Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Letter to the editor

Functional outcomes in inpatient rehabilitation facilities during the COVID-19 pandemic: An observational study

Dear Editor,

The Coronavirus Disease 2019 (COVID-19) pandemic, caused by the SARS-CoV-2 virus and first declared on March 11, 2020 [1], directly and indirectly affected the delivery of healthcare services worldwide. These effects included an excess mortality rate of 17% above that expected in 2020 and an overall reduction in life expectancy in the United States of 1.7 years [2]. Although 83% of these deaths are attributable to the direct effects of the pandemic, 17% are attributable to indirect effects [3]. These factors create stressors on individuals and the healthcare system, leading to poorer healthcare outcomes and increasing the risk of long-term debility.

The pandemic has led healthcare organizations to reexamine and reallocate healthcare resources according to dynamic and emerging needs. For example, healthcare workers have been reassigned from their regular job duties to support inpatient units and testing centers and to fill other gaps as needed, resulting in decreased availability of vital healthcare services, particularly chronic care and surgical services [4]. Additionally, researchers have identified significant reductions in quality of life measured with various self-reported measures, such as the risk of food insecurity, diet, and exercise [5,6]. The economic impact of COVID-19 may further exacerbate long-term increases in morbidity and mortality, given the role socioeconomic factors play in population health.

Understanding how the functional outcomes of people receiving inpatient rehabilitation services have changed as a result of the pandemic is essential to understanding how the pandemic has impacted the population's health. In this observational study, we analyzed functional outcomes in people admitted to 2 adolescent/adult inpatient rehabilitation facilities (IRFs) accredited by the Commission on Accreditation of Rehabilitation Facilities in a single not-for-profit health system located in the Mountain West area of the United States [7] from October 2018 to September 2021. The IRFs followed Centers for Disease Control and Prevention guidelines for healthcare workers during the COVID-19 pandemic (e.g., universal masking, social distancing, etc.).

The health system's Institutional Review Board determined that the study was exempt from ethical approval, and de-identified data were obtained from a third-party data repository used for submitting the Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI) to the Centers for Medicare & Medicaid Services (CMS). The IRF-PAI is a standardized instrument submitted to the CMS [8]. The first date of community transmission of COVID-19 was determined from an open-source data set provided by the Centers for Disease Control and Prevention [9].

The primary outcome of this study was functional ability at discharge. We hypothesized that there would be a statistically significant decrease in functional outcomes at discharge associated with the period after the first cases of COVID-19 were reported in the counties where the IRFs are located. Functional ability scores submitted as part of the IRF-PAI are entered into the medical record throughout the person's hospital stay by clinical staff who have undergone training in scoring these measures. We used 3 aggregate scores to evaluate functional outcomes, each representing a different functional domain: self-care, mobility, and walk. These aggregate scores are comprised of the various Section GG measures within the IRF-PAI [8]. A secondary outcome of this study was the length of stay (LoS). All study variables and their definitions are presented in Table 1 [8,10].

An *a priori* power analysis was conducted using G*Power with the alpha set to 0.05 and power to 0.80, and a minimum required sample size of 322 was determined. All further analyses were performed with IBM Statistical Product and Service Solutions Statistics 28. To evaluate how many of the outcome variables were predicted by the covariates, multiple linear regression with robust standard errors was employed using the procedure described by Hayes & Cai [11] to address violations of the assumption of homoscedasticity. Cases with missing variables, incomplete or interrupted stays, and extreme outliers were excluded from the analysis.

The sample consisted of 1,520 participants, including 611 in the pre-COVID-19 period and 909 in the peri-pandemic period (Table 2). The most common diagnoses were within the stroke rehabilitation impairment category (RIC) group (44%), followed by orthopedic (22%), and then general rehabilitation (11%). Median (Q1, Q3) participant age was 67 (56, 77) years, and people during the peri-COVID-19 period were a mean 1.9 (95% CI 0.24; 3.52) years younger $t(1518) = 2.258$, $p = 0.024$ (two-tailed). The average length of stay was 13.4 days. There was a statistically significant association between the pandemic period and comorbidity distribution: $X^2(3) = 8.096$, $p = 0.044$. Due to limitations in the data, other demographic factors were not included in this analysis.

