

Development and Validation of the Long Coronavirus Disease (COVID) Symptom and Impact Tools: A Set of Patient-Reported Instruments Constructed From Patients' Lived Experience

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Background. To develop and validate patient-reported instruments, based on patients' lived experiences, for monitoring the symptoms and impact of long coronavirus disease (COVID).

Methods. The long COVID Symptom and Impact Tools (ST and IT) were constructed from the answers to a survey with open-ended questions to 492 patients with long COVID. Validation of the tools involved adult patients with suspected or confirmed coronavirus disease 2019 (COVID-19) and symptoms extending over 3 weeks after onset. Construct validity was assessed by examining the relations of the ST and IT scores with health-related quality of life (EQ-5D-5L), function (PCFS, post-COVID functional scale), and perceived health (MYMOP2, Measure yourself medical outcome profile 2). Reliability was determined by a test-retest. The "patient acceptable symptomatic state" (PASS) was determined by the percentile method.

Results. Validation involved 1022 participants (55% with confirmed COVID-19, 79% female, and 12.5% hospitalized for COVID-19). The long COVID ST and IT scores were strongly correlated with the EQ-5D-5L ($r_s = -0.45$ and $r_s = -0.59$, respectively), the PCFS ($r_s = -0.39$ and $r_s = -0.55$), and the MYMOP2 ($r_s = -0.40$ and $r_s = -0.59$). Reproducibility was excellent with an interclass correlation coefficient of 0.83 (95% confidence interval .80 to .86) for the ST score and 0.84 (.80 to .87) for the IT score. In total, 793 (77.5%) patients reported an unacceptable symptomatic state, thereby setting the PASS for the long COVID IT score at 30 (28 to 33).

Conclusions. The long COVID ST and IT tools, constructed from patients' lived experiences, provide the first validated and reliable instruments for monitoring the symptoms and impact of long COVID.

Keywords. patient-reported outcome; COVID-19; long COVID.

As of February 2021, about 100 million people worldwide have been infected by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus [1]. According to some studies, from 10% to 70% of them, including many who only had a mild disease, report the presence of symptoms such as fatigue, dyspnea, chest pain, memory problems, and concentration disorders persisting beyond 3 weeks from the initial onset of symptoms [2–8]. Yet so far, surveillance systems around the world remain focused exclusively on the acute aspect of the pandemic, tracking new cases, hospitalizations, and deaths, while neglecting these long-term consequences of coronavirus disease 2019 (COVID-19) [9].

Persisting signs and symptoms three weeks after the acute COVID-19 infection may be associated with several distinct clinical entities: 1) organ injury from the acute disease or its treatment (e.g., lung scarring, complications of intensive care, etc.) [8, 10–12]; 2) postviral fatigue syndrome [13–15]; 3) prolonged viral shedding, especially in immunosuppressed patients [16]; 4) reinfection; and 5) mental factors, such as post-traumatic stress. From the patient's perspective, all or several of these causes are often intertwined and produce a substantial burden of disease. As a result, patients themselves created the term "long COVID" to describe all of the symptoms they could experience, independently of their specific cause [17].

Today, advances in understanding and treating long COVID are impeded by the heterogeneity of its assessment: each study uses different sets of symptoms, most generally defined from the caregivers' perspective [3, 18, 19]. There is currently no comprehensive, validated, and reliable instrument for monitoring either the course of long COVID symptoms or its impact on patients' lives—an absence that incurs the risk of missing

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important patient perspectives. For example, many patients with long COVID report an inability to sleep, difficulties concentrating, or exhaustion after mild exercise—manifestations not considered in all existing studies [20]. The National Institute for Health and Care Excellence (NICE) recently called for the development and validation of scales to assess long COVID [21], and in February 2021, the World Health Organization issued a standardized, albeit nonvalidated, case report form for the follow-up of patients after acute COVID-19 [22].

In this study, we aimed to develop and validate a set of patient-reported instruments for monitoring the symptoms and impact of long COVID, usable in clinical practice and constructed from patients' lived experience.

METHODS

The development and validation of these instruments applied a 2-stage method [23]. The study was nested within ComPaRe (Communauté de Patients pour la Recherche, www.compare.aphp.fr), an e-cohort of patients with chronic conditions who volunteer to participate in research by regularly answering patient reported outcome measures (PROMs) and patient reported experience measures (PREMs) [24]. Because of the similarities between long COVID and chronic conditions, recruitment in ComPaRe was extended to patients reporting symptoms of COVID-19 lasting more than 3 weeks past initial onset. All participants provide electronic consent before participating. The Institutional Review Board (IRB) of Hôtel-Dieu Hospital, Paris, approved ComPaRe (IRB: 0008367).

Stage 1: Development of a Set of Patient Reported Instruments to Monitor the Symptoms and Impact of Long COVID From the Patients' Lived Experiences

We sought to develop the contents of the instruments from the patients' lived experiences of long COVID. We invited adult patients in the ComPaRe cohort who reported a COVID-19 infection (laboratory confirmed or not) with symptoms persisting more than 3 weeks past the initial infection to complete an online survey of open-ended questions that asked them to describe in detail the symptoms, potential triggers, and the effects of long COVID on their lives. The survey, which took place from 14 October to 29 November 2020, used broad questions to avoid directing patients about long COVID's consequences (Supplementary material 1).

