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ORIGINAL ARTICLE

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Physical function and fatigue recovery at 6 months after hospitalization for COVID-19

Evelyn S. Qin MD, MPH[1] | Laura S. Gold PhD[2] | Namrata Singh MD, MSCI, FACP[3] | Katherine D. Wysham MD[3,4] | Catherine L. Hough MD, MSc[5] | Payal B. Patel MD[6] | Aaron E. Bunnell MD[1] | James S. Andrews MD[3]

[1]Department of Rehabilitation Medicine, University of Washington, Seattle, Washington, USA

[2]Department of Radiology, University of Washington, Seattle, Washington, USA

[3]Department of Medicine, University of Washington, Seattle, Washington, USA

[4]VA Puget Sound Health Care System, Seattle, Washington, USA

[5]Department of Medicine, Oregon Health & Science University, Oregon, Portland, USA

[6]Department of Neurology, University of Washington, Seattle, Washington, USA

Correspondence
Evelyn S. Qin, Department of Rehabilitation Medicine, University of Washington Medical Center, Seattle, WA, 325 Ninth Ave. Seattle, WA 98104, USA.
Email: eqin@uw.edu

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Abstract

Introduction: There are an increasing number of individuals with long-term symptoms of coronavirus-19 disease (COVID-19); however, the prognosis for recovery of physical function and fatigue after COVID-19 is uncertain.

Objective: To report the changes in functional recovery between 1 and 6 months after hospitalization of adults hospitalized for COVID-19 and explore the baseline factors associated with physical function recovery.

Design: A prospective cohort study.

Setting: Tertiary care hospital.

Participants: U.S. adult COVID-19 survivors.

Intervention: N/A.

Main Outcome Measures: Telephone interviews assessed three outcome domains: basic and instrumental activities of daily living (ADLs) performance, fatigue, and general physical function (Health Assessment Questionnaire [HAQ]).

Results: The age of participants (n = 92) ranged from 22 to 95 years (54.3 ± 17.2). Across outcome domains, a majority (63%–67%) of participants developed new ADL impairment, fatigue, or worsening HAQ severity by 1 month. Of those, 50%–79% partially or fully recovered by 6 months, but 21%–50% did not recover at least partially. Fifteen to 30% developed new impairment between 1 and 6 months. For those without any improvement in ADL impairments at 6 months, lower socioeconomic status was significantly more common ($p = .01$) and age ≥ 65 ($p = .06$), trending toward being more common.

Conclusion: In this cohort, a substantial proportion of the participants who developed new ADL impairment, worsening fatigue, or HAQ severity after hospitalization for COVID-19 did not recover at least partially by 6 months after discharge. Evaluating functional status 1 month after discharge may be important in understanding functional prognosis and recovery after hospitalization for COVID-19.

INTRODUCTION

Since the declaration of the COVID-19 pandemic in 2020, over 81 million Americans have contracted the virus, and over 4 million have required hospitalization due to severe disease.[1] As the pandemic persists, individuals continue to be infected by COVID-19, resulting in more people recovering from the acute infectious phase of the disease.[2] Many of those recovering are 6 months or longer from their initial infection and are dealing with a constellation of symptoms such as fatigue, weakness, and shortness of breath that is affecting their function and quality of life. These symptoms are often referred to as postacute sequelae of

SARS-CoV-2 (PASC).[2,3] Nevertheless, functional recovery outcomes after hospitalization for COVID-19 remain incompletely studied because PASC is a relatively new entity. We have shown that new patient-reported physical function impairment among survivors of hospitalization for COVID-19 at 1 month after hospital discharge is common and can occur in over 50% of people.[4] Few studies have described the longer-term recovery outcomes after COVID-19 hospitalization, such as whether new physical function impairments persist or improve over time. In addition, fatigue is one of the most reported symptoms among survivors of COVID-19[2,3] and can directly affect and/or limit physical function, yet little is known about how long fatigue persists. Advancing understanding of functional recovery and prognosis after hospitalization for COVID-19 is needed to create targeted management approaches and improve long-term clinical outcomes, including physical function and overall quality of life.

The primary objective of this study was to describe the trajectory of functional recovery 6 months after hospitalization for COVID-19. The secondary objective was to explore if specific participant- or illness-related factors are associated with recovery.

METHODS

Participants

We assembled a prospective cohort of adult survivors of hospitalization for COVID-19 from March 2020 to October 2021. Eligibility criteria were hospitalization for COVID-19 (admitted to the ward or intensive care unit and diagnosed by positive polymerase chain reaction testing via nasopharyngeal swab), age 18 years or older, English proficiency, and survival at 1 month after COVID-19 hospitalization discharge. Individuals were excluded if they tested positive for COVID-19 as part of routine screening, but COVID-19 was not the primary reason for hospitalization; or if they could not provide informed consent. Prisoners were also excluded. The study was approved by the institution's institutional review board.

