

How We Work Now: Preliminary Review of a Pediatric Neuropsychology Hybrid Model in the Era of COVID-19 and Beyond

Jonathan D. Lichtenstein^{1,2,*}, Jennifer T. Amato^{1,2}, Emily Z. Holding¹, Kelsey D. Grodner¹,
Erica N. Pollock¹, Kelsea P. Marschall¹, Sara Scull¹

¹Dartmouth-Hitchcock Medical Center, Pediatric Neuropsychology Program, Lebanon, NH, USA

²Geisel School of Medicine at Dartmouth, Hanover, NH, USA

*Corresponding author at: Department of Psychiatry, Dartmouth-Hitchcock Medical Center, One Medical Center Drive, Lebanon, NH 03756, USA. E-mail address: Jonathan.d.Lichtenstein@dartmouth.edu

Received 2 February 2021; revised 5 April 2021; Accepted 11 May 2021

Abstract

Objective: Although telehealth has become a central component of medical care in response to the coronavirus disease 2019 (COVID-19) pandemic, comprehensive pediatric neuropsychological assessment over virtual platforms lacks empirical efficacy. This paper presents: a) the results of a quality improvement project examining the feasibility of in-person evaluation in the context of safety measures that alter test standardization, b) the impact such changes had upon neuropsychological test scores, and c) how using a hybrid model of clinical service delivery affected access to care.

Method: We compared demographic and outcome variables between patients seen during the pandemic ($N = 87$) to a group of patients seen in our service immediately prior to COVID-19 ($N = 87$). A subset of those patients were case-matched for age and diagnosis ($N = 39$ per group). Children seen for neuropsychological re-evaluation during the pandemic ($N = 10$) were examined using pairwise comparison.

Results: Groups did not differ on age, sex, or FSIQ. Despite changes to standardized administration, no group differences were found for any selected neuropsychological test variables in the larger sample or subsamples. In fact, all variables were moderately to highly correlated in the re-evaluation subgroup. The hybrid model expedited feedback sessions and increased face-to-face (telehealth) feedbacks.

Conclusions: A hybrid model incorporating modified in-person testing and intake and feedback encounters via telehealth may be a feasible and effective way to provide pediatric neuropsychological services. These preliminary findings suggest such novel aspects of neuropsychological evaluation could represent an improvement over pre-COVID models, especially in rural settings.

Keywords: Assessment; Childhood neurologic disorders; Children and behavioral disorders; Professional issues

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has changed the way healthcare has been implemented across settings including private practice, hospitals, general medical care, and specialty fields. Clinicians have had to adapt to the pandemic in order to continue to offer necessary services while maintaining safety and physical distancing policies. Depending on the requirements of the specialty, implementation of safety protocols has resulted in different adaptations to traditional care, primarily transitioning to the use of telehealth appointments for service provision. Similarly, the field of neuropsychology has attempted to integrate telehealth in response to the pandemic; however, there have been a number of challenges in transitioning to a virtual model of service delivery. Traditionally, neuropsychologists have relied upon in-person, paper and pencil testing due to a preponderance of research to support their use (Hewitt, Rodgin, Loring, Pritchard, & Jacobson, 2020). Prior to the pandemic, more attention had been focused on incorporating technology through computer-based administration of measures and the potential role of telehealth in providing neuropsychological services (Harder et al., 2020; Ransom et al., 2020). With

the commencement of stay-at-home orders, social distancing protocols, and insurance reimbursement for telehealth services, a renewed emphasis has been placed on technology's role in neuropsychological evaluations, and its limitations (Hewitt et al., 2020; Ransom et al., 2020).

The difficulty of transitioning evaluations to a virtual format is reflected in two surveys conducted in 2020 (Zane, Thaler, Reilly, Mahoney III, & Scarisbrick, 2020). The results of the first (March 23–26, 2020) demonstrated that telehealth was primarily used for interviews (73%) and feedback (66%) services as opposed to full evaluations (30%; Zane et al., 2020). A follow-up survey in March 30–April 10, 2020 found that the type of services varied with 47% of their sample providing virtual interviews only, 19% offering inpatient/consult services, and 18% offering full neuropsychological evaluations via telehealth (Zane et al., 2020). Most of these telehealth neuropsychological testing evaluations consisted of measures more easily administered virtually (e.g., mental health status exams or verbally mediated tasks). Despite this rise in access to healthcare through telehealth services, the results of this study found that neuropsychological services have seen fewer patients overall in response to the pandemic.

Research has revealed general acceptance of telehealth practices in neuropsychology within adults and geriatric populations, and is especially useful to increase access to such services (Brearly et al., 2017; Cullum, Hynan, Grosch, Parikh, & Weiner, 2014). Consistent with prior research, a recent literature review similarly supports the validity of neuropsychological testing via telehealth in older adults (Marra, Hamlet, Bauer, & Bowers, 2020). However, the same literature review also highlighted limited evidence supporting the validity of intelligence, executive functioning, and processing speed measures, which are critical components of neuropsychological testing batteries (Marra et al., 2020). Thus, there is a continued need for research to support the validity of administering certain measures via telehealth, especially as their use has been expanded and increasingly relied upon in the current pandemic. In contrast, in the field of pediatric neuropsychology, telehealth is limited in its ability to replicate the traditional testing environment and subsequently has not been well investigated or utilized (Ransom et al., 2020).

