Perspectives of Stakeholders towards Usability and Deployment Locations of a Social Robot Assisted Telepresence System for Telerehabilitation

Anh T. Nguyen, *Member, IEEE*[1†], Ajay Anand, *Member, IEEE*[2†],
Michael J. Sobrepera, Ph.D. *Member, IEEE*[3], and Michelle J. Johnson, Ph.D., *Member, IEEE*[4]

***Abstract*— In this work, we present an exploratory analysis of novel data from 3 of our previous studies pertaining to the use of a Social Robot Augmented Telepresence (SRAT) system for remote rehabilitation interactions. We study comparisons between classical telepresence (CT) and SRAT in terms of patient-clinician communication, patient motivation to perform rehabilitation activities, patient compliance with instructions and patient adherence to treatment plans post interactions. We also study the feasibility of using the SRAT system in different deployment locations using stakeholder surveys from clinicians and patients. We aimed to gain a better understanding of the utility of SRAT systems for augmenting telerehabilitation and where they may be deployed to have the best effect. From our results, we found that the use of SRAT systems for telerehabilitation is promising. However, in order to achieve the best potential for clinical acceptability we need to deploy them in certain locations of high stakeholder interest such as rural clinics and schools for maximum effect. We also found that more work needs to be done in improving the ease of use of these systems to gain greater clinician acceptance.**

I. INTRODUCTION

A growing shortage of rehabilitation professionals [1] and wide gaps in access [2] have accelerated the need for development of alternative methods for the delivery of rehabilitation care. Telehealth, which refers to providing healthcare services remotely with the aid of technology has been proposed as one of the solutions to help address the growing demand for healthcare services, particularly in underserved and remote areas. Telehealth technologies provides patients with greater access to healthcare services regardless of their location, which then helps to reduce healthcare disparities. With the adoption of telehealth technologies, rehabilitation can be performed remotely; this telerehabilitation opportunity allows clinicians to provide patients with more exercise dosing, regular interactions with therapists, and more frequent assessments of function in daily life [3]. During the COVID-19 pandemic, telerehabilitation was extensively implemented to facilitate multiple healthcare services such as monitoring those with respiratory tract diseases, including those with COVID-19 and post-COVID-19 conditions [4], [5], rehabilitation for those suffering from spinal pathology, stroke, or neurodegenerative diseases [6], [7], [8], and physical therapy in pediatrics [9].

Rehabilitation robots such as social robots have been developed to bridge gaps in healthcare and are seen as technologies that can increase patients' enjoyment and engagement in routine exercise tasks [10]. A recent review [11] indicated that during the pandemic social robots enabled remote care in therapy settings at hospitals and nursing homes, and when deployed there, they were most often used by clinicians to provide functions such as telepresence, monitoring, and pre-diagnosis.

Driven by the need to increase access to rehabilitation for those with motor and cognitive impairments such as stroke or cerebral palsy survivors, we developed a social robot augmented telepresence (SRAT) system, named Flo (previously known as Lil'Flo), which combines a humanoid social robot with a telepresence platform that allows a clinician to remotely connect to a patient and direct the social robot to interact with the patient [12]. The Flo robot has been used in different therapy settings such as a geriatric care center, an inpatient rehabilitation center at a children's hospital, and outpatient rehabilitation settings. Multiple stakeholders interacted with the system, and their perceptions of the usability of the SRAT system are presented in this paper. We also describe the perspectives of clinicians, therapists, and patients on where they hope to use the SRAT system during telehealth applications with the goal of offering insights into how best to design future SRAT systems to optimize their use in diverse therapy settings.

This work was supported by the Department of Physical Medicine and Rehabilitation at the University of Pennsylvania and by the Eunice Kennedy Shriver National Institute of Child Health & Human Development of the National Institutes of Health (NIH) under Award Number F31HD102165. The content does not necessarily represent the views of the NIH.*(†Ajay Anand and Anh T. Nguyen contributed equally to this work)(corresponding author Anh T. Nguyen)*

[1]Anh T. Nguyen is with the School of Engineering and Applied Sciences, Department of Bioengineering, University of Pennsylvania, Philadelphia, PA, USA tuna28ng@seas.upenn.edu

[2]Ajay Anand is with the Rehab Robotics Lab (A GRASP Lab), University of Pennsylvania, Philadelphia, PA, USA. anandaj@seas.upenn.edu

[3]Michael J. Sobrepera is with the School of Engineering and Applied Sciences, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Philadelphia, PA, USA mjsobrep@live.com

[4]Dr. Michelle J. Johnson is an Associate Professor with a primary appointment in the Department of Physical Medicine and Rehabilitation and secondary appointments in BioEngineering and Mechanical Engineering and Applied Mechanics. She directs the Rehab Robotics Lab (A GRASP Lab), University of Pennsylvania, Philadelphia, PA, USA johnmic@pennmedicine.upenn.edu