Primary Measures

Standardized telephone interviews at 1 and 6 months following hospital discharge assessed three primary domains: activities of daily living (ADLs), general physical function, and fatigue. The ability to perform basic ADLs, instrumental ADLs, and mobility tasks were assessed and used to understand what specific tasks improved, stayed the same, or worsened over time. The Health Assessment Questionnaire-Disability Index (HAQ-DI)[5] was administered to provide an objective measure of self-reported physical function and included questions on ADLs, mobility, pain, and overall sense of health. The Patient-Reported Outcome Measures Information System (PROMIS) Fatigue Short Form 7a[6] assessed fatigue severity. Pre-COVID hospitalization ADL, fatigue symptom severity, and HAQ score were assessed retrospectively at the time of the 1-month visit. Participants who completed visits at 1 and 6 months after COVID-19 hospitalization discharge were included in the present analysis.

New impairment with ADLs, increased fatigue symptom severity, and new physical function impairment on the HAQ at 1 month compared to pre-COVID hospitalization baseline were evaluated. New ADL impairment at 1 month was defined as new difficulty with performing at least one ADL. New fatigue at 1 month was defined as an increase in PROMIS Fatigue Severity Short Form 7a score of at least 5 points, which corresponds to the minimum clinically important difference (MCID).[7] New impairment in physical function was defined as an increase in HAQ score of at least 0.22 points,[8,9] which corresponds to the MCID. Then, among those with new ADL, fatigue, or HAQ impairment at 1 month; we evaluated whether, at 6 months, there was (1) at least partial recovery compared to 1 month; and (2) full recovery back to pre-COVID hospitalization baseline status. Partial recovery of ADLs was defined as a decrease in the number of affected ADLs by at least 1. Partial recovery of fatigue was defined as a decrease in PROMIS fatigue Severity Short Form 7a score of at least 5 points. Partial recovery of physical function was defined as a decrease in HAQ score of at least 0.22 points. Full ADL recovery at 6 months was defined as having the same or fewer number of affected ADLs. Full fatigue recovery was defined as having the same or lower PROMIS Fatigue Severity Short Form 7a score. Full recovery of physical function was defined as having a HAQ score the same or less.

Additional Measures

Participant sociodemographic characteristics were collected by self-report at the 1-month initial interview and included age, gender, race, socioeconomic status, baseline medical comorbidities, and baseline anxiety and depressive symptoms (using the Hospital Anxiety and Depression Scale – [HADS]).[10] COVID-19 hospitalization characteristics (timing of admission, hospital length of stay, history of intensive care unit [ICU] admission, ICU length of stay, need for mechanical ventilation, number of days of mechanical ventilation, need for extracorporeal membrane oxygenation, need for vasopressors, receipt of COVID-19-related medications [dexamethasone, therapeutic anticoagulation,

remdesivir], acute physical therapy services received, and discharge disposition) were collected via medical record review. The number of COVID-19 signs and symptoms present at the time of hospitalization were collected by self-report and included fever, diarrhea, cough, shortness of breath, loss of taste or smell, fatigue, brain fog, confusion, nausea/vomiting, runny nose, congestion, hypoxia, chest pain/tightness, voice change, lack of appetite, sore throat, dizziness, muscle pain, joint pain, trouble swallowing, headaches, or malaise.

STATISTICAL ANALYSIS

Using these definitions, we first identified participants who had new ADL impairment, fatigue symptoms, or new HAQ impairment at 1 month and then determined the proportions of these participants who fully or partially recovered by 6 months. In addition, we looked at the participants without any new impairment or fatigue symptoms at 1 month and then determined the proportions of participants who had a new impairment or fatigue symptoms at 6 months.

We calculated numbers and proportions for categorical variables and means and SD for continuous variables describing participant demographic and hospitalization characteristics, stratified by whether participants had a new impairment (ADL, fatigue, or HAQ) at 1 month compared to pre-COVID-19. Then, in preplanned exploratory analyses, among those who had developed new impairment at 1 month after hospitalization, we compared baseline and hospitalization characteristics between individuals who recovered at least partially by 6 months and those who did not recover. Using *t*-tests for continuous measures and chi-square or Fischer's exact tests for categorical measures, we compared characteristics between those who did and did not recover from 1- to 6-months follow-up. Two-sided p values <.05 were considered statistically significant. Analysis was performed using SAS version 9.4 (Cary, NC).

RESULTS

Participant Baseline and Hospitalization Characteristics

Participant baseline and hospitalization characteristics, stratified by gender, among individuals who had completed 1-month study visits are published previously.[4] Table 1 shows the baseline and hospitalization characteristics, stratified by the presence or absence of new impairment at 1-month follow-up, among participants who had completed both 1-month and 6-month study visits (n = 92).

Difficulty with Activities of Daily Living

We have previously reported in detail on various patient-reported adverse ADL outcomes at 1 month after hospital discharge.[4] In the present analysis, we focus specifically on the development of new difficulties with ADL performance among individuals who completed both 1- and 6-month visits. At 1 month, 58 participants (63%) reported new ADL impairment and 34 (37%) reported no new ADL impairment (Figure 1A). Of the 58 participants with new ADL impairment, 10 (17%) were ≥ 65 years old, 29 (50%) were female, 39 (67%) were white, and 10 (17%) had limited socioeconomic status (Table 1). Thirty (52%) participants with new ADL difficulty required ICU admission and 7 (12%) were discharged to an acute rehabilitation facility (ARF) or skilled nursing facility (SNF). The most common ADL impairments among the 58 patients with new difficulty were difficulty grocery shopping (n = 45 [78%]), difficulty getting up from a chair without using arms (n = 33 [57%]), difficulty bathing or showering (n = 31 [53%]), and difficulty preparing meals (n = 30 [52%]).