Participants were recruited through a social media and media campaign and by partner patient associations. Participants who had participated were invited to encourage people in their entourage who may have had a COVID-19 infection, to participate, by a "snowball" sampling method [25].

Two investigators (V.T.T. and C.R.) used an inductive multiple-round qualitative content analysis to examine the participants' responses. First, they independently coded the responses (i.e., they identified within each response any

expression found in the text expressing a symptom or impact of long COVID and assigned it a code). Answers related to the acute phase of COVID-19 (i.e., symptoms during the first 3 weeks of infection) were removed from the analysis. For example, when a participant stated that "I had a cough and fever for 1 week and joint pain for 7 months," we considered only "joint pain" to be a potential long COVID symptom. If the response did not specify a timeframe, all reported symptoms were kept in the analysis. Next, the investigators grouped the identified codes into a standardized set of symptoms and consequences of long COVID, based on their medical knowledge and the literature [4, 18]. Analysis continued until data saturation was reached. The point of data saturation was assessed with a mathematical model to predict the number of new symptoms that could be identified by adding new participants to the study [26]. Finally, they reduced the number of symptoms by: 1) grouping closely related symptoms (eg, loss of taste and changes in taste were grouped as loss/change of taste) and 2) eliminating those expressed by less than 2% of participants in the open-ended survey.

The 2 investigators used the results of the open-ended survey to develop a preliminary patient reported instrument for monitoring long COVID's current symptoms and impact. We chose to split the instrument into 2 independent parts. The first part aimed at assessing patients' long COVID-related symptoms over the previous 30 days with the checklist of symptoms identified above, a list we named the long COVID Symptom Tool (ST). The second part aimed at assessing the disease's impact on their lives over the past 30 days from the responses to 6 questions constructed from themes identified and examples provided by patients in their open-ended answers. Items used a numeric scale ranging from 0 (no impact) to 10 (maximal impact). This second instrument was called the long COVID Impact Tool (IT). These 2 instruments were reappraised by the 2 author patients (B.C. and C.C.) for content validity, clarity, and wording during a telephone interview with the main investigator (V.T.T.) that used the double interview method [27].

Stage 2: Validation of the Long COVID Symptom and Impact Tools

A second sample of adult patients reporting a SARS-CoV -2 infection (laboratory confirmed or not) with symptoms persisting 3 weeks past the initial infection served as the validation sample. Patients who had participated in the first stage could also participate in the validation stage. In addition, we increased our sample through a call for participation on the "TousAntiCOVID" app, the official French contact tracing app used by 12 million people. As our instrument intends to evaluate patients' current symptoms and their impact, only patients reporting at least one symptom during the previous 30 days could participate in the validation study.

Each tool was validated independently. The long COVID ST score was defined as the number of symptoms reported by

patients, and the long COVID IT score as the sum of the responses to each impact question.

Construct validity was determined by confirming several theories or conceptions (ie, constructs) about long COVID. First, we hypothesized that both the ST and IT scores would be negatively correlated with patients' quality of life, which was evaluated with the EuroQol 5-dimension 5-level (EQ-5D-5L) questionnaire and the EuroQol visual analogue scale (EQ-VAS) [28]. Our second hypothesis was that both the ST and IT scores would be positively correlated with patients' functional status after COVID-19, assessed by the Post-COVID Functional Scale (PCFS), an ordinal tool categorizing patients in 5 grades ranging from 0 "No functional limitation" to 4 "Severe functional limitations" [29, 30]. Finally, we hypothesized that both the ST and IT scores would also be negatively correlated with patients' general perceived health, assessed with the measure yourself medical outcome profile 2 (MYMOP2) tool, an instrument focused on complaints that patients identified as most important to them [31]. Correlations were assessed by Spearman correlation coefficients (r_s) and considered high with $r_s > 0.50$ and moderate with $r_s = 0.35$ to 0.50 .

The structural validity of the IT score was assessed by a confirmatory factor analysis. We looked for a unidimensional structure and considered that the data fit the model if the Comparative Fit Index (CFI) was > 0.95 , the root mean square error of approximation (RMSEA) was < 0.06 or the standardized root mean square residual (SRMR) was < 0.08 [32]. The internal consistency of the IT score was assessed by Cronbach's α and was considered acceptable between 0.70 and 0.95 [33].

The reliability of both the ST and IT scores was determined by the test-retest method. Some patients completed the questionnaires twice: at baseline and two weeks later. Reproducibility was assessed by the intraclass correlation coefficient (ICC) for agreement [34]. The 95% confidence intervals (CIs) were determined by a bootstrap method. Reproducibility was considered acceptable with ICC > 0.70 [35]. Reliability was also tested by Bland and Altman plots, which present the differences between 2 measurements against the means of the 2 measurements [36].