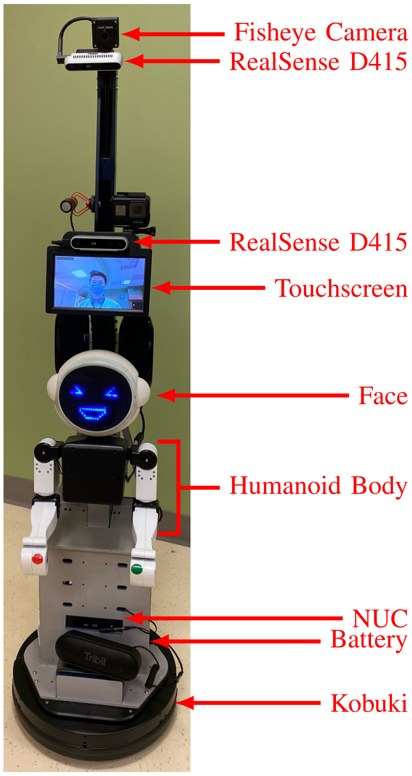

Fig. 1. Flo robot: Social Robot Augmented Telepresence System

II. METHODS

A. Design of Flo - A Social Robot Augmented Telepresence System

Each of the experiments described in the following section were based on using different aspects of the Flo system. Figure 1 shows the SRAT system; a small humanoid robot having a head, two arms and a torso was mounted on a mobile telepresence platform. The humanoid was designed to augment telerehabilitation activities by providing additional interaction and demonstration mechanisms. Key parts of the Flo robot are further described below:

1) A commercially available Kobuki base is used to provide mobility with a custom set of risers to hold the processing unit, screen, humanoid robot, cameras, and screen.
2) An Intel NUC mini PC system is integrated in the base to carry out processing tasks, to control the system, and to collect subject data
3) A custom designed humanoid robot is gravity mounted to the system at its midpoint and can be quickly detached to allow the system to become a pure telepresence platform.
4) A 7 inch 800x480 pixel TFT screen with a resistive touch overlay is used to allow the operator to interact with the subject.
5) Two RealSense D415 cameras and a fisheye camera are used to capture video and to aid robot navigation.

The head of the humanoid was designed to have a primitive system to depict facial expression, allowing the SRAT to convey different emotions to patients. This was tested independently with 10 healthy subjects, the results of this study are presented in our previous publication [13]. The design of the robot was also tested in a pilot study with three impaired and three typically developing pediatric subjects to finalize the system and the results of this study were reported in our prior publication [14]. The final design of Flo robot is described in further detail in Sobrepera *et al.* [12].

B. Experiments

The data analysed in this work was obtained from 3 different experiments.

Experiment 1 was a large scale survey of the rehabilitation community–hence forth referred to as the large scale clinician (LSC) survey. The LSC was conducted to gain a preliminary understanding of the current use and future need for telerehabilitation practices, the feasibility of using Flo robot for telepresence rehabilitation interactions, and the sentiments of clinicians towards robots in general. The survey was estimated to take 15 minutes to complete and was administered through REDCap. The survey was distributed using multiple channels including; state occupational therapy (OT), physical therapy (PT), and speech and language pathology (SLP) professional societies, Facebook groups, blogs, direct emails to connections, and direct emails to OTs and PTs in Ohio (where the state licensing board provides member emails) to extend its reach as far as possible. A total of 423 total completed responses were obtained, after exclusions we analysed the data of 351 therapists in the United States [15]. The survey methodology was:

(a) Subjects were asked to answer initial questions about demographics and the typical patient population treated by respondents
(b) This was followed by questions to determine the prior experience of the clinician with performing telerehabilitation
(c) The subjects were then asked to watch a short video of the Flo robot (https://youtu.be/OHybatsjzog), depicting the system being driven by a remote operator with the humanoid robot introducing itself and then demonstrating its capabilities including talking, moving the two upper limbs, and instructing the viewer in an exercise.
(d) Subjects were then asked to rate their general interest in the system on a sliding scale of 1 to 100 based on their level of interest in using the system.
(e) Finally, to better understand the usefulness of the Flo robot as perceived by the respondents, they were asked "How do you believe that adding a social robot as a companion for your patients during video+audio telepresence interactions (such as the Flo robot system) would change the following compared to traditional video + audio telepresence-based rehab?' and asked to rate 5 categories using sliding scales (Adherence, Compliance, Communication, Motivation, Assessment).