The advent of telehealth also has the potential to reduce travel burden and increase access for patients (Ransom et al., 2020). A study conducted in a private practice setting prior to the pandemic supports the potential benefits of telehealth, demonstrating that brief neuropsychological screenings conducted via telehealth decreased time to diagnosis, and treatment and was financially feasible for patients (Salinas, Edgar, Berrios Siervo, & Bender, 2020). It may also increase the involvement of caregivers and care team members who previously could not attend in-person appointments (Bilder et al., 2020). Further, using telehealth for triage assists in increasing the efficiency of the clinic, reduces waitlist length, and the overall potential to increase timely access to appropriate care (Pritchard, Sweeney, Salorio, & Jacobson, 2020). The feasibility of using telehealth has increased since the beginning of the pandemic as there is increased guidance on how to use the technology (Bilder et al., 2020) and reimbursement for the service (Bilder et al., 2020; Hewitt et al., 2020; Ransom et al., 2020). One preliminary study (Harder et al., 2020) suggested that telehealth-based neuropsychological testing was feasible and valid in pediatric patients with demyelinating disorders. However, additional research is needed to generalize these findings to other pediatric populations and demonstrate the efficacy and larger breadth of pediatric service provision in the future.

Although there are a number of benefits to telehealth, its current application to neuropsychological assessment has a number of important limitations. For models using telehealth-based testing, test security is an important consideration that must be managed as there are limits to the clinician's ability to control test duplication or recording of assessment administration outside the traditional testing environment (Peterson, Ludwig, & Jashar, 2020; Pritchard et al., 2020). As previously mentioned, despite preliminary findings by Harder et al. (2020), validity of testing using a telehealth platform must be considered. There is insufficient evidence on how to modify specific tests and navigate technological limitations that further affect their standardization when administering measures via telehealth (Bilder et al., 2020). For example, visual or auditory stimuli may be distorted, an unstable internet connection may affect timed tasks, parent/caregiver limitations in navigating technology, and lack of control of the environment (e.g., visual and auditory distractions, limited ability to ensure patient compliance with instructions or providing effective structure to reduce interfering behaviors; Hewitt et al., 2020). In addition, socioeconomic status (SES) has the potential to limit access to neuropsychological services, especially assessment provided via telehealth, if patients do not have access to appropriate electronic equipment and broadband internet access (Bilder et al., 2020; Peterson, Ludwig, & Jashar, 2020). A number of studies assessing telehealth utilization received funding to provide disadvantaged patients with appropriate electronic devices or internet access, which cannot be duplicated in all settings (Pritchard et al., 2020; Ransom et al., 2020). Hewitt et al. (2020) and Bilder et al. (2020) detail other considerations and limitations when conducting neuropsychological services using telehealth platforms.

In response to the pandemic, some sites have introduced a tiered model to triage patients based on their specific needs. These models provide a comprehensive interview and record review for all patients via telehealth. Based on the diagnostic question and clinical characteristics, the child is triaged to telehealth-based testing or in-person testing, when available (Peterson et al.,

Table 1. Demographics

Characteristic	Pre-COVID-19 (n = 87)			COVID-19 (n = 87)			p
	M	SD	Range	M	SD	Range	
Age, yrs.	12.22	3.74	5–22	13.16	3.51	5–19	0.354
	n	%		n	%		
Sex							1.000
Female	43	49.4		42	48.2		
Male	44	50.6		45	51.8		
Insurance Type							0.745
Private Insurance	38	43.6		42	48.2		
State Insurance	46	53.0		45	51.8		
Unavailable	3	3.4		0	0.0		
Ethnicity							
White	81	93.1		75	86.2		
Black/African American	3	3.4		5	5.7		
Hispanic/Latino	1	1.1		4	4.6		
Asian	1	1.1		1	1.1		
Native Hawaiian/Pacific Islander	1	1.1		0	0		
Undisclosed	0	0		2	2.3%		

Note: p-values were calculated with chi-square tests.

2020; Pritchard et al., 2020; Ransom et al., 2020). Telehealth-based testing may include rating scales and/or administration of some traditional assessment measures (Peterson et al., 2020; Pritchard et al., 2020). Ransom et al. (2020) found that the majority of pediatric patients tested via telehealth (63%) required an in-person follow-up to complete the neuropsychological evaluation due to a limited capacity to remotely measure important domains (e.g., tests involving visuomotor, graphomotor, academic achievement, and social cognition). Many pediatric patients, particularly those with medical presentations, require results from full neuropsychological evaluations to assist with decision-making. As the pandemic continues, pediatric neuropsychologists will need to implement methods of conducting evaluations that extend beyond telehealth-based testing. To provide valid and comprehensive results, in-person testing that incorporates safety protocols remains necessary to guide intervention and resource allocation in support of educational trajectories/special education eligibility and activities of daily living (Pritchard et al., 2020).

The current paper expands upon the existing literature by reporting on a hybrid model for pediatric neuropsychology, in which a combination of in-person assessment and telehealth interviews/feedbacks can be used. Importantly, however, in order for in-person assessment to be conducted during the pandemic, changes to test administration standardization had to be made. The main objectives of the current project are threefold: 1) to present this service delivery model, 2) to determine if pandemic-driven changes to testing practice (i.e., with safety protocols implemented) have significant impact upon neuropsychological testing outcomes, and 3) to examine how the use of a combination of in-person testing and telehealth for non-testing activities affected access to care and patient engagement.