After controlling for other variables, we found multiple statistically significant predictors of functional outcomes (Table 3). Discharge from the IRF located in an acute care regional medical center (RMC IRF) was associated with higher functional outcome scores across all 3 categories ($p < 0.05$). The difference in scores was small, ranging from 0.89 to 2.16 points, with the greatest differences found between walk scores at discharge. Although the 2 units are part of

Abbreviations: CMS, Centers for Medicare & Medicaid Services; COVID-19, Coronavirus Disease 2019; IRF, Inpatient Rehabilitation Facility; IRF-PAI, Inpatient Rehabilitation Facility Patient Assessment Instrument; LoS, Length of Stay; RH IRF, Rehabilitation Hospital Inpatient Rehabilitation Facility; RIC, Rehabilitation Impairment Category; RMC IRF, Regional Medical Center Inpatient Rehabilitation Facility; SCI, Spinal Cord Injury

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Table 1
Study variables.

Variable Type	*Variable*	*Definition*
Covariate	Rehabilitation Impairment Category (RIC) Group	RIC group, based on the CMG code. Stroke Brain Injury Spinal Cord Injury Orthopedic Neurologic General Rehabilitation
	Pandemic Period	Pre-COVID-19: Discharges occurring before the first reported COVID-19 case in the county. Peri-COVID-19: Discharges occurring after the first reported COVID-19 case in the county.
	Comorbidity Distribution (in tiers)	Comorbidity score in three tiers or no tier. Tier 1 is the most acute; tier 3 is the least acute. Tier 0 denotes that there were no tier-assigning comorbidities scored.
	Average Age (Avg. Age)	The average age at admission for the selected population.
	Individual Minutes per Day (Avg. Therapy Min.)	The sum of individual therapy minute values for weeks 1 and 2 divided by the total number of days the person was in the facility during the first 14 calendar days starting from admission.
	Length of Stay[1] (LoS)	The length of stay (in days). Length of stay is calculated excluding the day of discharge in keeping with Medicare practice.
	Self-Care Score at Admission	This measure includes: Eating, oral hygiene, toileting hygiene, shower/bathe self, upper body dressing, lower body dressing, and putting on/taking off footwear.
	Mobility Score at Admission	This measure includes: Roll left and right, sit to lying, lying to sitting on side of bed, sit to stand, chair/bed-to-chair transfer, toilet transfer, and car transfer.
	Walk Score at Admission	This measure includes: Walk 10 feet, walk 50 feet with two turns, walk 150 feet, walking 10 feet on uneven surfaces, 1 step (curb), 4 steps, 12 steps, and picking up object.
Outcome Variable	Self-Care Score at Discharge	This measure includes: Eating, oral hygiene, toileting hygiene, shower/bathe self, upper body dressing, lower body dressing, and putting on/taking off footwear.
	Mobility Score at Discharge Mobility Score	This measure includes: Roll left and right, sit to lying, lying to sitting on side of bed, sit to stand, chair/bed-to-chair transfer, toilet transfer, and car transfer.
	Walk Score at Discharge	This measure includes: Walk 10 feet, walk 50 feet with two turns, walk 150 feet, walking 10 feet on uneven surfaces, 1 step (curb), 4 steps, 12 steps, and picking up object.

[1] Secondary outcome variable.

Table 2
Frequencies & descriptive statistics.