Experiment 2 was a long-term deployment (LTD) study which used the SRAT system at an elder care facility. The objective of the LTD study was to understand how clinicians

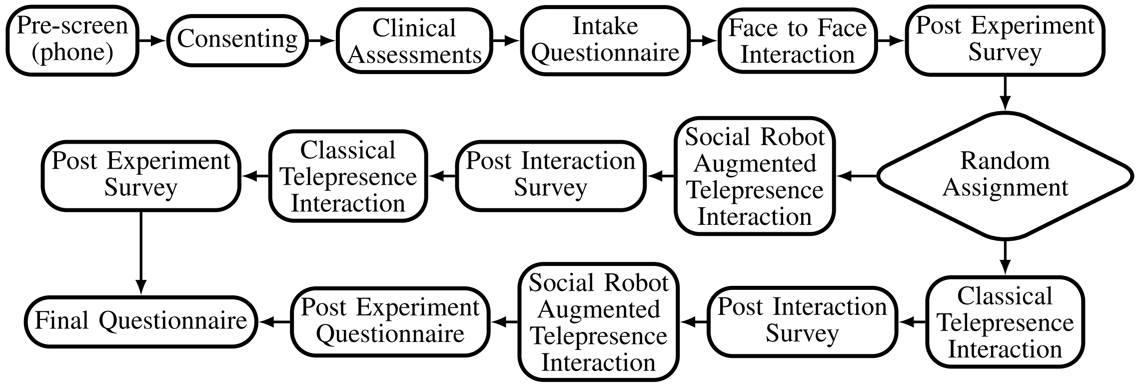

Fig. 2. Experiment flow of the multi-modal deployment study.

and patients would put a novel social robot augmented telepresence system to use in the community-based therapy setting environment. It sought to understand how they might use the system to perform different activities as well as their response to the interactions. The main goals of the study were to explore the following questions:

(a) How do clinicians choose to use the system?
(b) How well do patients react to the system?
(c) How useful do patients and clinicians find the system?
(d) What challenges arise while using the system?

The study was conducted at a Program of All-inclusive care for the Elderly (PACE) center. PACE centers provide the full spectrum of care in one location, including primary care, rehabilitation, and eye care as well as social interaction with staff and other patients. Patients treated by the center live in the local community and have a wide range of function level as well as diverse sources of impairment. Suitable patients for the study were identified with the help of the rehabilitation teams and staff at the clinical facility. Three therapists were identified with the interest and availability to operate the robot for the study, due to scheduling constraints only two therapists were able to participate in the study. Selected participants were those who were pre-existing patients of the therapists who operated the robot for the study [16].

Experiment 3 was a prospective study comparing multiple modes of carrying out rehabilitation therapy. This experiment will be referred to as the multi-modal deployment (MMD) survey. In the MMD study, 42 subjects with varying ages participated in rehabilitation exercises in either simulated or real clinical environments to test the SRAT system versus traditional face to face (FTF) rehabilitation methods and classical telepresence (CT). For the simulated clinical environments, the following locations were used: The Penn Rehab Robotics Lab, the Penn Gait Lab, the CHOP Neuromotor Performance Lab, and the Penn Clinical Simulator. The trials which took place in a clinical environment occurred at the teen activity room in the CHOP Division of Rehabilitation Medicine. Each trial took place with the participation of two or more researchers

(a) An operator who delivered the rehabilitation activities and operated the robot
(b) An interviewer who administered the subject surveys
(c) For some trials, additional observers were also present during the study

The flow of the experiment can be seen in fig. 2. For subjects who completed the trial in the clinical setting, the trial

TABLE I
CHARACTERISTICS OF STUDIES INCLUDED IN THIS REVIEW

Study	Study design	Demographics	Level of interaction with the robot	Survey question design
Large scale clinician survey (Sobrepera *et al.*, 2021 [15])	Online surveys	165 occupational therapists, 131 physical therapists, 41 speech language pathologists and 14 other types of therapists	Watching robot video overview	Exploratory surveys on the use of social robots to augment telerehabiliation
Long term deployment [16]	Case study with clinicians	2 physical therapists specializing in elder care	Directly operating the SRAT to perform rehabilitation therapy with preexisting patients	In-person surveys after long term deployments
Multi-modal deployment [16]	Multi-modal patient activities	32 impaired subjects and 10 unimpaired subjects	Experiencing rehabilitation activities through SRAT	In-person surveys comparing different rehabilitation modalities and overall experience post 3 interaction modalities