The patient acceptable symptom state (PASS) is the level of a continuous treatment outcome measure below which patients consider themselves well [37]. The PASS for the long COVID IT was determined by matching the scores to an anchor question: "Taking into account all your symptoms in daily life and your functional impairment, do you consider that your current state is satisfactory?" The threshold was the impact score below which 75% of patients considered their symptom state acceptable [38]. Percentile bootstrap with 2000 replications provided the 95% CIs.

Statistical analyses were performed with R software v. 3.6.3.

Patient and Public Involvement

The tools were developed from qualitative data about patients' lived experiences, captured during a survey with open-ended

questions. The qualitative results and the implementation of the items in the patient reported tools were discussed in detail with 2 patients meeting the criteria for long COVID. They also participated in the critical revision of the manuscript and are coauthors of the article (B.C. and C.C.).

RESULTS

Step 1: Development of the Long COVID Symptom and Impact Tools From Patients' Lived Experiences

During the survey period (from 14 October to 29 November 2020), 528 eligible members of the ComPaRe cohort received emails inviting them to complete the open-ended survey, and 492 (93%) did so. Their median age was 45 years (interquartile range [IQR] 35 to 50.25), and 414 (84%) were women. In total, 210 (43%) had tested positive for SARS-CoV-2 by polymerase chain reaction (PCR) swab or serological assay and were considered confirmed COVID-19 patients. Median time since symptom onset was 217 days (IQR 205 to 230) ([Supplementary material 2](#)).

Participants' open-ended answers represented a corpus of 116 657 words. Inductive content analysis of patients' answers was stopped after the analysis of 380 answers and the definition of 53 symptoms of long COVID because models showed that 99.99% of all possible symptoms had been identified in both the total sample and in the subgroups of confirmed and suspected cases ([Supplementary material 3](#)). The list of symptoms was further organized in 10 categories: general symptoms ($n = 11$), thorax ($n = 6$), digestive ($n = 3$), ear/nose/throat ($n = 5$), eyes ($n = 3$), genitourinary ($n = 2$), hair and skin ($n = 4$), musculoskeletal ($n = 4$), neurological ($n = 11$), and blood and lymph circulation ($n = 4$) symptoms ([Supplementary material 4](#)).

The analysis of patients' open-ended answers also enabled us to identify 6 aspects of patients' lives that were affected by long COVID: 1) difficulties in performing personal activities such as driving, shopping, or doing household chores; 2) difficulties in their professional lives; 3) difficulties in fulfilling their family roles and/or feeling that they're a burden to their family or friends; 4) difficulties related to social activities; 5) morale, fear of the future and of not returning to normal; and 6) negative impact on relationships with care providers. Examples of what patients wrote are provided in [Supplementary material 5](#).

Thus, the list of symptoms and the themes and examples related to the impact of long COVID on patients' lives were used to develop preliminary versions of the long COVID tools, which were further reviewed and improved by the 2 patients. The box presents the items for both tools.

Step 2: Validation of the Long COVID Symptom and Impact Tools

From 30 November 2020 to 15 February 2021, 1360 ComPaRe participants reported they had had long COVID. In all, 1022 had experienced at least 1 COVID-19-related symptom in the 30 days before responding to the survey and were included in

the validation sample. Among them, 418 (40%) had participated in the development sample, in the first stage. **Table 1** presents the characteristics of all patients included in the validation sample. Their median age was 45 years (IQR 37 to 52), and 817 (79.9%) were women. Overall, 564 (55%) had tested positive for SARS-CoV2 by PCR swab or serological assay and were considered confirmed cases. Among all cases, 128 (12.5%) patients had been hospitalized for COVID-19, and 17 (1.7%) had been admitted to an intensive care unit (ICU). The median time since symptom onset was 263 days (IQR 123–289), with a bimodal distribution corresponding to the first (260–300 days) and second waves (50–100 days) in France.

Symptoms and Impact of Long COVID

The median long COVID ST score was 16 (IQR 11–23). This score reports the number of symptoms patients experienced over the last 30 days and has a theoretical range from 0 (no symptoms) to 53 (all symptoms identified during step 1). The symptoms most frequently reported were fatigue ($n = 899$), headaches ($n = 709$), difficulties concentrating/mental fog

($n = 650$), sleep disorders ($n = 603$), and dyspnea ($n = 570$) (**Figure 1**). Symptom frequency was similar in confirmed and suspected cases except for “change/loss of taste” and “change/loss of smell,” both more frequent in confirmed cases. Besides symptoms, 824 patients (80.6%) reported a relapsing-remitting disease course with daily ($n = 285$, 34.6%), weekly ($n = 320$, 38.8%), or less than weekly ($n = 219$, 26.6%) relapses.

Patients’ median long COVID IT score was 36 (IQR 24–45). This score represents the sum of item scores for the six questions related to the disease’s impact on patients’ lives and has a theoretical range of 0 (no impact) to 60 (maximum impact) and. In all, 265 (26%) patients rated the impact of the disease on their work lives at 10 (out of 10). In general, the disease’s impact on patients’ lives was similar for patients with confirmed and suspected infections, except for the item about its effect on their relationships with care givers, which was rated higher in suspected cases (**Supplementary material 6**).

The long COVID ST and IT scores were highly correlated ($r_s = 0.54$, $P < .0001$) and did not seem to differ by time from symptom onset (**Supplementary material 7**).