By 6 months, a total of 39 of the initial 92 participants (42%) reported new ADL impairment compared to pre-COVID (Figure 1A). Among the 58 participants who had developed new ADL impairment at 1 month, 24 (41%) fully recovered, 14 (24%) partially recovered, and 20 (34%) did not recover at least partially at 6 months compared to pre-COVID (Figure 1A). In comparison, among those without new ADL impairment at 1 month, 29 (85%) remained without new ADL impairment and 5 (15%) developed new ADL impairment by 6 months. Among the 39 people who did not fully recover or had new impairments in the last 1 month, the most common difficulties were again difficulty grocery shopping (n = 28; 72%), difficulty preparing meals (n = 20; 51%), difficulty getting up from a chair without using arms (n = 20; 51%), and difficulty dressing (n = 14; 36%).

Fatigue

We have previously reported on the incidence of new fatigue at 1 month after hospital discharge.[4] In the present analysis we focus specifically on the development of new fatigue among individuals who completed both 1- and 6-month visits. Sixty-two participants (67%) reported new fatigue at 1 month (increase in PROMIS Fatigue Severity Short Form 7a score of at least 5 points) compared to pre-COVID (Figure 1B). Eleven (37%) were ≥ 65 years, 30 (48%) were female, 42 (68%) were white, and 11 (18%) had limited socioeconomic status (Table 1). Thirty-seven (60%) participants with new fatigue were admitted to the ICU compared to 11 (37%) in those without worse

TABLE 1 Baseline Participant and COVID-19 Hospitalization Characteristics Stratified by either Activity of Daily Living (ADL), Fatigue Severity, or Health Assessment Questionnaire (HAQ) Status at 1-Month

	ADL		Fatigue severity		HAQ	
	No new impairment* n = 34 (37)	New impairment* n = 58 (63)	No new fatigue+ n = 30 (33)	New fatigue+ n = 62 (67)	No new impairment# n = 34 (37)	New impairment# n = 58 (63)
Baseline Characteristics						
Age in years, mean ± SD	59.0 ± 16.2	51.6 ± 17.3	57.8 ± 18.3	52.6 ± 16.5	56.6 ± 18.8	52.9 ± 16.2
Age ≥ 65 years	12 (35)	10 (17)	11 (37)	11 (18)	10 (29)	12 (21)
Female gender	12 (35)	29 (50)	11 (37)	30 (48)	12 (35)	29 (50)
Race						
African American	3 (9)	7 (12)	2 (7)	8 (13)	3 (9)	7 (12)
American Indian, Alaska Native	0	3 (5)	1 (3)	2 (3)	1 (3)	2 (3)
Asian American	3 (9)	3 (5)	1 (3)	5 (8)	2 (6)	4 97)
Native Hawaiian, Pacific Islander	0	5 (9)	2 (7)	3 (5)	2 (6)	3 (5)
White	27 (79)	39 (67)	24 (80)	42 (68)	24 (71)	42 (72)
Other	1 (3)	1 (2)	0	2 (3)	2 (6)	0
Hispanic ethnicity	3 (9)	11 (19)	5 (17)	9 (15)	3 (9)	11 (19)
Limited socioeconomic status	3 (9)	10 (17)	2 (7)	11 (18)	2 (6)	11 (19)
Body mass index, mean ± SD	30.6 ± 5.9	35.9 ± 10.8	31.1 ± 7.8	35.3 ± 10.1	31.6 ± 8.0	35.4 ± 10.3
Comorbidities (y/n)						
Falls in the last year	6 (18)	12 (21)	3 (10)	15 (24)	4 (12)	14 (24)
Non-skin cancer	6 (18)	9 (16)	5 (17)	10 (16)	8 (24)	7 (12)
Congestive heart failure	2 (6)	8 (14)	3 (10)	7 (11)	5 (15)	5 (9)
Coronary artery disease	6 (18)	9 (16)	4 (13)	11 (18)	6 (18)	9 (16)
Stroke	2 (6)	3 (5)	3 (10)	2 (3)	0	5 (9)
Rheumatoid arthritis	1 (3)	2 (3)	2 (7)	1 (2)	2 (6)	1 (2)
Depression	4 (12)	8 (14)	2 (7)	10 (16)	4 (12)	8 (14)
Diabetes	10 (29)	15 (26)	9 (30)	16 (26)	7 (21)	18 (31)
Hypertension	11 (32)	18 (31)	8 (27)	21 (34)	9 (26)	20 (34)
Asthma/chronic obstructive pulmonary disease	5 (15)	12 (21)	5 (17)	12 (19)	8 (24)	9 (16)
Renal impairment	6 (18)	8 (14)	7 (23)	7 (11)	6 (18)	8 (14)
Any basic or instrumental ADL difficulty	7 (21)	17 (29)	8 (27)	16 (26)	7 (21)	17 (29)
Any basic or instrumental ADL dependence	2 (6)	4 (7)	3 (10)	3 (5)	0	6 (10)
PROMIS Fatigue Short Form 7a score, mean ± SD	42.4 ± 6.7	43.4 ± 8.3	43.6 ± 7.9	42.8 ± 7.7	43.1 ± 7.3	43.0 ± 8.1
Health Assessment Questionnaire Disability Index score, mean ± SD	0.14 ± 0.33	0.26 ± 0.41	0.24 ± 0.43	0.21 ± 0.36	0.19 ± 0.30	0.23 ± 0.43
Hospital Anxiety and Depression Scale – Anxiety Subscale score, mean ± SD	1.7 ± 2.0	2.7 ± 2.3	2.3 ± 2.2	2.3 ± 2.2	2.4 ± 2.2	2.3 ± 2.2
Hospital Anxiety and Depression Scale – Depression Subscale score, mean ± SD	2.5 ± 1.6	3.5 ± 2.6	3.0 ± 1.7	3.2 ± 2.6	2.7 ± 1.8	3.4 ± 2.6

