PSYCHOMETRIC PROPERTIES OF A SCALE FOR MEASURING LONG COVID IN THE MEXICAN POPULATION

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ABSTRACT

Objective: This study aimed to translate, adapt, and validate the psychometric properties of the Modified Yorkshire Rehabilitation Scale (C19-YRSm) in Spanish for the Mexican population. Method: A total of 889 participants were recruited from February to November 2023. Invitations were extended through social media to Mexican men and women over 18 years old who had experienced COVID-19 symptoms at any point, to participate in this study by completing the C19-YRSm. Data collection took place from February to November 2023. **Results:** The C19-YRSm instrument demonstrated adequate scale characteristic properties. Item-total correla-

tions ranged from 0.28 to 0.67 for SS and 0.45 to 0.75 for FD, with good internal reliability (Cronbach's alpha of 0.87 for SS and 0.82 for FD). Convergent validity showed a strong positive association between SS and FD. Factor analysis supported a two-factor structure of SS and FD. **Conclusions:** The evidence presented in this research project, along with findings reported by other authors in different validations of the C19-YRSm, suggests it is a specific, valid, and reliable tool for assessing and monitoring Long Covid.

Keywords: post-acute COVID-19 syndrome; long COVID; disability evaluation; validation

RESUMEN

Propiedades psicométricas de una escala para la medición de COVID persistente en la población mexicana. Objetivo: Este estudio buscó traducir, adaptar y validar las propiedades psicométricas de la Escala de Rehabilitación de Yorkshire Modificada (C19-YRSm) al español para la población mexicana. Método: Se reclutaron 889 participantes entre febrero y noviembre de 2023. Se invitó a través de redes sociales a hombres y mujeres mexicanos mayores de 18 años que hubieran presentado síntomas de COVID-19 en algún momento a participar en este estudio completando la C19-YRSm. La recolección de datos se realizó entre febrero y noviembre de 2023. **Resultados:** El instrumento C19-YRSm demostró propiedades características de la escala adecuadas. Las correlaciones ítem-total oscilaron entre 0.28 y 0.67 para SS y entre 0.45 y 0.75 para DF, con una buena confiabilidad interna (alfa de Cronbach de 0.87 para SS y 0.82 para DF). La validez convergente mostró una fuerte asociación positiva entre SS y DF. El análisis factorial respaldó una estructura bifactorial de SS y DF. **Conclusiones:** La evidencia presentada en este proyecto de investigación, junto con los hallazgos reportados por otros autores en diferentes validaciones del C19-YRSm, sugiere que es una herramienta específica, válida y confiable para la evaluación y el monitoreo de la Covid persistente.

Palabras clave: síndrome post-COVID-19; COVID largo; evaluación de la discapacidad; validación

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INTRODUCTION

Long Covid, or Post-COVID-19 Syndrome, is a multisystemic condition characterized by signs and symptoms that appear or worsen after recovering from COVID-19. The WHO defines it as «the continuation or development of new symptoms 3 months after the initial infection with SARS-CoV-2, lasting at least 2 months without another explanation» (Jangnin et al., 2024). Over 200 symptoms associated with Long Covid have been reported across different organs and systems. The most frequently reported symptoms include fatigue, cognitive disturbances, pain, sleep problems, and difficulty breathing. These persistent symptoms can negatively impact the quality of life of affected individuals (Sivan et al., 2021). Some studies estimate its prevalence among 10-20% of individuals infected with SARS-CoV-2 (Chen et al., 2022).

Various hypotheses have been proposed regarding the mechanisms involved in the development of Long Covid, including possible immunological alterations, disruptions in the gastrointestinal microbiota, vascular abnormalities, and endothelial dysfunction with micro clots (Davis et al., 2023). Immunological studies have reported alterations in lymphocyte function and levels of inflammatory mediators such as immunoglobulins, autoantibodies, cytokines, interferons, and interleukins (Klein et al., 2022; Phetsouphanh et al., 2022). Cardiovascular dysfunction, endothelial dysfunction, micro clots, and oxygen transport impairment have been reported in the cardiovascular system, along with decreased capillary density (Charfeddine et al., 2021). Neurological findings include neuroinflammation, cellular hypometabolism, myelin loss, and abnormal cerebrospinal fluid findings (Reiken et al., 2022; Visser et al., 2022; Guedj et al., 2021).