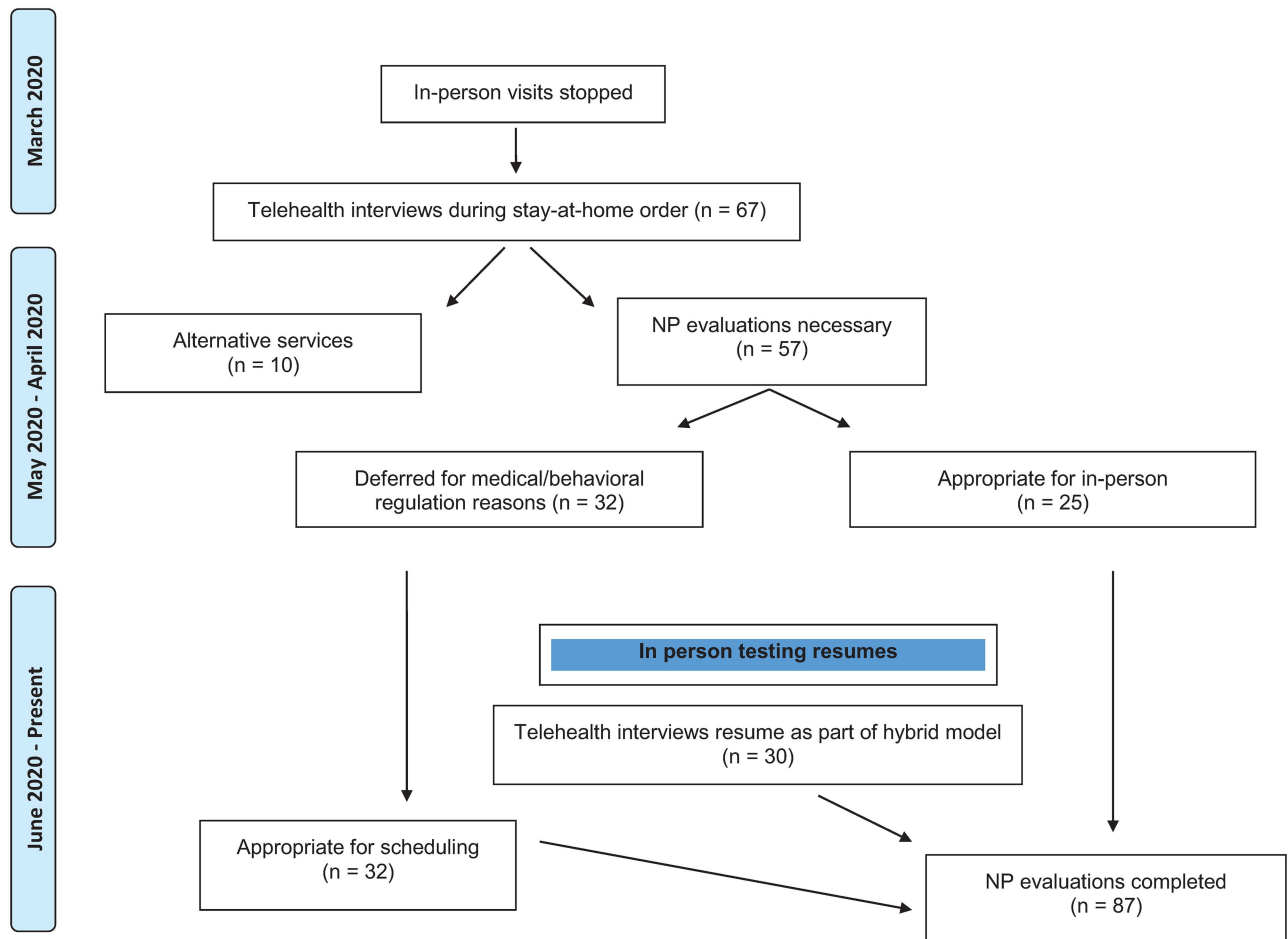
Methods

Participants

This project was carried out at an academic medical center in rural New England. We used a retrospective sample of children and adolescents either seen or referred for outpatient evaluation within a pediatric neuropsychology service. The sample included a total of 170 participants: 87 (49.4% women; $M = 12.2$ years, $SD = 3.74$) who underwent assessment prior to the pandemic (pre-COVID group), and 87 (48.8% women; $M = 13.16$ years, $SD = 3.51$) who were tested with modifications during the pandemic (COVID group). All patients were native English speakers, and the majority of patients were White (see Table 1). Patients evaluated with in-person testing during the pandemic (between June 17 and December 22, 2020) were identified. A pre-COVID comparison cohort was assembled by selecting the patients seen immediately prior to the stay-at-home orders until an equivalent sample size was achieved. Primary diagnostic categories included neurodevelopmental differences (i.e., developmental delays, attention-deficit/hyperactivity disorder (ADHD), learning difficulties, autism spectrum disorders, and intellectual disability), epilepsy, traumatic brain injury, hematology/oncology, genetics, and psychiatric presentations (Table 2).

Table 2. Primary Diagnostic Categories across Groups

Diagnostic Category	Pre-COVID (n = 87)		COVID (n = 87)	
	n	%	n	%
ADHD/Learning	5	5.7	24	27.6
Autism	6	6.9	5	5.7
Developmental Delay	9	10.3	15	17.2
Epilepsy	20	23.0	15	17.2
Genetic Condition	11	12.6	5	5.7
Hematology/Oncology	11	12.6	2	2.3
Neurologic/Medical	9	10.3	5	5.7
Psychiatric	4	4.8	7	8.0
TBI	12	13.8	9	10.3



Note: NP = neuropsychological. “Alternative services” indicates that NP evaluation was not deemed necessary and other services were recommended (e.g., psychiatry, therapy, etc.).

