are n (column %), and may sum up to 99-101% due to rounding of decimal points.
[b]Synchronous mode (video and/or audio calla) – 2-way interactive medium where both patients and clinicians exchange information instantaneously during the same time period using either video or audio calls
[c]Asynchronous mode (no video or audio calls) – e-visits not in real time, eg, text messaging or applications/links to educational materials

[d]Mixed modes – both synchronous and asynchronous mediums are used during the same episode of care

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