Table 1. Characteristics of Patients Included in the Validation Step (n = 1022)

Characteristic	Total (n = 1022)	Confirmed COVID-19 (n = 564) ^a	Suspected COVID-19 (n = 458)
Age, median (Q1 – Q3) – yr	45 (37 – 52)	46 (37.75 – 53)	43 (37 – 51)
Male sex, no. (%)	205 (20.1)	123 (21.8)	82 (17.9)
Educational level, no. (%)			
Middle school or equivalent	58 (5.7)	30 (5.3)	28 (6.1)
High school or equivalent	128 (12.5)	61 (10.8)	67 (14.6)
Associate’s degree	213 (20.8)	126 (22.3)	87 (19.0)
Higher education	601 (58.8)	336 (59.6)	265 (57.9)
Other	22 (2.2)	11 (2.0)	11 (2.4)
Perceived poverty, ^b no. of patients self-reporting that they (%)			
Cannot cope without getting into debt	15 (1)	6 (1)	9 (2)
Cope but with difficulty	70 (7)	33 (6)	37 (8)
Are in a tight financial situation	170 (17)	86 (15)	84 (18)
Feel just right financially	208 (20)	109 (19)	99 (22)
Feel somewhat at ease financially	185 (18)	96 (17)	89 (19)
Feel totally at ease financially	50 (5)	30 (5)	20 (4)
Missing	324 (32)	204 (36)	131 (29)
Comorbidities, no. (%)			
High blood pressure	35 (3.4)	23 (4.1)	12 (2.6)
Diabetes	18 (1.8)	13 (2.3)	5 (1.1)
Stroke or cardiac ischemic disease	3 (0.3)	2 (0.4)	1 (0.2)
Asthma/COPD	81 (7.9)	38 (6.7)	43 (9.4)
Cancer	8 (0.8)	8 (1.4)	0 (0)
Depression/Anxiety	39 (3.8)	22 (3.9)	17 (3.7)
Fibromyalgia	20 (2.0)	6 (1.1)	14 (3.1)
Time since symptom onset, median (Q1–Q3), days	263 (123–289)	234 (82–280)	270 (260–299)
Hospitalized for COVID-19, no. (%)	128 (12.5)	76 (13.5)	52 (11.4)
Hospitalized in ICU for COVID-19, no. (%)	17 (1.7)	13 (2.3)	4 (0.9)
Duration of hospitalization, median (Q1–Q3)	4 (1 – 7.25)	5 (2 – 9.25)	2.5 (1 – 5.25)

Abbreviations: COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; ICU, intensive care unit.

^aReported positive testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by polymerase chain reaction (PCR) swab or serological assay.

^bPerceived poverty was assessed by using the question used in the EU-SILC survey. The number of missing information is related to the fact that this information is not collected until 4 months after enrollment and has not yet been asked of all patients included in the present study.