(Continues)

TABLE 1 (Continued)

	ADL		Fatigue severity		HAQ	
	No new impairment* n = 34 (37)	New impairment* n = 58 (63)	No new fatigue+ n = 30 (33)	New fatigue+ n = 62 (67)	No new impairment# n = 34 (37)	New impairment# n = 58 (63)
Hospitalization Characteristics						
Date of admission						
Mar-June 2020	5 (15)	14 (24)	7 (23)	12 (19)	8 (24)	11 (19)
July-Sept 2020	3 (9)	5 (9)	2 (7)	6 (10)	3 (9)	5 (9)
Oct-Dec 2020	8 (24)	7 (12)	4 (13)	11 (18)	6 (18)	9 (16)
Jan-Apr 2021	7 (21)	11 (19)	3 (10)	15 (24)	5 (15)	13 (22)
May-Oct 2021	11 (32)	21 (36)	14 (47)	18 (29)	12 (35)	20 (34)
Number of initial COVID symptoms, mean ± SD	5.1 ± 2.3	5.5 ± 2.6	4.8 ± 2.8	5.6 ± 2.3	5.2 ± 2.5	5.4 ± 2.5
Hospital length of stay in days, mean ± SD	11.9 ± 10.2	19.8 ± 19.0	11.8 ± 13.1	19.3 ± 17.8	12.4 ± 14.7	19.5 ± 17.4
Any ICU admission	18 (53)	30 (52)	11 (37)	37 (60)	15 (44)	33 (57)
ICU length of stay in days, mean ± SD	7.4 ± 6.4	15.3 ± 12.9	12.5 ± 10.9	12.3 ± 11.9	9.8 ± 10.9	13.5 ± 11.8
Any mechanical ventilation	9 (26)	15 (26)	5 (17)	19 (31)	7 (21)	17 (29)
Days of mechanical ventilation, mean ± SD	9.9 ± 8.8	14.3 ± 9.9	10.4 ± 11.6	13.3 ± 9.2	15.4 ± 12.1	11.5 ± 8.4
Any ECMO	2 (6)	2 (3)	0	4 (6)	1 (3)	3 (5)
Days of ECMO, mean ± SD	6.5 ± 2.1	21.0 ± 11.3	--	13.8 ± 10.7	8.0	15.7 ± 12.2
Any vasopressor support	7 (32)	9 (16)	1 (3)	15 (25)	6 (18)	10 (18)
Any dexamethasone	23 (68)	40 (69)	17 (57)	46 (74)	21 (62)	42 (72)
Any therapeutic anticoagulation	3 (9)	2 (3)	1 (3)	4 (6)	2 (6)	3 (5)
Any remdesivir	27 (79)	37 (64)	20 (67)	44 (71)	26 (76)	38 (66)
Any PT/OT/SLP	16 (47)	31 (53)	11 (37)	36 (58)	16 (47)	31 (53)
Discharge to ARF/SNF	1 (3)	7 (12)	3 (10)	5 (8)	1 (3)	7 (12)

Values are n (%) unless otherwise specified.
*New ADL impairment = New difficulty performing at least 1 ADL compared to prior to COVID-19 hospitalization.
+New Fatigue = Increase in PROMIS Fatigue Severity Short Form 7a score of at least 5 points compared to prior to COVID-19 hospitalization.
#New HAQ Impairment = Increase in HAQ score of at least 0.22 points compared to prior to COVID-19 hospitalization.
Abbreviations: ADL, activities of daily living; ARF, acute rehabilitation facility; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; OT, occupational therapy; PROMIS, Patient-Reported Outcome Measures Information System; PT, physical therapy; SLP, speech language therapy; SNF, skilled nursing facility.

fatigue. Mean baseline PROMIS Fatigue score was 42.8 ± 7.7 among those with new fatigue compared to 43.6 ± 7.9 among those without new fatigue. Five (8%) participants with new fatigue were discharged to ARF/SNF.

At 6 months, 11 of the 62 (18%) participants with new fatigue at 1 month fully recovered to pre COVID-19 status, 20 (32%) partially recovered (decrease in PROMIS Fatigue Severity Short Form 7a score of at least 5 points compared to 1 month), and 31 (50%) did not recover at least partially at 6 months (Figure 1B). Among the 30 participants (33%) without new fatigue at 1 month compared to pre-COVID, 21 (70%) remained without new fatigue and 9 (30%) developed new fatigue at 6 months compared to pre-COVID.