Fig. 1. Evaluation Process during COVID-19.

Procedures

Prior to the pandemic, referred patients were triaged by the program’s director. Priority was given to patients with medical conditions affecting central nervous system (CNS) function, followed by patients with developmental, learning, and behavioral complexities. Patients not identified as priority often remained on the wait list for 12 to 16 months. Standard neuropsychological evaluations were day-long appointments. The child and family members would participate in a clinical interview in the morning,

testing would occur throughout the day, and feedback was given the same day, or scheduled for phone or in-person appointments on a later day.

As the COVID-19 pandemic intensified and stay-at-home orders were issued, our services were converted entirely to telehealth interviews only (platforms included Zoom, WebEx, and a platform unique to our medical center). Goals of these sessions included streamlining interviews for patients who would eventually need comprehensive assessment, keeping current with incoming referrals, and interviewing patients who had been on the waitlist for an extended period of time. Telehealth interviews helped to determine the need for comprehensive or abbreviated neuropsychological assessment, whether a referral to other providers (e.g., psychiatry or psychology) was necessary, and if any immediate treatment recommendations could be offered or acted upon.

Between April 14 and May 15, 2020, 67 patients were seen for telehealth interviews. A total of 57 were identified as needing comprehensive neuropsychological assessment. When stay-at-home restrictions were lifted, in-person appointments resumed, and patients were evaluated for appropriateness of in-person testing (June 2020). To determine whether or not patients could indeed be scheduled for in-person visits, we weighed factors such as immuno-compromised status (e.g., recently completed chemotherapy, autoimmune disorders, demyelinating disorders, etc.), underlying health conditions, ability to comply with hospital policy (e.g., wearing a mask throughout the visit), and level of behavioral dysregulation (highly dysregulated patients may not be able to tolerate continuous mask-wearing, complying with hand hygiene requests, etc.). When community transmission became less common, patients initially deferred due to behavioral concerns were reintegrated into the service (Fig. 1). Following the visit, all families were contacted to schedule a feedback appointment. As part of this hybrid model, interviews for incoming referrals and feedback sessions continued to be delivered via telehealth. Patients who were identified as appropriate for in-person assessment were screened 2 days prior to their visit, assessing five domains: 1) if the patient or someone in the home had a positive COVID-19 test, 2) symptoms associated with COVID-19, 3) sickness in the home, 4) health problems in the last 48 hr, and 5) for underlying health conditions. As long as none of these conditions applied, patients were offered in-person visits. Families were asked to notify the office should anyone in the household develop symptoms prior to their appointment. Consistent with hospital policy, patients and family members were screened for symptoms at the entrance, had their temperature taken, and were provided with a mask.

All testing was completed in-person, with patients and providers in the same room and face-to-face (not “remote in-person” testing, in which provider and patient are in different rooms at the same facility using document cameras). None of the testing described in this paper involved a telehealth or teleconference platform. Large spaces in our department (e.g., conference rooms) were converted into testing labs, each set up with an examiner table and patient table, positioned 6 to 10 feet apart. The patient’s table was adorned with a computer monitor, and the examiner’s table was equipped with a laptop or desktop computer (controlling what the patient was presented) and monitor. Images of stimuli made available through testing companies were projected onto the patient’s screen. The examiner used the mouse’s cursor as a substitute for pointing. When not delivering oral answers, patients pointed to the screen to select their options, which was in full view of the examiner. All materials and spaces were disinfected following testing.

Safety protocols for working in the same room with patients were developed in consultation with our hospital’s Infection Prevention department and implemented for in-person assessment. Personal protective equipment (PPE) for the examiner included gloves for handling shared materials, face shields, and Level 2 masks (i.e., moderate barrier protection). In August 2020, safety glasses were determined to be suitable eye protection by the hospital and were worn by providers in lieu of face shields. Patients were required to wear a mask at all times. A Plexiglas screen was used for test administration when social distancing was not possible (detailed in the following text). Patients were provided their own manipulatives, rather than using shared materials on certain tasks. On the Block Design test, for example, to reduce the likelihood of touching the same surfaces before they were sanitized, the patient had one set of blocks and the examiner had another set of blocks.

Measures

Data were collected through retrospective chart reviews. The following variables were selected *a priori*: California Verbal Learning Test; Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V), Digit Span and Figure Weight subtests; Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV), Digit Span Forward subtest; and Delis-Kaplan Executive Function System (D-KEFS), Color Word Interference (Condition 3). These tasks were selected to examine the possible impact of masks (auditory interference), social distancing (being further away from patients), and projection of materials onto the computer screen (as opposed to a booklet). Several scores were aggregated: Full Scale intelligence quotients from the WISC-V and WAIS-IV, scaled scores for Digit Span Forward and Matrix Reasoning from the WISC-V and WAIS-IV, as well as from total acquisition (T-score) from the California Verbal Learning Test, Children’s Version, and the California Verbal Learning Test, Second Edition. Due to this being a quality improvement project, it was considered exempt by the institutional review board.