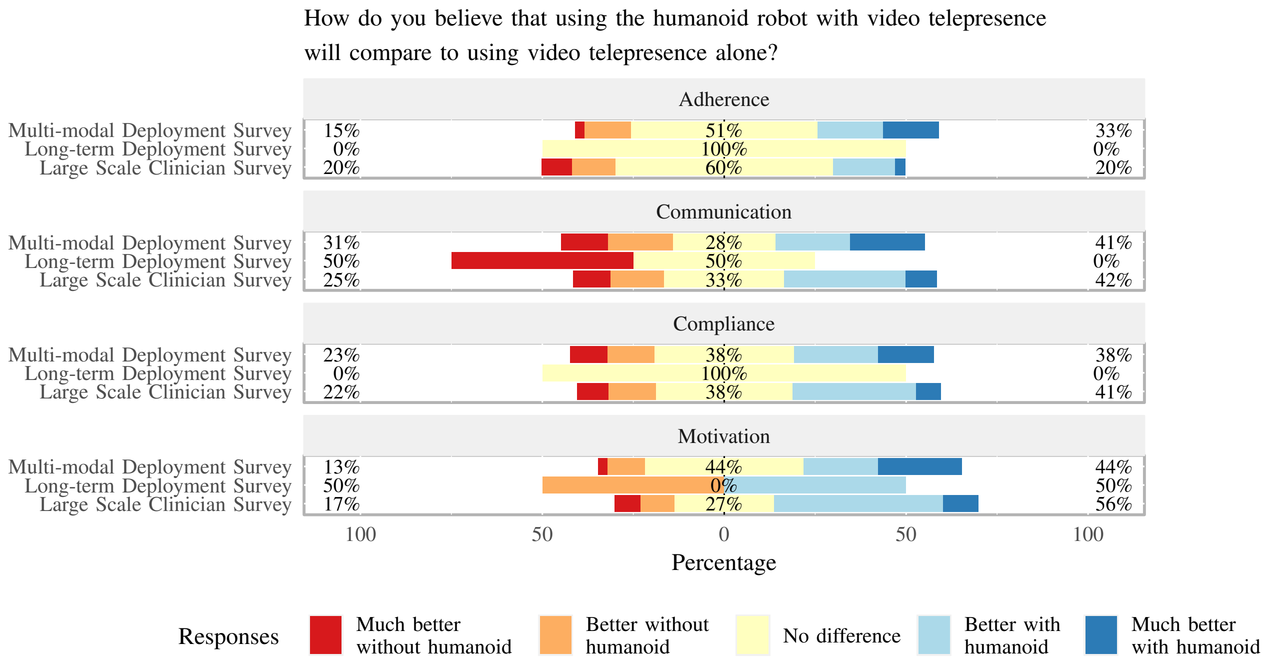

Fig. 3. Agglomerated survey results on the metrics of usability of SRAT system comparing to classical telepresence.

occurred over a span of two days, with an approximately one hour experiment activity each day. In the first day, the subjects completed the clinical assessments, intake survey, FTF interaction, and the first post experiment survey. On the second day, they completed the SRAT and CT interactions, the remaining post experiment survey and the final survey. For subjects who completed the trial in one of the simulated environments, the entire trial was completed in a single block of approximately two hours in a single day [16].

The stakeholders in these experiments were rehabilitation clinicians and patients with varying levels of experience with telehealth technologies and rehabilitation robots. For this paper, we examine respondents opinions on the usability of the Flo SRAT robot for telerehabilitation tasks in terms of four metrics; Adherence, Communication, Compliance, and Motivation. For this purpose, we posed the question ”How do you believe that using the humanoid robot with video telepresence will compare to using video telepresence alone?” We present the responses in the usability results.

Given that the number of rehabilitation care providers differ across the various types of rehabilitation locations from inpatient to outpatient settings [17], stakeholders were also asked to comment on which locations SRAT systems may be deployed. We report stakeholders responses about deployment locations and where they perceive these robots would have the most utility. We expected that SRAT systems may not be well suited to be deployed in all locations.

III. RESULTS

A. Usability

The responses of stakeholders from the MMD, LTD and LSC surveys on whether the Flo SRAT robot would improve Adherence, Communication, Compliance, and Motivation as compared to standard telehealth technologies are presented in fig. 3. We obtained the following results from our tests:

1) Adherence: Respondents of the MMD survey leaned neutral to positive with 33% responding that using SRATs would either make adherence to clinicians instructions either better or much better compared to CT, 51% were neutral and only 15% were negative. Respondents to the LTD survey were neutral and respondents to the LSC surveys were also largely neutral with 20% positive, 20% negative and 60% neutral.
2) Communication: Respondents of the MMD survey were largely positive with 41% responding that using SRATs would either make communication with clinicians either better or much better compared to CT, 28% were neutral and 31% were negative. Respondents of the LTD survey were somewhat negative with 50% negative and 50% neutral responses. Respondents to the LSC survey were also largely positive with 42% positive responses, 33% neutral responses and 25% negative responses.
3) Compliance: Respondents of the MMD survey were positive with 38% responding that using SRATs would either make compliance with clinicians instructions either better or much better compared to CT, 38% were neutral and 23% were negative. Respondents to the LTD survey were 100% neutral. Respondents to the LSC survey were also largely positive with 41% positive responses, 38% neutral responses and 22% negative responses.
4) Motivation: Respondents of the MMD survey were positive with 44% responding that using SRATs would