Health Assessment Questionnaire

Fifty-eight (63%) participants had new impairment in general physical function (increase in HAQ disability score of at least 0.22 points) at 1 month compared to before COVID-19 hospitalization (Figure 1C), of whom 12 (21%) were ≥ 65 years, 29 (50%) were female, and 42 (72%) were white (Table 1). The most common baseline comorbidities among those with increased HAQ score at 1 month were falls in the last year (24%), diabetes (31%), and hypertension (34%). Seven (12%) with increased HAQ disability scores compared to one (3%) without increased HAQ disability scores were discharged to ARF/SNF.

At 6 months, 19 (33%) of the participants who had an increased HAQ disability score at 1 month fully

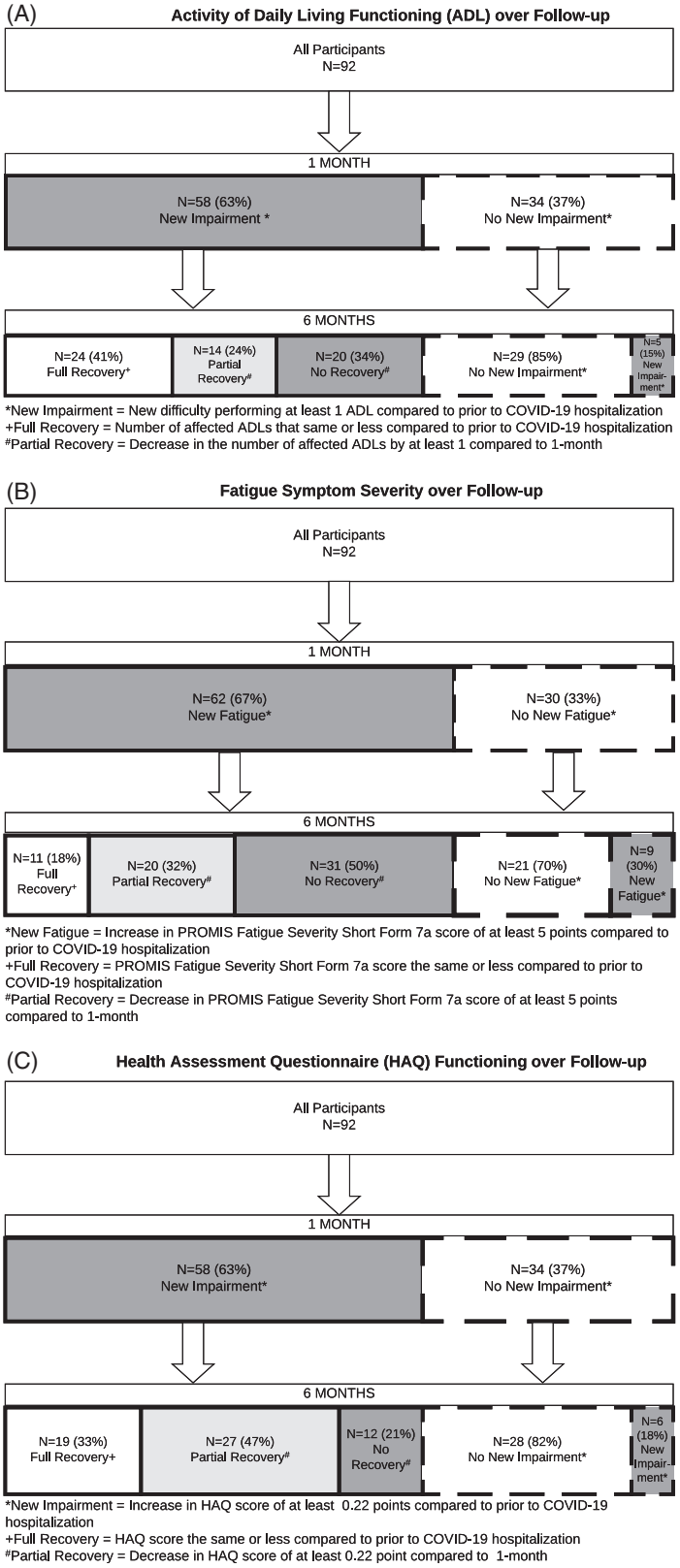

FIGURE 1 (a). Activity of daily living over follow-up (b). Fatigue symptom severity over follow-up (c). Health Assessment Questionnaire (HAQ) functioning over follow-up. Abbreviation: PROMIS, Patient-Reported Outcome Measures Information System

recovered, 27 (47%) partially recovered, and 12 (21%) did not recover at least partially (Figure 1C). Among those without an increased HAQ disability score at 1 month, 28 (82%) remained without an increased HAQ disability score and 6 (18%) had an increase in HAQ disability score by 6 months.

Exploratory Analyses: Comparison of Characteristics between Those with and without at Least Partial Recovery from 1- to 6-Months Follow-up

Exploratory analyses examined whether baseline participant and hospitalization characteristics may be risk factors for lack of ADL, fatigue, and HAQ disability score recovery (Table 2). We did not observe differences in race, body mass index, or baseline comorbidities between those who recovered at least partially and those who did not.