Table 3. COVID and Pre-COVID Mann–Whitney *U* group comparisons

Variable	<i>Pre-COVID</i>		<i>COVID</i>		<i>U</i>	<i>p</i>
	<i>n</i>	Mean ± SD	<i>n</i>	Mean ± SD		
Full Scale IQ	64	88.86 ± 15.61	76	87.91 ± 16.21	2426.000	0.980
Digit Span Forward	84	7.60 ± 2.68	83	8.06 ± 3.12	3860.000	0.229
Matrix Reasoning	67	8.76 ± 3.13	76	8.33 ± 3.44	2280.500	0.280
Figure Weights	53	8.15 ± 2.73	54	8.80 ± 3.13	1606.500	0.271
Color-Word Condition 3	67	8.19 ± 3.23	71	7.76 ± 4.02	2311.500	0.774
CVLT Total Acquisition	77	44.14 ± 12.47	80	43.38 ± 11.38	2966.000	0.689

Note: Full Scale IQ (Standard Scores), Digit Span Forward (scaled scores), and Matrix Reasoning (scaled scores) are aggregates of WISC-V and WAIS-IV performances. Figures Weights (scaled scores) is from the WISC-V. Color-Word Condition 3 (scaled scores) is from the D-KEFS. CVLT Total Acquisition (T-score) is an aggregate of CVLT-C and CVLT-II.

Table 4. COVID and Pre-COVID Case-Matched Sample: Mann–Whitney *U* Group Comparisons

Variable	<i>Pre-COVID (Age: 13.36, 3.16)</i>		<i>COVID (Age: 13.60, 3.08)</i>		<i>U</i>	<i>p</i>
	<i>n</i>	Mean ± SD	<i>n</i>	Mean ± SD		
Full Scale IQ	32	85.22 ± 13.01	37	87.19 ± 16.43	638.500	0.576
Digit Span Forward	39	7.72 ± 3.00	39	8.18 ± 2.92	832.000	0.472
Matrix Reasoning	32	8.16 ± 3.25	36	8.17 ± 3.84	565.500	0.897
Figure Weights	23	7.43 ± 2.45	26	8.73 ± 2.86	380.500	0.099
Color-Word Condition 3	33	7.85 ± 3.58	36	7.81 ± 3.96	576.000	0.828
CVLT Total Acquisition	36	42.50 ± 12.36	37	43.35 ± 9.89	683.000	0.851

Note: Full Scale IQ (Standard Scores), Digit Span Forward (scaled scores), and Matrix Reasoning (scaled scores) are aggregates of WISC-V and WAIS-IV performances. Figures Weights (scaled scores) is from the WISC-V. Color-Word Condition 3 (scaled scores) is from the D-KEFS. CVLT Total Acquisition (T-score) is an aggregate of CVLT-C and CVLT-II.

Statistical analyses

Statistical analyses were conducted using IBM SPSS Version 27. Descriptive statistics and frequencies were acquired for primary diagnoses and demographic variables for the pre-COVID and COVID groups. Chi square analyses were used to assess differences in demographic variables. Type of insurance (i.e., state vs. private) was used as a proxy for socioeconomic status. Prior to performing statistical analyses to assess group differences, distributions for each outcome measure for pre-COVID and COVID samples were evaluated. Both visual inspections, as well as statistical tests of normality, revealed variability across distributions for most outcome measures. Therefore, nonparametric analyses (i.e., Mann–Whitney *U*) were used to assess group differences between the pre-COVID and COVID groups on each outcome measure (McKnight & Najab, 2010). The COVID group had a larger proportion of neurodevelopmental disorders, such as ADHD and learning difficulties, than the pre-COVID group. To account for these diagnostic differences, propensity score matching was used to match patients between groups on age and diagnosis. Nonparametric analyses (i.e., Mann–Whitney *U*) assessed group differences. We also identified 10 patients seen by our service before the pandemic and then during the pandemic for re-evaluation. On average, patient visits were between 2 and 5 years apart. Paired sample *t*-tests and correlations were run to examine the relationship between performance across time points.

Results

Analysis of demographic variables in the pre-COVID and COVID groups revealed no significant differences for age, sex, type of insurance, or FSIQ. Consistent with criteria for in-person assessment, children with underlying medical conditions (i.e., epilepsy, genetics, and cancer) were seen less frequently during the pandemic. Children with developmental delays, psychiatric presentations, and those with ADHD/learning problems were seen more frequently during the pandemic.

Despite the incorporation of safety protocols (e.g., wearing masks, remaining at a social distance, using Plexiglas screens, and projecting stimuli on a computer screen), no significant group differences were found on neuropsychological measures (Table 3). This finding remained when patients were matched on age and diagnosis (Table 4). In the subsample of patients tested both pre-COVID and during COVID, results of paired sample *t*-tests revealed no significant differences across testing time points. Full Scale IQ, Digit Span Forward, and Matrix Reasoning variables were significantly correlated in the re-evaluation sample, whereas Figure Weights, Color-Word Condition 3, and CVLT Acquisition were not (Table 5).