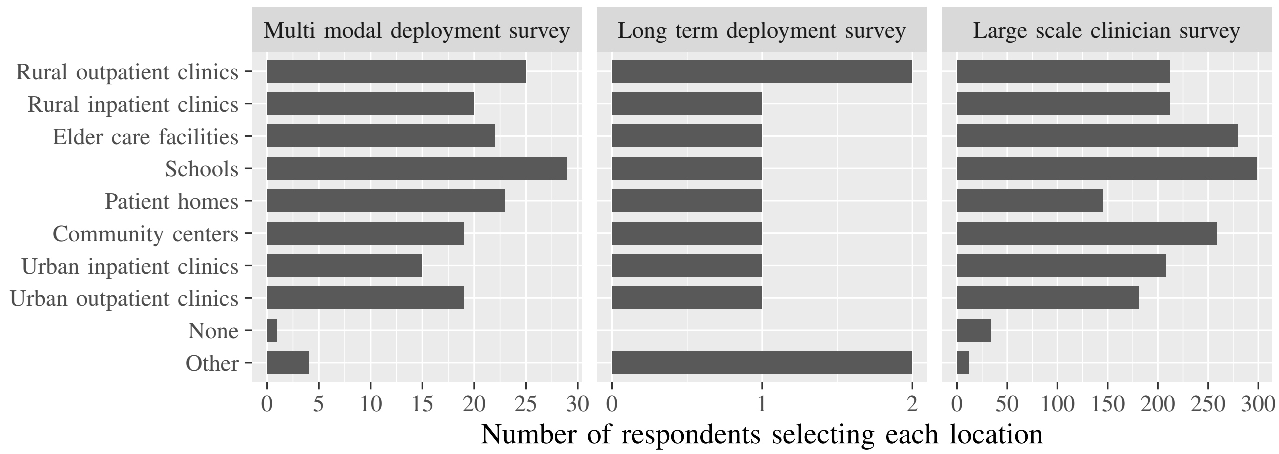

Fig. 4. Agglomerated survey results on deployment locations: Respondents selected multiple answers to the question ”What locations do you think Flo robot could be deployed in?”.

either make motivation to perform rehabilitation activities either better or much better compared to CT, 44% were neutral and 13% were negative. Respondents to the LTD survey were largely neutral with 50% positive and 50% negative responses. Respondents to the LSC survey were also largely positive with 56% positive responses, 21% neutral responses and 17% negative responses.

B. Deployment Locations

We present the results of the location survey in fig. 4. Each of the respondents was presented with questions pertaining to where they thought SRAT systems such as Flo robot might be deployed; they were allowed to choose one or multiple responses with none being available as an option if they thought that the system would not be useful at any of the presented locations. They were also allowed to present other locations where they thought the system might be useful. We obtained the following results from our surveys on deployment locations for SRATs:

1) Rural outpatient clinics: 62.5% respondents of the MMD survey, 100% respondents of the LTD survey and 60.4% respondents to the LSC survey supported the use of SRATs in rural outpatient clinics.
2) Rural inpatient clinics: 50% respondents of the MMD survey, 50% respondents of the LTD survey and 60.4% respondents to the LSC survey supported the use of SRATs in rural inpatient clinics.
3) Elder care facilities: 55% respondents of the MMD survey, 50% respondents of the LTD survey and 79.8% respondents to the LSC survey supported the use of SRATs in elder care facilities.
4) Schools: 72.5% respondents of the MMD survey, 50% respondents of the LTD survey and 85.2% respondents to the LSC survey supported the use of SRATs in schools.
5) Patient homes: 57.5% respondents of the MMD survey, 50% respondents of the LTD survey and 41.3% respondents to the LSC survey supported the use of SRATs in patient homes.
6) Community centers: 47.5% respondents of the MMD survey, 50% respondents of the LTD survey and 73.8% respondents to the LSC survey supported the use of SRATs in community centers.
7) Urban inpatient clinics: 37.5% respondents of the MMD survey, 50% respondents of the LTD survey and 59.3% respondents to the LSC survey supported the use of SRATs in urban inpatient clinics.
8) Urban outpatient clinics: 47.5% respondents of the MMD survey, 50% respondents of the LTD survey and 51.6% respondents to the LSC survey supported the use of SRATs in urban outpatient clinics.
9) None: 2.5% respondents of the MMD survey, 0% respondents of the LTD survey and 9.7% respondents to the LSC survey did not support the use of SRATs in any location.
10) Other: 10% respondents of the MMD survey, 100% respondents of the LTD survey and 3.41% respondents to the LSC survey supported the use of SRATs in other locations than the options provided to them.