		N		*%*	*p-value*	
Unit[a]	RMC IRF[1]	586		39%	0.31	
	RH IRF[2]	934		61%		
Discharge Location[a]	Community	1442		95%	0.878	
	SNF[3]/Subacute	78		5%		
RIC[4] Group[a]	Stroke	667		44%	0.074	
	Brain Injury	165		11%		
	Spinal Cord Injury	105		7%		
	Orthopedic	331		22%		
	Neurological	85		6%		
	General Rehabilitation	167		11%		
Comorbidities Tier[a]	Tier 0	678		45%	0.044	
	Tier 3	620		41%		
	Tier 2	200		13%		
	Tier 1	22		1%		
Pandemic Time Period	Pre-COVID-19	611		40%		
	Peri-COVID-19	909		60%		
	N	*Minimum*	*Maximum*	*Median*	*Q1, Q3*	*p Value*
Age[b]	1520	13	99	67	56, 77	0.024
	N	*Minimum*	*Maximum*	*Mean*	*SD*	*p Value*
Length of Stay[b]	1520	3	79	13.4	7.7	0.609
Therapy Min. per Day[b]		16.4	277.5	135.8	16.5	0.11
Valid N (listwise)	1520					

[1] Regional Medical Center Inpatient Rehabilitation Facility.
[2] Rehabilitation Hospital Inpatient Rehabilitation Facility.
[3] Skilled Nursing Facility.
[4] Rehabilitation Impairment Category.
[a] Pearson X^2.
[b] Independent samples *t*-test.

Table 3
Regression of rehabilitation functional outcomes and Length of Stay (LoS) by pandemic timeframe and control variables.

Variable	Model coefficients (robust SE) *p*-value			
	Self-Care at Discharge	*Mobility at Discharge*	*Walk at Discharge*	*LoS*
Unit				
RMC IRF[1]	0.893 (0.287)	1.083 (0.293)	2.155 (0.509)	0.799 (0.271)
	0.002*	<0.001*	<0.001*	0.003*
RH IRF[2]	Ref.			
RIC[3] Group				
Stroke	-1.004 (0.471)	-1.001 (0.502)	0.081 (0.896)	2.287 (0.423)
	0.033*	0.046*	0.928	<0.001*
Brain Injury	-1.050 (0.544)	-0.973 (0.577)	-0.520 (1.008)	1.401 (0.509)
	0.054	0.092	0.606	0.006*
Spinal Cord Injury	-0.293 (0.680)	-1.104 (0.747)	-2.105 (1.318)	2.878 (0.706)
	0.667	0.139	0.110	<0.001*
Orthopedic	-0.778 (0.487)	-1.277 (0.539)	-7.131 (0.993)	-2.243 (0.454)
	0.110	0.018*	<0.001*	<0.001*
Neurological	-0.725 (0.664)	-0.798 (0.737)	-0.783 (1.238)	1.291 (0.671)
	0.275	0.279	0.527	0.055
General Rehabilitation	Ref.			
Comorbidity Tier				
Tier 0	3.252 (1.384)	3.172 (1.310)	6.401 (2.103)	-2.116 (1.376)
	0.019*	0.016*	0.002*	0.124
Tier 3	2.734 (1.382)	2.628 (1.308)	4.623 (2.103)	-1.838 (1.375)
	0.048*	0.045*	0.028*	0.181
Tier 2	3.026 (1.438)	2.396 (1.370)	6.214 (2.190)	-1.621 (1.402)
	0.036*	0.080	0.005*	0.248
Tier 1	Ref.			
Pandemic Period				
Pre-COVID-19	-0.417 (0.256)	-0.370 (0.275)	0.130 (0.474)	1.780 (0.252)
	0.103	0.179	0.783	<0.001*
Peri-COVID-19	Ref.			
Age	-0.068 (0.008)	-0.055 (0.008)	-0.074 (0.016)	-0.003 (0.008)
	<0.001*	<0.001*	<0.001*	0.750
Avg. Therapy Min.	0.018 (0.008)	0.005 (0.008)	0.012 (0.017)	-0.006 (0.007)
	0.027*	0.560	0.467	0.380
Length of Stay	-0.128 (0.024)	-0.191 (0.027)	-0.309 (0.037)	–
	<0.001*	<0.001*	<0.001*	
Functional Ability at Admit				
Self-Care at Admit	0.583 (0.027)	–	–	-0.382 (0.028)
	<0.001*			<0.001*
Mobility at Admit	–	0.518 (0.029)	–	-0.158 (0.031)
		<0.001*		<0.001*
Walk at Admit	–	–	0.742 (0.033)	-0.166 (0.021)
			<0.001*	<0.001*