Table 5. COVID and Pre-COVID Re-evaluation Sample: Paired Sample T-Tests and Correlations

Variable	n	Pre-COVID Mean ± SD	COVID Mean ± SD	t-test p	R
Full Scale IQ	10	90.80 ± 17.79	89.50 ± 16.89	0.541	0.932
Digit Span Forward	10	8.40 ± 3.41	8.90 ± 4.86	0.472	0.794
Matrix Reasoning	8	8.63 ± 3.99	9.00 ± 4.93	0.897	0.877
Figure Weights	6	8.67 ± 3.50	8.33 ± 3.45	0.099	0.508
Color-Word Condition 3	8	6.13 ± 3.36	7.38 ± 4.03	0.828	0.355
CVLT Total Acquisition	9	43.22 ± 11.58	45.33 ± 9.69	0.851	0.624

Note: Full Scale IQ (Standard Scores), Digit Span Forward (scaled scores), and Matrix Reasoning (scaled scores) are aggregates of WISC-V and WAIS-IV performances. Figures Weights (scaled scores) is from the WISC-V. Color-Word Condition 3 (scaled scores) is from the D-KEFS. CVLT Total Acquisition (T-score) is an aggregate of CVLT-C and CVLT-II.

Table 6. Feedback Data

	Pre-COVID (n = 87)					COVID (n = 87)					
	M	SD	Range	n	%	M	SD	Range	n	%	p
Days from Evaluation to Feedback	35.88	24.67	4–110	43	—	24.98	17.31	3–77	84	—	0.0045
Miles from Medical Center	68.05	26.58	3–127	87	—	68.90	28.63	3–122	87	—	0.8394
Feedback Method											
Telehealth	—	—	—	7	8.0	—	—	—	82	97.6	—
Telephone	—	—	—	8	9.2	—	—	—	1	1.2	—
In-Person	—	—	—	30	34.5	—	—	—	1	1.2	—
Same Day In-Person	—	—	—	23	26.4	—	—	—	0	0.0	—
Missing Data	—	—	—	19	21.8	—	—	—	0	0.0	—

Note: p-values calculated with independent samples t-tests.

In terms of feedback occurrence, in the pre-COVID group, patients received documented feedback 78.2% of the time, across three distinct methods (34.5% in-person on a later day, 26.4% in-person on the day of testing, and 9.2% by phone). Some patients straddled the pre-COVID and COVID time periods and therefore received telehealth feedback (8%). The missing 21.8% of patients either declined participation, did not return phone calls requesting to schedule a feedback, were lost to follow-up, or may have received feedback that went undocumented (see Table 6). In the COVID group, feedback sessions were documented for 96.5% of patients: 97.6% occurred via telehealth, 1.2% was in-person on a later day, and 1.2% was conducted by telephone. Feedback occurred more efficiently (as measured by days from in-person testing to feedback; $t(125) = -2.894$, $p = 0.0045$) in the COVID group ($M = 24.98$, $SD = 17.31$) as compared to the pre-COVID group ($M = 35.88$, $SD = 24.67$).

Discussion

We introduced a hybrid model for pediatric neuropsychology at our academic medical center, using telehealth services for all non-testing activities, while conducting in-person visits with social distancing and PPE for the psychometric testing aspect of the evaluation. This model was developed in response to the COVID-19 pandemic, and this paper reports on our evaluation of how the model has been functioning. We examined aspects of the model's performance as part of ongoing quality improvement endeavors within our neuropsychology section.

Importantly, this model, which had not been tried at our center before, proved itself to be technically feasible. Clinical interviewing was conducted via telehealth on a day prior to the in-person assessment. This change expanded the capacity for providers to interview and ultimately assess patients and triage them based on medical necessity. Previously, patients lacking medical complexity would have been triaged into a lower urgency category, and would likely have remained on the waitlist. Additionally, utilization of telehealth for patient interviews ahead of the testing visit was another measure of increased safety precautions, as we were able to limit the number of individuals coming to the hospital. Before the pandemic, we would routinely host multiple parents and siblings in the same office for clinical interviews.

In-person testing had to be redesigned to satisfy safety concerns (e.g., using computer monitors to present stimuli, using Plexiglas dividers, wearing masks and goggles/face shields). Positively, there were no statistically significant differences in test performance between the in-pandemic testing and pre-pandemic testing groups, despite changes to standardization. However, our COVID group had a disproportionate amount of children with less complex medical disorders. Out of concern that such differences might mask any potential differences in performance, we established case-matched groups on diagnosis and

age. There were also no statistically significant differences in neuropsychological test scores. Additionally, when examining performances in children seen by our service both before and during the pandemic, we found that not only were there no significant differences across time points, but several tasks were highly correlated.

The use of PPE and other safety precautions, such as social distancing, certainly resulted in changes to test standardization. This was a concern and the main reason this quality improvement was undertaken. The fact that test scores were similar with or without the use of these changes to standardization was reassuring. The necessary adaptations taken did not have an effect on our outcome measures, giving us more confidence in the results of these assessments, now and moving forward. One contributing factor to the lack of significant differences across conditions may be the skill, training, and experience of pediatric neuropsychologists. Responding to changes in environmental demands and behavioral challenges is part of our clinical repertoire. Clinicians working with children are used to being flexible and are comfortable working on the fringes of standardized test administration (e.g., testing under a table, in a closet, in a hallway, etc.). Similarly, pediatric neuropsychology patients are often not strangers to medical settings, in which wearing masks may have been previously required for various procedures or treatments.