Among those without at least partial ADL recovery, compared to those who did not recover, limited socioeconomic status was significantly more common ($p = .01$), and age ≥ 65 years was more common, but did not reach statistical significance ($p = .06$). Comorbidities such as falls ($p = .01$), coronary artery disease ($p = .03$), and stroke ($p = .05$) were significantly more common among those who did not recover their ADL impairments. A lower baseline HAQ score was significantly more common ($p = .04$) in those with at least partial ADL recovery. Interestingly, hospital characteristics including longer hospital length of stay ($p = .02$), admission to the ICU ($p = .02$), and need for mechanical ventilation ($p = .01$) were more common in participants with at least partial ADL recovery. There were no significant differences observed between those who did and did not recover from new fatigue. Participants who did not recover from new HAQ disability were older compared to those who had partial or full recovery (mean ± SD, 61.5 ± 17.0 vs 50.7 ± 15.4 years, respectively; $p = .04$) (Table 2). The presence of baseline basic or instrumental ADL difficulty was more common among those without at least partial HAQ disability score recovery (58% among those who did not have at least partial recovery versus 22% among those who did; $p = .01$). Participants without HAQ score recovery at 6 months had a higher baseline HAQ score (0.5 ± 0.5) compared to those with at least partial recovery (0.2 ± 0.4) ($p = .04$).

DISCUSSION

Prior studies have focused on the prevalence and timing of when PASC symptoms developed[2,3,11,12]; however, few studies have described the functional status of COVID-19 survivors[13] and none to our knowledge have described the functional recovery of these participants longitudinally. Our study evaluated the recovery of function by assessing three primary domains: ADLs, general physical function, and fatigue at 1 month and 6 months after hospital discharge among survivors of COVID-19 hospitalization. Specifically, we examined the patterns of recovery by 6 months among those who had developed new impairment at 1 month and found that 505–75% recovered at least partially by 6 months within these three domains; but importantly, 25%–50% did not recover at least partially. This observation suggests that new functional impairment among survivors of hospitalization for COVID-19 may persist longer than 6 months in a large proportion of individuals. Moreover, we observed that most new impairments that arise after hospitalization for COVID-19 develop by 1 month, and only a small percentage (less than 10%) of individuals develop new impairments between 1 and 6 months after hospitalization.

Our finding that new impairments after COVID-19 hospitalization often persist beyond 6 months may have important implications for health care providers, patients, and family members. First, 34 (67%) participants in our cohort are of working age (between 18 and 65 years), and those with persistent impairments likely will have increased difficulty returning to work. Furthermore, those with persistent impairments may have higher long-term caregiving needs. We plan to examine these hypotheses further in future studies. In addition, most new impairments in our cohort, occurred by 1 month with only 5%–10% of participants developing new impairments between 1 and 6 months. This is earlier than the World Health Organization (WHO) clinical case definition of post-COVID-19 condition from October 2021, which specifies that post-COVID syndrome includes a proportion of patients with new symptoms 3 months postacute infection. Thus, functional status at 1 month following COVID-19 hospitalization may be an important measure, and efforts to promote functional recovery and rehabilitation among survivors of hospitalization for COVID-19 may wish to focus on identifying individuals with new impairment earlier in follow-up (such as at 1 month).

In exploratory analyses, we identified several characteristics that may be more common among individuals who fail to recover than among those that recover at least partially. This may be related to individuals' baseline impairments. Higher age, lower socioeconomic status, comorbidities such as a history of falls, coronary artery disease, and stroke may be more common in those who do not recover from new ADL impairments. Admission to the ICU, mechanical ventilation, and longer length of stay were also associated with more recovery. These trends, in which COVID disease severity and hospital and ICU length of stay are greater in those who recover compared to

TABLE 2 Baseline participant and COVID-19 hospitalization characteristics stratified by recovery status at 6 months among individuals who developed either new activities of daily living (ADL), fatigue severity, or health assessment questionnaire (HAQ) impairment at 1-month follow-up*