IV. DISCUSSION

In this paper, we presented opinions on usability and deployment locations for a social robot augmented with telepresence capabilities from three studies targeting multiple stakeholders. The large scale clinician (LSC) study collected responses from 351 therapists across the USA who assessed the perceived usefulness of the SRAT system from speculating the introductory video. The long term deployment (LTD) study investigated how therapists actually use the system to interact with their patients, and their perspectives based on their repetitive hands-on operation of the system. The third study, multi-modal deployment (MMD), examined how a wide range of participants with different levels of motor and cognitive impairment perceived the system after interacting with it in several physical therapeutic games. We targeted four metrics of usability; communication, motivation, compliance, and adherence, and one deployment location question.

A. Usability

Overall we found that respondents from the MMD survey (healthy and impaired subjects who participated in therapeutic activities with the SRAT) had the most positive response, while LTD respondents (rehabilitation clinicians who operated the robot) had the most negative response towards the usability of the SRAT. For clinicians in the LTD study, we theorized that the cognitive load of operating the robot might have skewed their responses to these questions. The current version of the SRAT system required clinicians to program all the humanoid movements explicitly [12], which clinicians felt was too much, suggesting that a SRAT system with a humanoid robot with higher levels of autonomy may be needed. The results from the MMD participants suggest that SRAT systems can play a strong role in improving adherence to instructions, communication with clinicians, compliance with instructions and motivation to carry out rehabilitation exercises for patients undergoing rehabilitation therapy. Our results from the MMD surveys are in line with findings from Casas *et al.* about positive perceptions towards usefulness of a social assistive robot by a majority of patients (75%) [18]. The agreement between multiple stakeholders about the positive contribution of the humanoid in the SRAT system to patient motivation also matches up with findings from several previous studies [19], [20], [21]. These findings are further reinforced by results in the LSC study with the caveat that LSC respondents were fairly neutral in their response as to whether SRAT systems can improve adherence to instructions post interactions. However, the LTD respondents were either neutral or negative towards the queried metrics. Since they were the only respondents with direct experience operating the system, this suggests that more work needs to be done to make SRAT systems like the Flo robot easier for rehabilitation clinicians to operate before wider adoption can be achieved.

B. Deployment Locations

We expected that with the ongoing shortage of rehabilitation clinicians, especially in rural medical care locations[2][22], that respondents would be strongly in favor of the deployment of SRAT systems in rural clinics for both inpatient and outpatient therapy. On the whole, respondents were largely in favor of the deployment of SRAT systems in rural outpatient clinics, with the most positive response being from the LTD survey with all respondents in favor of this location, it was also second most popular with MMD respondents and LSC respondents were largely positive as well. The respondents were also generally positive about the deployment of SRATs in rural inpatient clinics, with the MMD and LSC respondents being largely in favor and the LTD respondents evenly divided on the utility of SRATs in rural inpatient clinics. Although rural medical centers are disproportionately affected by the shortage of rehabilitation clinicians, we expected respondents to believe that urban clinics can also benefit from the deployment of SRATs to enhance rehabilitation care. MMD, LTD, and LSC respondents were generally less positive in their support for SRATs being deployed in urban inpatient clinics. Urban outpatient clinics show similar results to inpatient clinics with MMD being marginally more positive and LSC being marginally more negative towards SRAT deployment in those locations.

Given the statistics on the rapidly aging population worldwide and the subsequent increase in need for elder care, we expected that respondents would strongly be in favor of the deployment of SRAT systems to elder care facilities [23]. However, only the LSC respondents were strongly in favor of using SRAT systems in elder care facilities, the MMD respondents were somewhat in favor, and LTD respondents were split.

Of all the deployment categories, schools were the most frequently selected category with MMD and LSC respondents selecting it most often. These results support the need for studies to explore how best to use social robots in schools; a few studies have documented the positive deployment of social robots in schools [10] [24] to enhance learning for students with intellectual disabilities and autism [25].

LSC respondents ranked Community centers quite highly as a good deployment location, which is in contrast to both MMD and LTD respondents. We believe that more research is required to determine the feasibility and usefulness of having SRAT systems deployed at community centers and their purpose there.

Several of the surveyed participants from the MMD, LTD and LSC surveys opted to enter their own additional locations where they believed an SRAT system could feasibly be deployed. These responses are locations that further research must be carried out to quantify the utility of SRATs; they were speech therapy environments, independent living centers, recreational centers, pediatric environments, locations that treat immunocompromised individuals, centers for special needs and university training programs.

C. Limitations

We would like to acknowledge several shortcomings that might impact the results of our studies. The limited sample size (2 therapists) in the LTD study and difficulty experienced in learning to operate the system of the long term deployment experiment restricts the scope of this study and impedes us from statistically analyzing the difference between the number of ratings of usability of the SRAT system by different groups of stakeholders. The responses of the LSC participants, while useful in determining directions that SRAT research can take, are limited by the nature of interaction with the SRAT (short video overview).