On top of the concrete and visible differences encountered by testing in the midst of a pandemic, we also have to call attention to the unseen elements of pandemic life. The patients in our COVID group may have all been enduring some form of stress, ambivalence, and forced social withdrawal. Although this quality improvement project did not focus on this aspect of the patient experience, it is one of the qualitative differences between our comparison groups. Positively, if our patients seen during COVID were experiencing elevated levels of distress, it was not borne out in aspects of test performance including overall intellectual functioning, attention, or active learning. In fact, it is possible that our ability to offer in-person assessment was an affirming and positive social experience for these children and adolescents. After months of social isolation, they had the opportunity to engage and interact with other people, in a stimulating environment not mediated by computer technology. Furthermore, our patient population is generally experiencing significant levels of stress secondary to medical problems, behavioral dysfunction, bullying, or familial discord. When considering pre-pandemic and in-pandemic group comparisons, we should not overlook the distress that pediatric neuropsychology patients seen in academic medical centers generally endure. They might even be better equipped than children in the general population to manage ambiguity and uncertainty.

The use of telehealth as part of this model also allowed us to increase our percentage of families receiving face-to-face (via video) feedback as compared to our pre-pandemic practices. As feedback is an essential facet of pediatric neuropsychological evaluation (Baron, 2018), we believe that this model enhances clinical care by allowing families to be more engaged in the evaluation process and more available to interact with findings and recommendations. Historically, in-office feedback sessions have been challenging to schedule for multiple-household families, which typically resulted in fewer key stakeholders in the child's life being able to attend. Telehealth has allowed for face-to-face interaction over video while minimizing logistical concerns, as family members, other providers, or community-team members can log into these meetings from anywhere (e.g., work, home, their car, etc.). Feedback also occurred on a more expedited timeline when delivered via telehealth versus the pre-COVID default of in-office meetings. This was likely the result of a simpler scheduling process and added ease on families, as they did not have to coordinate travel to the medical center for feedback.

Furthermore, the ability to conduct intake encounters via telehealth allowed us to access more patients than prior to the pandemic. The hybrid model also may provide cost savings to the patient and their family, as telehealth feedback sessions allowed families to stay home and not make the second trip to the medical center. Due to our rural setting and large geographic catchment area, families do not typically live close to the hospital. In the COVID group, patients lived an average of 68.90 miles ($SD = 28.63$, range 3–122) from the medical center. Thus, returning for a second in-person visit for feedback would amount to, on average, 146 round-trip miles. Based on the 2021 IRS standard mileage rates (\$0.56 per mile), an average of \$81.76 per family can be spared by conducting feedbacks via telehealth. Any financial savings we can provide is meaningful to the patient, while also reducing the need for travel reimbursement provided through public insurance.

An incidental benefit of this hybrid model was a sense of regimentation and order. Prior to the pandemic, our provision of clinical services was more variable in “the how,” even if “the what” remained generally constant (Table 6). In fact, in our retrospective review, it was difficult to determine the method of feedback services due to inconsistent documentation methods (i.e., different providers with differing styles of documentation). Our hybrid model provides better definition of the services we deliver with more predictability. Such qualities increase the clarity of data provided to section heads and hospital administrators for analysis, while also making it easier on schedulers as services are more predictable. Ultimately, our entire process map changed, and the way we work now looks very different from how it did before the pandemic. Much of what has changed will likely endure into the future: informal feedback from patients suggests families enjoy the convenience that telehealth affords, patient access appears to be increased, patients are receiving care faster, and in-person testing continues to be feasible and valid despite changes to standardization to accommodate PPE and safety demands.

The COVID-19 pandemic presents significant logistical issues for obtaining and delivering pediatric neuropsychological services. Although telehealth-based testing has demonstrated some efficacy in adult populations, the literature supporting its use in pediatric populations, especially for the purposes of psychometric measurement, is preliminary at best. Ransom et al. (2020) demonstrated the feasibility of brief telehealth-based testing examinations. Importantly, the authors noted that 63% of children seen for these abbreviated screenings required in-person follow-up. Such screenings with pediatric neuropsychology populations may be feasible, but they are clinically inadequate at this time.

Although private practices have needed to rapidly embrace telehealth-based testing out of financial necessity during the pandemic, the fact remains that such practices with children lacks efficacy or an evidence-base. We were fortunate to have the support of our departmental administration to develop such a hybrid model, as well as access to safety resources that did not come at an expense to our cost center's bottom line.

Limitations

Although there are many important takeaways from this paper, it has several limitations. First, this was a quality improvement project and not a research study. As such, we did not have a set of hypotheses or outcomes we intended to measure. We could only report on the information that we had as it related to our professional services. A prospective design comparing models of care, including this hybrid model, is needed before definitive statements about its efficacy can be made. Second, what we described and detailed in this manuscript only applies to what we conducted within our section and our medical center. We cannot be sure it would be as effective in other settings or if the concepts herein would generalize outside of our particular environment. Third, our ability to use a hybrid of in-person testing and telehealth practices for interviews and feedbacks in an ongoing way is contingent upon CMS allowing for the neuropsychological interpretation and evaluative codes to be used after the state of emergency has been lifted. We hope that this paper might play a role in our professional organizations' advocacy for ensuring that such billing is permitted to continue indefinitely. Fourth, although we do believe that the model described in this paper can contribute to improved access for patients with limited resources, the only variable we had to account for SES was insurance type (i.e., state vs. private). Thus, within this particular sample, we cannot draw significant conclusions regarding how this model would positively affect communities of low SES. Furthermore, our geographic region is disproportionately white compared to the general population of the United States. As such, we cannot be sure how these findings would extend to communities with more racial and ethnic diversity.