* $p < .05$
[1] Regional Medical Center Inpatient Rehabilitation Facility
[2] Rehabilitation Hospital Inpatient Rehabilitation Facility
[3] Rehabilitation Impairment Category

the same health system, the rehabilitation hospital's IRF (RH IRF) is in an urban metropolitan area, whereas the RMC IRF is in a smaller rural community. During the COVID-19 pandemic, the RH IRF began to accept people with a lower expected ability to participate in therapy, although they continued to meet the CMS "60% rule" [12].

Participants with a diagnosis of stroke had lower self-care scores at discharge (B = -1.004, p = 0.033) than those with other pathologies, and both stroke (B = -1.001, p = 0.046) and orthopedic (B = -1.277, p = 0.018) participants had lower mobility scores at discharge, whereas orthopedic participants had lower walk scores (B = -7.131, p <0.001). Being in tier 3 (lowest acuity) or having no comorbidities were associated with higher scores at discharge across all outcome measures (self-care, p = 0.048, mobility, p = 0.045, walk, p = 0.028), and the self-care scores of individuals in tier 2 (B = 3.026, p = 0.036) were also higher than those in tier 1. These results contradict past research [13]. Higher functional scores at admission were associated with higher functional scores at discharge (self-care, p <0.001, mobility, p <0.001, walk, p <0.001). This effect is intuitive. There were no statistically significant differences in functional outcome scores at discharge by pre-and peri-COVID-19 pandemic timeframes.

LoS was negatively associated with all 3 functional outcome scores (self-care, p = 0.001, mobility, p <0.001, walk, p <0.001). This contradicts previous research findings that demonstrated a positive correlation between LoS and functional outcomes [14] and is counterintuitive. We expected longer stays to be associated with higher functional outcome scores at discharge, as participants had additional time to receive the therapeutic intervention. Our findings suggest that participant selection during the COVID-19 pandemic favored individuals with a lower ability to benefit from therapy regardless of LoS or those who had already achieved maximal ability. This is consistent with other research showing that individual ability to participate in therapy is a significant predictor of functional outcomes [15].

Higher self-care (B = -.382, p <0.001) and walk (B = -.166, p <0.001) scores at admission and RIC group were the strongest predictors of LoS in our model, with higher scores (p <0.001) and an orthopedic RIC group (B = -2.243, p <0.001) associated with shorter stays, and RIC groups of stroke (B = 2.287, p <0.001), brain injury (B = 1.401, p <0.006), and SCI (B = 2.878, p <0.001) associated with longer stays. These results are consistent with other research findings that demonstrated the predictive power of functional ability scores on LoS [16].

Although other researchers have found that LoS increased in the peri-COVID-19 timeframe among specific cohorts, these may be best explained by increased comorbidity related to delayed access to healthcare services during the pandemic [17]. Again, our results suggest participant selection is a determinant of LoS. Furthermore, people admitted to the health system receive therapy during acute care before transfer to the IRFs. Given reported delays in admission to the IRF because of census and staffing challenges, participants may have received additional days of therapy prior to IRF admission than they normally would.

This study has several limitations. First, several key demographic characteristics, such as race and sex, are not represented in the data; therefore, we could not consider the role of these factors in our analyses. Additionally, because different communities experienced different levels of pandemic-related stresses that impacted the delivery of healthcare services, the generalizability of these findings is limited. This study adds to the understanding of the effect of the COVID-19 pandemic on the delivery of rehabilitation medicine. Although previous studies have shown a worsening of functional outcomes among those admitted to the IRF in this context, our results demonstrated resilience to the disruptive effects of the pandemic among individuals admitted to the IRF. We propose that participant selection and the ability to participate in therapy are crucial to understanding how the pandemic has affected people admitted to IRFs. Future studies should explore the role of the COVID-19 pandemic in the selection of individuals for admission and participation in therapy.

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Declarations of interest

None.

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