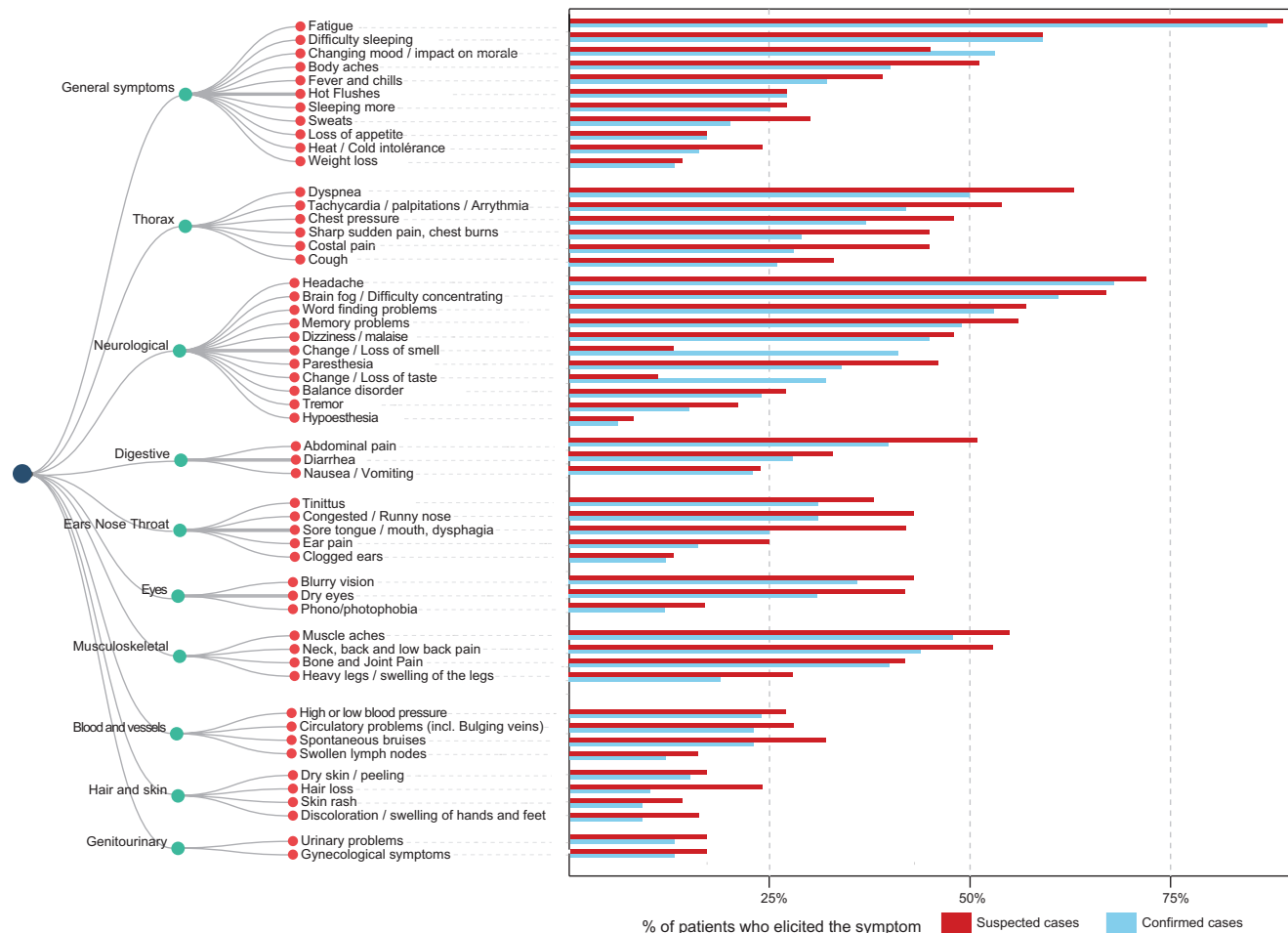


Figure 1. Symptoms reported by patients during the validation step (n = 1022).

Construct Validity

Overall, 970 (95%) patients completed the EQ-5D-5L quality of life questionnaire, the EQ-VAS scale, and the PCFS functional status scale, while 746 (73%) answered the MYMOP2 questionnaire.

For health-related quality of life, the median EQ-5D-5L and EQ-VAS values in our sample were respectively 0.83 (IQR 0.60 to 0.89) and 51 (IQR 40 to 70). As hypothesized, we found that the long COVID ST score was moderately and negatively correlated with the EQ-5D-5L questionnaire ($r_s = -0.45$) and the EQ-VAS ($r_s = -0.39$), whereas the long COVID IT score had a strongly negative correlation with the EQ-5D-5L questionnaire ($r_s = -0.59$) and the EQ-VAS ($r_s = -0.54$).

For functional assessments, 469 (48%) patients in our sample indicated that they were no longer able to perform some activities at home or at work by themselves (grade 3 or 4 of the PCFS), and 371 (38%) reported that they had had to reduce some of their activities (grade 2 of the PCFS). We found a moderate correlation between the long COVID ST score and the PCFS score ($r_s = -0.39$) and a high correlation between the long COVID IT score and the PCFS score ($r_s = -0.55$).

Similarly, for patients’ perceived health state, we found that the long COVID ST score was moderately correlated with the MYMOP2 score ($r_s = -0.40$), whereas the long COVID IT score was highly correlated with it ($r_s = -0.59$) (Table 2).

Structural Validity

The unidimensional structure of the IT score was assessed by a confirmatory factor analysis. Fit measures indicated good structural validity with a Comparative Fit Index (CFI) of 0.95, a Root Mean Square Error of Approximation (RMSEA) of 0.13, 90% CI .11 – .15, and a Standardized Root Mean Square Residual (SRMR) of 0.045. Internal consistency of the IT score was excellent, with Cronbach’s alpha 0.86 (95% CI, .85–.88).

Reliability

Of the 351 patients invited to complete the long COVID ST and IT twice for the test-retest, 235 (67%) did so. The symptom score had an ICC of 0.83 (95% CI .8–.86), with Bland and Altman plots showed a mean difference of 0.8 (95% limits of agreement, –14 and 16). The impact score’s ICC was 0.84 (95% CI .80–.87),

Table 2. Relations Between Patients' Long COVID Symptom Tool (ST) Score, Impact Tool (IT) Score, Quality of Life, Functional Status, and Perceived Health (n = 970)

Characteristic	Relationship With the Long COVID ST Score	Relationship With Long COVID IT Score
Quality of life (EQ5D-5L) ^a	-0.46	-0.59
Quality of life (EQ-VAS) ^a	-0.39	-0.54
Post-COVID functional status (PCFS) ^a	0.39	0.55
MYMOP2 score ^a	0.40	0.59

Relations between the scores and continuous variables were explored with Spearman's correlation coefficient. Correlation coefficients range from -1 (perfect negative correlation) to 1 (perfect positive correlation) with 0 indicating no correlation.
Abbreviation: COVID, coronavirus disease; MYMOP2, measure yourself medical outcome profile 2; PCFS, post-COVID functional scale.
^aHigher EQ5D scores indicate better quality of life; higher PCFS scores indicate more severe functional limitations; higher MYMOP2 scores indicate worse general health.

with Bland and Altman plots showing a mean difference of 0.5 (95% limits of agreement, -11 to 12 (Figure 2).