Future directions

Prospective, multi-site research is needed to study the various models of delivering pediatric neuropsychological care. A hybrid model like the one described here may have advantages over traditional styles of practices. It is also clear that the interest in telehealth-based testing practices is not going away, and pediatric neuropsychology may be a possible player in this space. At the present time, however, more research is needed before such practices can be widely accepted. Additional studies that examine the differences in billing optimization and reimbursement rates across models would be helpful in aiding neuropsychological practices in their planning and decision-making. Further, monetizing the impact that using telehealth can have for patients and families (e.g., reduced time off work, copay savings, etc.) will strengthen the argument for ensuring that neuropsychological interpretation CPT codes remain covered by CMS for telehealth service delivery. Patient satisfaction is another area that needs evaluation when determining the use of newer models of care. Follow-up surveys could satisfy this need as well. Finally, as other groups have demonstrated (Pritchard et al., 2020), there is value in using telehealth for triage purposes. Research determining how these triage clinics improve access to care, especially for Medicaid patients, would be useful to our field.

Conclusions

This paper described and detailed a hybrid model of pediatric neuropsychology, which we believe wisely allocates available resources, while remaining true to evidence-based practices. Telehealth-based screening with children might be feasible, but it does not provide the answers to comprehensive referral questions being asked by medical specialists who refer to our clinics for neuropsychological evaluation. A hybrid model provides a feasible and effective approach to delivering neuropsychological service both during the pandemic and beyond, with an emphasis on safety while garnering improved engagement from families.

Acknowledgments

The authors wish to thank several members of our department. In particular, without the support of Will Torrey, AJ Horvath, Christine Finn, and Julie Balaban, this quality improvement project would not have been possible. We also owe a great deal of gratitude to Angela Waszkiewicz and Lea LaClair for their technical support, and a big shout out to Stephanie Gaudons for achieving herculean feats with scheduling. Finally, we dedicate this paper and project to the memory of Alan I. Green.

Conflict of Interest

None declared.

References

- Baron, I. S. (2018). *Neuropsychological Evaluation of the Child: Domains, Methods, & Case Studies* (2nd ed.). New York, NY: Oxford University Press.
- Bilder, R. M., Postal, K. S., Barisa, M., Aase, D. M., Cullum, C. M., Gillaspay, S. R. et al. (2020). Inter organizational practice committee recommendation/s/guidance for teleneuropsychology in response to the COVID-19 pandemic. *Archives of Clinical Neuropsychology*, *35*(6), 647–659.
- Brearly, T. W., Shura, R. D., Martindale, S. L., Lazowski, R. A., Luxton, D. D., Shenal, B. V. et al. (2017). Neuropsychological test administration by videoconference: A systematic review and meta-analysis. *Neuropsychology Review*, *27*(2), 174–186. doi: [10.1007/s11065-017-9349-1](https://doi.org/10.1007/s11065-017-9349-1).
- Cullum, C. M., Hynan, L. S., Grosch, M., Parikh, M., & Weiner, M. F. (2014). Teleneuropsychology: Evidence for video teleconference-based neuropsychological assessment. *Journal of the International Neuropsychological Society: JINS*, *20*(10), 1028.
- Harder, L., Hernandez, A., Hague, C., Neumann, J., McCreary, M., Cullum, C. M. et al. (2020). Home-based pediatric teleneuropsychology: A validation study. *Archives of Clinical Neuropsychology*, *35*(8), 1266–1275.
- Hewitt, K. C., Rodgin, S., Loring, D. W., Pritchard, A. E., & Jacobson, L. A. (2020). Transitioning to telehealth neuropsychology service: Considerations across adult and pediatric care settings. *The Clinical Neuropsychologist*, *34*(7–8), 1335–1351.
- Pritchard, A. E., Sweeney, K., Salorio, C. F., & Jacobson, L. A. (2020). Pediatric neuropsychological evaluation via telehealth: Novel models of care. *The Clinical Neuropsychologist*, *34*(7–8), 1367–1379.
- Peterson, R. K., Ludwig, N. N., & Jashar, D. T. (2020). A case series illustrating the implementation of a novel tele-neuropsychology service model during COVID-19 for children with complex medical and neurodevelopmental conditions: A companion to Pritchard et al., 2020. *The Clinical Neuropsychologist*, *35*(1), 99–114.
- Marra, D. E., Hamlet, K. M., Bauer, R. M., & Bowers, D. (2020). Validity of teleneuropsychology for older adults in response to COVID-19: A systematic and critical review. *The Clinical Neuropsychologist*, *34*(7–8), 1411–1452.
- McKnight, P. E., & Najab, J. (2010). *Mann-Whiney U test*. *The Corsini encyclopedia of psychology*. New York, NY: John Wiley & Sons, Inc.
- Ransom, D. M., Butt, S. M., DiVirgilio, E. K., Cederberg, C. D., Srnka, K. D., Hess, C. T. et al. (2020). Pediatric teleneuropsychology: Feasibility and recommendations. *Archives of Clinical Neuropsychology*, *35*(8), 1204–1214.
- Salinas, C. M., Edgar, V. B., Berrios Siervo, G., & Bender, H. A. (2020). Transforming pediatric neuropsychology through video-based teleneuropsychology: An innovative private practice model pre-COVID-19. *Archives of Clinical Neuropsychology*, *35*(8), 1189–1195.
- Zane, K. L., Thaler, N. S., Reilly, S. E., Mahoney, J. J., III, & Scarisbrick, D. M. (2020). Neuropsychologists' practice adjustments: The impact of COVID-19. *The Clinical Neuropsychologist*, *35*(3), 490–517.