V. CONCLUSIONS

We agglomerated the results of 3 different studies used to test an SRAT system and contrasted how stakeholder opinions on usability and deployment locations change based on therapy role (patient vs clinician) and level of experience with the system (ranging from a short 2 minute video to 2 hour therapy session to a series of interactions over a period of weeks). We found that while overall results showed that participants of the three studies were largely positive in the benefits of using SRATs, more work needs to be done to facilitate ease of use for clinicians operating the system. We also found that our survey respondents largely expressed views in line with each other on the matter of deployment locations with few outliers.

Based on the results of our work, we would like to carry out more experiments with larger numbers of clinicians to obtain feedback on how to reduce the learning curve to operate such systems and to increase their viability as aids for rehabilitative care.

ACKNOWLEDGMENT

We would like to thank everyone who directly or indirectly assisted us in carrying out this work including all of the clinicians who participated in the large scale survey. We would also like to thank Emily S. Gavin, without whom our work in elder care would have been possible as well as the the therapists and patients from Mercy LIFE West Philadelphia who participated in the long term deployment study. We would especially like to thank the clinicians, Dr. Sally H. Evans and Dr. Laura A. Prosser, as well as the therapists Kyla A. Madden and Jessica L. Whittington, at the Children's Hospital of Philadelphia, who actively supported us in carrying out the multi-modal deployment study. We would also be remiss in not acknowledging the work done by multiple people in the design of our robot and for their aid in carrying out our studies including Dr. Rochelle Mendonca, Vera G. Lee, Suveer Garg, Julie Elfishawy, and Maria Ovando.

REFERENCES

[1] V. Lin, X. Zhang, and P. Dixon, "Occupational Therapy Workforce in the United States: Forecasting Nationwide Shortages," *PM&R*, vol. 7, no. 9, pp. 946–954, Sep. 2015.

[2] W. Shultis, R. Graff, C. Chamie, C. Hart, P. Louangketh, M. McNamara, N. Okon, and D. Tirschwell, "Striking Rural-Urban Disparities Observed in Acute Stroke Care Capacity and Services in the Pacific Northwest," *Stroke*, vol. 41, no. 10, pp. 2278–2282, Oct. 2010.

[3] W. A. Steiner, L. Ryser, E. Huber, D. Uebelhart, A. Aeschlimann, and G. Stucki, "Use of the ICF model as a clinical problem-solving tool in physical therapy and rehabilitation medicine," *Physical Therapy*, vol. 82, no. 11, pp. 1098–1107, Nov. 2002.

[4] S. Taito, K. Yamauchi, and Y. Kataoka, "Telerehabilitation in Subjects With Respiratory Disease: A Scoping Review," *Respiratory Care*, vol. 66, no. 4, pp. 686–698, Apr. 2021.

[5] A. G. d. S. Vieira, A. C. P. N. Pinto, B. M. S. P. Garcia, R. A. C. Eid, C. G. Mól, and R. K. Nawa, "Telerehabilitation improves physical function and reduces dyspnoea in people with COVID-19 and post-COVID-19 conditions: A systematic review," *Journal of Physiotherapy*, vol. 68, no. 2, pp. 90–98, Apr. 2022.

[6] B. Fiani, I. Siddiqi, S. C. Lee, L. Dhillon, B. Fiani, I. Siddiqi, S. C. Lee, and L. Dhillon, "Telerehabilitation: Development, Application, and Need for Increased Usage in the COVID-19 Era for Patients with Spinal Pathology," *Cureus*, vol. 12, no. 9, Sep. 2020.

[7] P. M. Ostrowska, M. Śliwiński, R. Studnicki, and R. Hansdorfer-Korzon, "Telerehabilitation of Post-Stroke Patients as a Therapeutic Solution in the Era of the Covid-19 Pandemic," *Healthcare*, vol. 9, no. 6, p. 654, Jun. 2021.

[8] S. Bernini, F. Stasolla, S. Panzarasa, S. Quaglini, E. Sinforiani, G. Sandrini, T. Vecchi, C. Tassorelli, and S. Bottiroli, "Cognitive Telerehabilitation for Older Adults With Neurodegenerative Diseases in the COVID-19 Era: A Perspective Study," *Frontiers in Neurology*, vol. 11, 2021.

[9] A. Alonazi, "Effectiveness and Acceptability of Telerehabilitation in Physical Therapy during COVID-19 in Children: Findings of a Systematic Review," *Children*, vol. 8, no. 12, p. 1101, Dec. 2021.