Patient Acceptable Symptom State

Only 229 (22.4%) patients reported an acceptable symptomatic state, whereas 793 (77.5%) patients reported it was unacceptable. Long COVID's impact was considered acceptable for >75% of patients with IT scores < 30 (95% CI, 28–33), that is, below 50% of the maximum score (Figure 3).

DISCUSSION

In this study, we present the long COVID ST and IT. They are the first set of validated and reliable instruments for monitoring this disease's symptoms and impact and assess, respectively, 53 long COVID symptoms and 6 dimensions of patients' lives that it can affect.

Until now, measurement of long COVID relied on heterogeneous and un-validated sets of symptoms, defined from the

care givers' perspective [3, 7, 8, 19, 39]. Moreover, studies have usually failed to cover difficulties in concentration, even though several report that this symptom is frequent in long COVID [8, 39]. The long COVID ST and IT were built from patients' lived experiences, captured during a survey with open-ended questions. Our tools thus provide a comprehensive picture of the disease. By using mathematical models to assess data saturation, we ensured that our instruments covered all manifestations and impacts of long COVID relevant to patients. In addition, both of our tools showed robust psychometric properties. Construct validity was demonstrated by the high correlations with patients' quality of life, functional status, and perceived health state. Reliability was excellent with an ICC ≥ 0.8 during the test-retest. Finally, we defined a PASS for long COVID that provides thresholds to be met by pharmacological and/or nonpharmacological interventions aimed at reducing its impact on patients' lives.

Second, most studies have focused on counting symptoms but have failed to assess the disease's impact on patients' lives [4, 5, 7, 18, 19]. The long COVID IT fills this gap by providing validated and reliable questions for assessing its burden. This is critical, in view of the major impact that long COVID has on the quality of life and functioning of the patients in our study. The health-related quality of life for patients with long COVID, assessed with the EQ-VAS, was on average 40% lower than in the reference general population [40], and similar to that of patients living with epilepsy or multiple sclerosis [41]. Half reported impaired functioning; that is, they were no longer able to perform some activities unassisted at home or at work (PCFS grade 3 or 4), a figure similar to that described in the study by Davis et al [39]. The long COVID IT thus represents a short instrument that can be used in clinical practice as a screening tool to identify impact problems, that could be further explored with specific instruments.

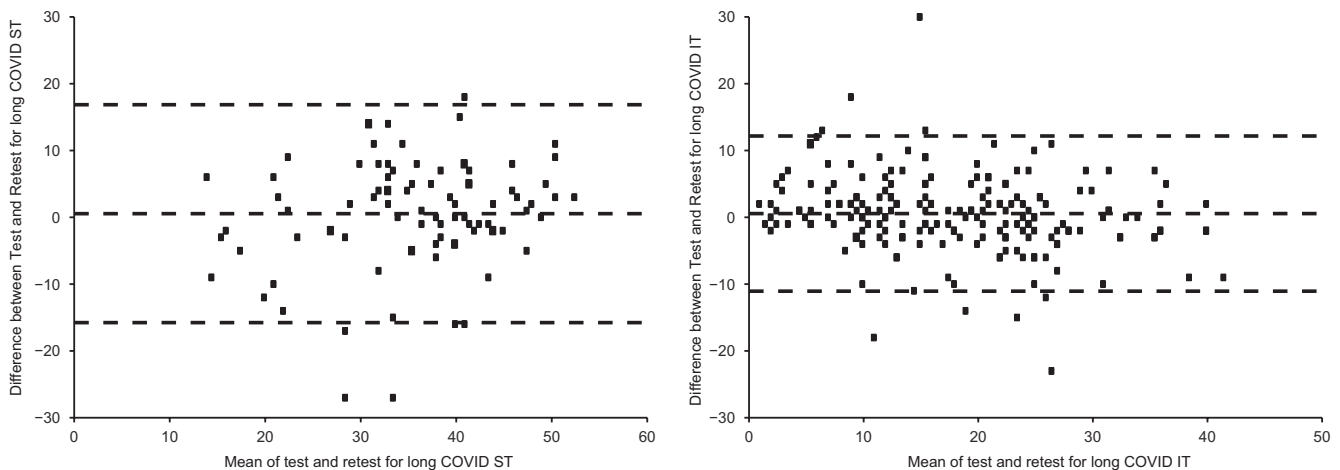


Figure 2. Bland and Altman plots for the test-retest of the long COVID symptom tool score (A) and impact tool score (B) scores (n = 235). Abbreviation: COVID, coronavirus disease.