	ADL n = 58			**Fatigue severity n = 62**			**HAQ n = 58**		
	No recovery n = 20 (34%)	**Partial or full recovery n = 38 (66%)**	***p*^**	**No recovery n = 31 (50%)**	**Partial or Full Recovery n = 31 (50%)**	***p*^**	**No recovery n = 12 (21%)**	**Partial or full recovery n = 46 (79%)**	***p*^**
Baseline Characteristics									
Age in years, mean ± SD	**58.6 ± 20.4**	**47.9 ± 14.4**	**.02**	51.7 ± 14.5	53.6 ± 18.5	.65	**61.5 ± 17.0**	**50.7 ± 15.4**	**.04**
Age ≥ 65 years	**6 (30)**	**4 (11)**	**.06**	6 (19)	5 (16)	.74	4 (33)	8 (17)	.25
Female gender	10 (50)	19 (50)	.99	15 (48)	15 (48)	.99	4 (33)	25 (54)	.33
Race									
African American	4 (20)	3 (8)		6 (19)	2 (6)		3 (25)	4 (9)	
American Indian, Alaska Native	2 (10)	1 (3)		1 (3)	1 (3)		1 (8)	1 (2)	
Asian American	1 (5)	2 (5)	.51	3 (10)	2 (6)	.72	0	4 (9)	.19
Native Hawaiian, Pacific Islander	2 (10)	3 (8)		1 (3)	2 (6)		1 (8)	2 (4)	
White	11 (55)	28 (74)		19 (61)	23 (74)		7 (58)	35 (76)	
Other	0	1 (3)		1 (3)	1 (3)		0	0	
Hispanic Ethnicity	2 (10)	9 (24)	.21	4 (13)	5 (16)	.26	1 (8)	10 (22)	.43
Limited socioeconomic status	**8 (40)**	**2 (5)**	**.01**	8 (26)	3 (10)	.18	3 (25)	8 (17)	.68
Body mass index, mean ± SD	35.6 ± 8.5	36.1 ± 11.9	.86	34.0 ± 7.8	36.7 ± 12.1	.30	37.3 ± 14.4	34.9 ± 9.1	.50
Comorbidities (y/n)									
Falls in the last year	**9 (45)**	**3 (8)**	**.01**	9 (29)	6 (19)	.37	3 (25)	11 (24)	.99
Non-skin cancer	5 (25)	4 (11)	.25	4 (13)	6 (19)	.73	0	7 (15)	.33
Congestive heart failure	5 (25)	3 (8)	.11	5 (16)	2 (6)	.42	2 (17)	3 (7)	.27
Coronary artery disease	**6 (30)**	**3 (8)**	**.03**	6 (19)	5 (16)	.74	3 (25)	6 (13)	.37
Stroke	**2 (10)**	**1 (3)**	**.05**	2 (6)	0	.49	2 (17)	3 (7)	.27
Rheumatoid arthritis	1 (5)	1 (3)	.46	1 (3)	0	.99	1 (8)	0	.21
Depression	3 (15)	5 (13)	.85	7 (23)	3 (10)	.30	3 (25)	5 (11)	.34
Diabetes	6 (30)	9 (24)	.60	10 (32)	6 (19)	.25	4 (33)	14 (30)	.99
Hypertension	7 (35)	11 (29)	.64	11 (35)	10 (32)	.79	4 (33)	16 (35)	.99
Asthma/chronic obstructive pulmonary disease	4 (20)	8 (21)	.99	5 (16)	7 (23)	.52	1 (8)	8 (17)	.67
Renal impairment	4 (20)	4 (11)	.43	5 (16)	2 (6)	.42	2 (17)	6 (13)	.66
Any basic or instrumental ADL^ difficulty	8 (40)	9 (24)	.19	7 (23)	9 (29)	.56	**7 (58)**	**10 (22)**	**.01**
Any basic of instrumental ADL^ dependence	2 (10)	2 (5)	.60	1 (3)	2 (6)	.99	2 (17)	4 (9)	.59

(Continues)

TABLE 2 (Continued)

	ADL n = 58			**Fatigue severity n = 62**			**HAQ n = 58**		
	No recovery n = 20 (34%)	**Partial or full recovery n = 38 (66%)**	***p*^**	**No recovery n = 31 (50%)**	**Partial or Full Recovery n = 31 (50%)**	***p*^**	**No recovery n = 12 (21%)**	**Partial or full recovery n = 46 (79%)**	***p*^**
PROMIS Fatigue Short Form 7a score, mean ± SD	42.7 ± 7.9	43.9 ± 8.6	.61	41.3 ± 7.5	44.3 ± 7.7	.13	44.5 ± 6.6	42.7 ± 8.4	.48
Health Assessment Questionnaire Disability Index score, mean ± SD	**0.41 ± 0.47**	**0.18 ± 0.35**	**.04**	0.20 ± 0.36	0.22 ± 0.37	.83	**0.46 ± 0.47**	**0.17 ± 0.40**	**.04**
Hospital Anxiety and Depression Scale – Anxiety Subscale score, mean ± SD	2.1 ± 2.3	3.1 ± 2.2	.12	2.6 ± 2.2	2.1 ± 2.3	.44	2.1 ± 2.1	2.3 ± 2.3	.77
Hospital Anxiety and Depression Scale – Depression Subscale score, mean ± SD	4.0 ± 2.9	3.2 ± 2.5	.28	3.5 ± 2.7	2.9 ± 2.5	.39	3.5 ± 2.3	3.4 ± 2.7	.91
Date of admission									
Mar-June 2020	**4 (20)**	**10 (26)**		6 (19)	6 (19)		2 (17)	9 (20)	
July-Sept 2020	**4 (20)**	**1 (3)**		3 (10)	3 (10)		2 (17)	3 (7)	
Oct-Dec 2020	**4 (20)**	**3 (8)**	**.02**	7 (23)	4 (13)	.79	2 (17)	7 (15)	.79
Jan-Apr 2021	**5 (25)**	**6 (16)**		8 (26)	7 (23)		3 (25)	10 (22)	
May-Oct 2021	**3 (15)**	**18 (47)**		7 (23)	11 (35)		3 (25)	17 (37)	
Number of initial COVID symptoms, mean ± SD	4.9 ± 1.7	5.8 ± 2.9	.20	5.3 ± 2.3	5.9 ± 2.2	.34	6.1 ± 2.5	5.2 ± 2.5	.30
Hospital length of stay in days, mean ± SD	**11.9 ± 7.9**	**23.9 ± 21.8**	**.02**	17.3 ± 16.0	21.4 ± 19.4	.38	16.1 ± 14.9	20.4 ± 18.0	.45
Any ICU admission	**6 (30)**	**24 (63)**	**.02**	19 (61)	18 (58)	.80	4 (33)	29 (63)	.10
ICU length of stay in days, mean ± SD	**5.2 ± 3.4**	**17.8 ± 13.2**	**.03**	10.7 ± 12.1	14.0 ± 11.7	.40	13.0 ± 9.8	13.6 ± 12.2	.93
Any mechanical ventilation	**0**	**15 (39)**	**.01**	8 (26)	11 (35)	.41	2 (17)	15 (33)	.48
Days of mechanical ventilation, mean ± SD	--	14.3 ± 9.9	--	12.4 ± 10.8	13.9 ± 8.4	.73	11.5 ± 10.6	11.5 ± 8.6	.99
Any ECMO	0	2 (5)	.54	1 (3)	3 (10)	.61	0	3 (7)	.99
Days of ECMO, mean ± SD	--	21 ± 11.3	--	13.0	14.0 ± 13.1	--	--	15.7 ± 12.2	--
Any vasopressor support	1 (5)	8 (22)	.14	6 (19)	9 (30)	.33	1 (8)	9 (20)	.35
Any dexamethasone	15 (75)	25 (66)	.56	22 (71)	24 (77)	.56	9 (75)	33 (72)	.99
Any therapeutic anticoagulation	0	2 (5)	.54	2 (6)	2 (6)	.99	0	3 (7)	.99
Any remdesivir	14 (70)	23 (61)	.48	21 (68)	23 (74)	.58	6 (50)	32 (70)	.20