[10] I. Papadopoulos, C. Koulouglioti, R. Lazzarino, and S. Ali, "Enablers and barriers to the implementation of socially assistive humanoid robots in health and social care: A systematic review," *BMJ Open*, vol. 10, no. 1, p. e033096, Jan. 2020.

[11] L. Aymerich-Franch and I. Ferrer, "Liaison, safeguard, and well-being: Analyzing the role of social robots during the COVID-19 pandemic," *Technology in society*, vol. 70, p. 101993, Aug. 2022.

[12] M. J. Sobrepera, V. G. Lee, and M. J. Johnson, "The design of Lil'Flo, a socially assistive robot for upper extremity motor assessment and rehabilitation in the community via telepresence," *Journal of Rehabilitation and Assistive Technologies Engineering*, vol. 8, p. 205566832110018, Jan. 2021.

[13] M. J. Sobrepera, E. Kina, and M. J. Johnson, "Designing and evaluating the face of lil'flo: an affordable social rehabilitation robot," in *2019 IEEE 16th International Conference on Rehabilitation Robotics (ICORR)*. IEEE, pp. 748–753. [Online]. Available: https://ieeexplore.ieee.org/document/8779416/

[14] M. J. Sobrepera and M. J. Johnson, "Feasibility and Acceptability of Remote Rehabilitation Assessments Using a Social Robot Augmented Telepresence Platform," p. 8.

[15] M. J. Sobrepera, V. G. Lee, S. Garg, R. Mendonca, and M. J. Johnson, "Perceived Usefulness of a Social Robot Augmented Telehealth Platform by Therapists in the United States," *IEEE Robotics and Automation Letters*, vol. 6, no. 2, pp. 2946–2953, Apr. 2021.

[16] M. Sobrepera, "Social robot augmented telepresence for remote assessment and rehabilitation of patients with upper extremity impairment," Ph.D. dissertation, 2022. [Online]. Available: https://repository.upenn.edu/edissertations/5582

[17] T. S. Jesus, M. D. Landry, G. Dussault, and I. Fronteira, "Human resources for health (and rehabilitation): Six Rehab-Workforce Challenges for the century," *Human Resources for Health*, vol. 15, no. 1, p. 8, Jan. 2017.

[18] J. A. Casas, N. Céspedes, C. A. Cifuentes, L. F. Gutierrez, M. Rincón-Roncancio, and M. Múnera, "Expectation vs. reality: Attitudes towards a socially assistive robot in cardiac rehabilitation," vol. 9, no. 21, p. 4651, number: 21 Publisher: Multidisciplinary Digital Publishing Institute. [Online]. Available: https://www.mdpi.com/2076-3417/9/21/4651

[19] J. Casas, E. Senft, L. F. Gutiérrez, M. Rincón-Rocancio, M. Múnera, T. Belpaeme, and C. A. Cifuentes, "Social assistive robots: Assessing the impact of a training assistant robot in cardiac rehabilitation," vol. 13, no. 6, pp. 1189–1203. [Online]. Available: https://doi.org/10.1007/s12369-020-00708-y

[20] R. J. F. van den Heuvel, M. A. S. Lexis, and L. P. de Witte, "ZORA robot based interventions to achieve therapeutic and educational goals in children with severe physical disabilities," vol. 12, no. 2, pp. 493–504. [Online]. Available: https://doi.org/10.1007/s12369-019-00578-z

[21] V. Vasco, C. Willemse, P. Chevalier, D. De Tommaso, V. Gower, F. Gramatica, V. Tikhanoff, U. Pattacini, G. Metta, and A. Wykowska, "Train with me: A study comparing a socially assistive robot and a virtual agent for a rehabilitation task," in *Social Robotics*, ser. Lecture Notes in Computer Science, M. A. Salichs, S. S. Ge, E. I. Barakova, J.-J. Cabibihan, A. R. Wagner, Castro-González, and H. He, Eds. Springer International Publishing, pp. 453–463.

[22] D. Goodridge, M. Rogers, L. Klassen, B. Jeffery, K. Knox, N. Rohatinsky, and G. Linassi, "Access to health and support services: Perspectives of people living with a long-term traumatic spinal cord injury in rural and urban areas," *Disability and Rehabilitation*, vol. 37, no. 16, pp. 1401–1410, Jul. 2015.

[23] "Ageing and health," https://www.who.int/news-room/fact-sheets/detail/ageing-and-health.

[24] I. Papadopoulos, R. Lazzarino, S. Miah, T. Weaver, B. Thomas, and C. Koulouglioti, "A systematic review of the literature regarding socially assistive robots in pre-tertiary education," *Computers & Education*, vol. 155, p. 103924, Oct. 2020.

[25] D. Silvera-Tawil and C. R. Yates, "Socially-Assistive Robots to Enhance Learning for Secondary Students with Intellectual Disabilities

and Autism," in *2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*, Aug. 2018, pp. 838–843.