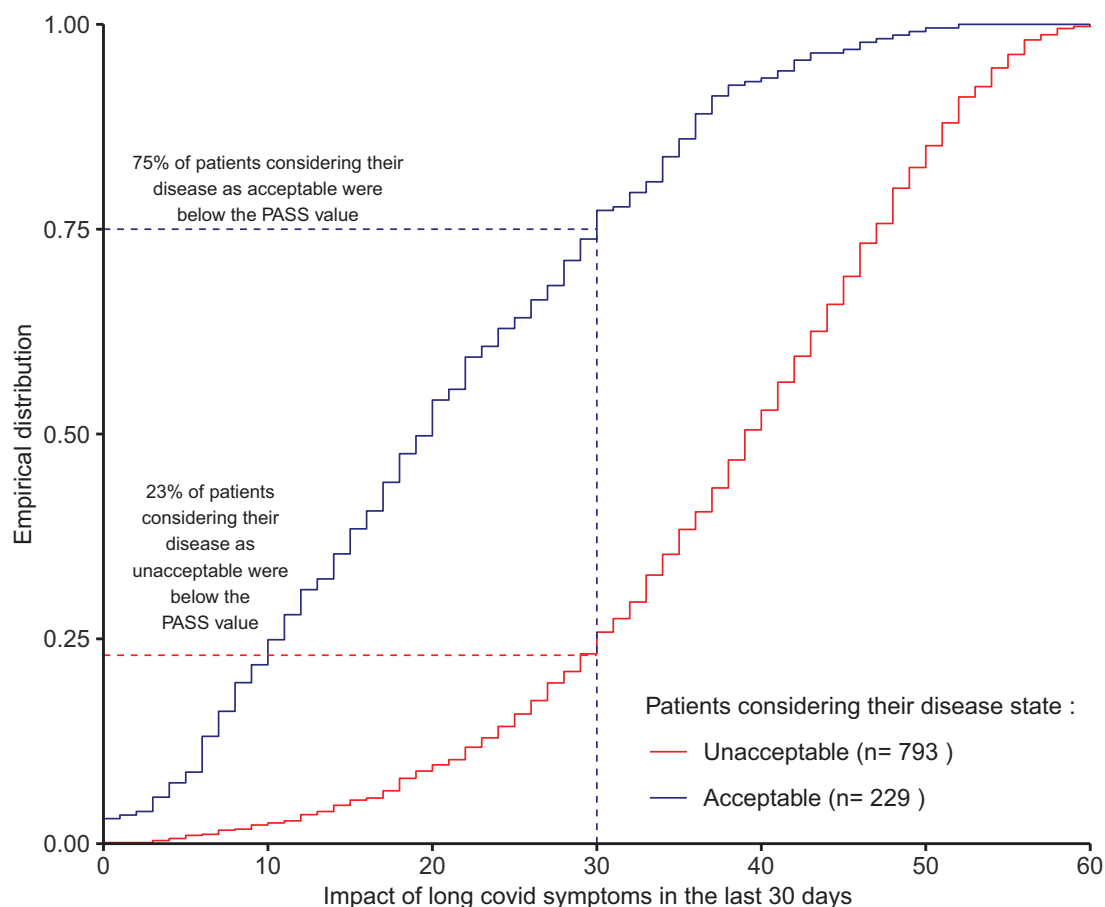


Figure 3. Empirical cumulative distribution function for long COVID impact tool score, in patients considering their levels of symptoms and impact acceptable ($n = 229$) and not acceptable ($n = 793$). Abbreviations: COVID, coronavirus disease; PASS, patient acceptable symptomatic state.

The long COVID ST and IT overlap with sections 2.5 and 2.6 of the recent case report form issued by the World Health Organization (WHO) for the follow-up of patients after their acute illness, which covers 45 symptoms of long COVID (all included in our instrument) and includes questions on patients' functioning [22]. Our set of instruments goes further by inquiring about patients' perceptions of the disease's impact on their lives, roles, and relationships, beyond assessing whether they can or cannot perform specific activities. Moreover, besides collecting information, our instruments provide a scoring method that produces valid and reproducible measurements of the disease and patient-relevant cut-offs to interpret these measures. In all, the overlap of the long COVID ST and IT with the WHO case report form strengthens the content validity of our instruments and provides a glimpse of the potential validity and reliability of the WHO form.

This study has limitations. Generalization of the estimates obtained in this study must be cautious. Our study recruited volunteer patients who reported persistent symptoms. In particular, our recruitment strategy included a social media and general media campaign that could have selected younger, better

educated, and more often female patients willing to share their experiences with others and/or with more severe conditions. In addition, our sample involved fewer patients with socioeconomic difficulties even though this group was more strongly affected by the pandemic. Nonetheless, we were able to involve and validate our instrument in a diverse sample of participants by using a broad media campaign and a call for participation on the "TousAntiCOVID" app [42]. Second, our study may not be appropriate for examining the longitudinal impact of the disease. Although we recruited patients with various times from symptom onset, the assessment of symptoms and impact was cross-sectional. Future follow-up of patients with standardized, validated tools is required to investigate the duration of the disease and the course of the symptoms over time. Third, the content validity and clarity of the long COVID ST and IT were only assessed by the 2 author patients. Nonetheless, although asked to comment on the questionnaire, none of the patients involved in its validation step stated that they found the tools difficult to understand. Finally, in view of the limited number of patients who were hospitalized in ICUs in our study, we cannot confirm that our tool is suitable for measuring these consequences on

Box: Items of the long COVID symptom and impact tools (ST and IT)

Check the symptoms you experienced in the last 30 days:

General symptoms

- Weight loss
- Loss of appetite
- Sweats
- Fever and chills
- Hot flushes
- Fatigue
- Sleeping more
- Difficulty sleeping
- Heat/Cold intolerance
- Changing mood/impact on morale
- Body aches

Thorax

- Rib cage pain
- Chest pressure
- Sharp sudden pain, chest burns
- Tachycardia/Bradycardia/palpitations/Arrhythmia
- Cough
- Dyspnea

Neurological

- Headache
- Tremor
- Dizziness/Malaise
- Balance disorder
- Word finding problems
- Brain fog/Difficulty concentrating
- Memory problems
- Paraesthesia (pricking, tingling, or creeping on the skin)
- Impaired/decreased tactile sensibility
- Change/loss of taste
- Change/loss of smell

Assess the impact of your illness during the last 30 days . . .