(Continues)

TABLE 2 (Continued)

	ADL n = 58			Fatigue severity n = 62			HAQ n = 58		
	No recovery n = 20 (34%)	Partial or full recovery n = 38 (66%)	p^	No recovery n = 31 (50%)	Partial or Full Recovery n = 31 (50%)	p^	No recovery n = 12 (21%)	Partial or full recovery n = 46 (79%)	p^
Any PT/OT/SLP	9 (45)	22 (58)	.35	18 (58)	18 (58)	.99	6 (50)	25 (54)	.79
Discharge to ARF/SNF	1 (5)	6 (16)	.40	1 (3)	4 (13)	.35	3 (25)	4 (9)	.15

Values are n(%) unless otherwise specified.
Bold font denotes $p < .1$.
^p values calculated from chi-square test for cells where n ≥ 5; Fisher's exact test when cells <5; t-test for continuous variables.
*New ADL impairment = New difficulty performing at least 1 ADL compared to before COVID-19 hospitalization. New Fatigue = Increase in PROMIS Fatigue Severity Short Form 7a score of at least 5 points compared to prior to COVID-19 hospitalization. New HAQ Impairment = Increase in HAQ score of at least 0.22 points compared to prior to COVID-19 hospitalization.
Abbreviations: ARF, acute rehabilitation facility; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; OT, occupational therapy; PROMIS, Patient-Reported Outcome Measures Information System; PT, physical therapy; SLP, speech language therapy; SNF, skilled nursing facility.

those who do not recover, should be viewed as hypothesis-generating. Future studies including multivariable regression models are needed to better understand these potentially unexpected findings. Higher age, presence of basic or instrumental ADL difficulty at baseline, and a higher HAQ score at baseline were significantly more common in participants who had worsening HAQ scores after COVID-19. Although further studies are needed, these findings may indicate that participants with baseline ADL difficulty or HAQ impairments are less likely to recover at 6 months. There were no observed differences in characteristics affecting fatigue recovery. Consensus recommendations on PASC fatigue will be beneficial to guide the assessment and treatment of these patients.[14]

This study has limitations. Only individuals hospitalized with COVID-19, and thus with more severe disease, are included. Length of hospitalization may also relate to functional and ADL outcomes as patients in the hospital longer would presumably be more likely to have an ADL limitation. Prolonged symptoms and functional impairment are also common among participants with mild COVID-19 disease not requiring hospitalization,[15] and whether our findings may generalize to individuals with milder COVID-19 is not known. This is a single-center study with a relatively small sample size that can affect generalizability. Interviews were conducted at 1 month and 6 months after discharge, and thus new impairments and recovery in between this time may not have been captured. Because non-English speaking individuals were excluded, our results may or may not be generalizable to individuals who speak other languages. Lastly, prehospitalization data for patient baseline comorbidities and patient-reported measures of physical function and fatigue were collected retrospectively for safety and logistical reasons, which creates the potential for recall bias.

Strengths of the study included a diversity of ages, races, and ethnicities, a systematic and detailed assessment of key participant-reported physical function outcomes at 1 month and 6 months after hospitalization for COVID-19, and the inclusion of detailed clinical information from participants' COVID-19 hospitalization.

CONCLUSION

We observed a wide spectrum of functional outcomes among our cohort of survivors of hospitalization for COVID-19. However, a large proportion of adults who developed new physical function and fatigue impairment by 1 month after hospitalization for COVID-19 did not recover meaningfully at 6 months. Moreover, only a small proportion of patients without new impairment at 1 month went on to develop new impairments by

6 months. Although additional longitudinal data are needed on long-term recovery outcomes in survivors of COVID-19, evaluating patient function at 1 month may be important in understanding patients' functional prognosis and may facilitate efforts to develop targeted rehabilitation strategies.

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ORCID

Evelyn S. Qin https://orcid.org/0000-0001-9618-2766
Laura S. Gold https://orcid.org/0000-0002-4289-5231
Aaron E. Bunnell https://orcid.org/0000-0001-8673-1231

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