- On your personal activities (not being able to do personal activities, driving a vehicle)
- On your family life (feeling isolated or as a burden to others, having to ask for help, not being able to do household chores or take care of your family)
- On your professional life (having to stop working, being unable to work as well as before)
- On your social life (avoiding relationships because of the way people look at you, coping with others not taking your disease seriously, being afraid of infecting others)
- On your morale/mood (low morale, feeling that life is passing you by, fearing of the future or not recovering)
- On your relationship with caregivers (guilt, taking the illness seriously, lack of response, complexity of the care pathway)

Digestive

- Abdominal pain
- Nausea/Vomiting
- Diarrhea

Ear/Nose/Throat

- Sore throat/tongue/mouth/dysphagia
- Ear pain
- Clogged ears
- Tinnitus
- Congested/Runny nose

Eyes

- Dry eyes
- Blurry vision
- Photophobia/Phonophobia

Musculoskeletal

- Bone and joint pain
- Heavy legs/swelling of the legs
- Muscle aches
- Neck, back, and low back pain

Blood and lymph circulation

- Circulatory problems (including bulging veins)
- Spontaneous bruises
- Swollen lymph nodes
- High or low blood pressure

Skin and hair

- Dry/peeling skin
- Hair loss
- Skin rash
- Discoloration/swelling of hands and feet

Urinary and gynaecological

- Gynecological problems
- Urinary symptoms

patients. Similarly, although 10% of the patients included had been hospitalized, most of the patients included had had mild infections and some rarer long-term consequences of severe COVID-19 might have been omitted.

According to the UK Office for National Statistics, 10% of people who were infected with SARS-CoV-2 still experience symptoms after 3 months, including those whose acute infection was asymptomatic [43]. With about 100 million cases of COVID-19 worldwide, long COVID may well affect millions of patients. The severe burden of illness and the impairment of quality of life associated with it call for urgent research to understand this

disease and to develop interventions to help patients. Using scientific, valid, and reliable measurements in these initiatives will enable the comparison and combination of study results.

CONCLUSION

The long COVID Symptom and Impact Tools, constructed from patients' lived experience, provide the first validated, reliable instruments for monitoring the symptoms and impact of long COVID. It may help the development of treatment strategies to mitigate the considerable burden of this disease.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Supplementary material 1: Open-ended questions used for the development of the tool (step 1).

Supplementary material 2: Characteristics of patients included in the survey with open-ended questions (step 1) (n = 492).

Supplementary material 3: Data saturation for symptoms identified during the survey with open-ended questions.

Supplementary material 4: Symptoms identified in the survey with open-ended questions (n = 380).

Supplementary material 5: Examples of what patients wrote about the impact of long COVID on their lives (n = 380).

Supplementary material 6: Patients' scores (median [interquartile range]) to the items assessing the impact of long COVID (n = 1022).

Supplementary material 8: Long COVID Symptom Tool (ST) score, Impact Tool (IT) score and EQ-5D-5L scores over time (n = 970).

Notes

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Author contributions. Generated the idea: V.-T. T. and P. R. Conceived and designed the experiments: V.-T. T., M. D., and P. R. Collected data: V.-T. T., Y. Y., and P. R. Analyzed data: V.-T. T., C. R., B. C., C. C. Wrote the first draft of the manuscript: V.-T. T. Contributed to the writing of the manuscript: V.-T. T., C. R., B. C., M. D., C. C., Y. Y., and P. R. ICMJE criteria for authorship read and met: V.-T. T., C. R., B. C., M. D., C. C., Y. Y., and P. R. Agree with manuscript results and conclusions: V.-T. T., C. R., B. C., M. D., C. C., Y. Y., and P. R. V.-T. T. is the guarantor, had full access to the data in the study, and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Potential conflicts of interest. P. R. reports being a minority shareholder of SKEZI and INATO, outside the submitted work. V.-T. T. reports being a minority shareholder of SKEZI, outside the submitted work. The Long COVID Symptom tool (ST) and Impact tool (IT) are protected by international copyright, with all rights reserved to V. T. T. and P. R. The long Covid Symptom tool (ST) and Impact tool (IT) are protected by international copyright, with all rights reserved to Tran VT and Ravaud P. Do not use without permission. For information on, or permission to use the long Covid ST and IT, please contact Mapi Research Trust, official distributor of the long Covid ST and IT, on behalf of Tran VT and Ravaud P, on ePROVIDE™ at <https://eprovide.mapi-trust.org>. All other authors report no potential conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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