The Modified Yorkshire Rehabilitation Scale (C19-YRSm) was developed to assess symptom severity, functional independence, and disability level in Long Covid patients evaluated its psychometric properties, finding

strong internal consistency (Cronbach's alpha 0.891) and robust reliability (Smith et al., 2024). Since its development and validation, it has been widely used in clinical and research settings, including hospitals, primary care centers, and rehabilitation centers, making it a valuable tool for determining the need for rehabilitation interventions and epidemiological recording of long-term COVID symptoms. The structure of the Modified Yorkshire Rehabilitation Scale (C19-YRSm) is a 17-item instrument designed to capture some symptoms of Long Covid and assess their impact on daily activities and overall health. The 17 items form four subscales: Symptom Severity (SS, 10 items, range from 0-30), Functional Disability (FD, 5 items, range from 0-15), Overall Health (OH, 1 item, range from 0-10), and Other Symptoms (OS, 1 item, range from 0-25) (Ho et al., 2023).

The C19-YRSm was created to address the need for an assessment tool that records the intensity and characteristics of Long Covid symptoms, providing comprehensive information on the syndrome's characteristics and monitoring treatment and rehabilitation. It has been translated and validated for use in various populations, including Italy, Thailand, China, Japan, India, Iran, Poland, and Turkey (Straudi et al., 2022; Partiprajak et al., 2023; Zhang et al., 2023; Tamadoni et al., 2024; Kabir et al., 2023; Go dziewicz et al., 2024; Do an, 2024). However, there is currently no translation, adaptation, or validation of a version of C19-YRSm in Spanish. Therefore, the objective of this project is to translate, adapt, and validate the metric, reliability, and validity properties of the English version of the Modified Yorkshire Rehabilitation Scale (C19-YRSm) into Spanish for application in the Mexican population.

Materials and Methods

Participants: Through social media invitations, men and women over 18 years of age, with a history of being suspected or confirmed cases of COVID-19, were invited to participate in this study. The Modified Yorkshire Rehabilitation Scale was applied to a convenience sample of 889 participants with a history of being suspected or confirmed cases of COVID-19. The study consisted of an electronic questionnaire that could be completed on any mobile device. After reading and accepting the informed consent, participants who accessed the evaluation tool completed it, which was designed for self-administration. However, a direct communication channel was available to resolve any doubts during the study, without this influencing their potential responses. Data collection was conducted from February to November 2023.

Questionnaire adaptation: The researchers requested authorization from the University of Leeds to use, translate, and adapt the C19-YRSm scale into Spanish in Mexico. After obtaining authorization, the translation, adaptation, and validation process proposed by Ortiz-Gutierrez in 2018 was initiated. The steps followed were as follows:

Preparation: The feasibility of the process was analyzed.

Translation: Two translations were requested from experts in the field who were native speakers of the target language and had extensive proficiency in the original language.

Integration: The two obtained translations were compared and integrated, ensuring their conceptual equivalence. Back-translation: A different translator conducted a reverse translation into the original language. Back-translation review: The original instrument was compared with the back-translated version in the original language.

Wording review: Adaptations and modifications were discussed to ensure semantic equivalence.

Harmonization: All versions were compiled to detect discrepancies.

Pilot: A pilot test was conducted with participants similar to the target population.

Finalization: Errors detected during the pilot test were corrected.

Statistical analysis: All analyses were performed using R Studio (R version 2024.09.1+334).

Data distribution was verified using the Shapiro-Wilks test.

For sociodemographic and clinical data (age, sex, education level, marital status, offspring, hours of sleep, alcohol, tobacco, and cannabis consumption, hospitalization), descriptive statistics (n and percentage) were conducted.

For the analysis of the SS, FD, and OH subscales, means (standard deviation), median (interquartile ranges), score ranges, and skewness (evaluated from -0.5 to +0.5) were calculated. For the SS and FD subscales, item characteristics such as item mean score, missing values, item-total correlations were estimated.

Ethical considerations: The research protocol and the informed consent were developed in accordance with the principles of the Declaration of Helsinki (WMA, 1964). The research protocol was approved by the Research Committee of the Institute of Biological Research (CI-IIB) under registration number 23-01. The evaluations were conducted in compliance with Chapter VII of the Bioethics Code for Healthcare Personnel in Mexico (SSA 2002), the Federal Law on Protection of Personal Data Held by Private Parties (D.O.F. July 5, 2010), and the Regulations of the Federal Law on Protection of Personal Data Held by Private Parties (D.O.F. December 21, 2011).

RESULTS

A total of 889 participants with a history of COVID-19 (Table 1) completed the C19-YRSm once. The sample notably included a high percentage of female participants (80%) and a substantial proportion with bachelor's or postgraduate education (74%).

Table 1. Basic sociodemographic details

Variable	Subcategory	N	%
Sex	Male	182	20
	Female	707	80
Age	18-40	552	62
	41-71	337	38
Years of Education	Secondary	15	02
	High School	216	24
	University	472	53
	Posgraduate	186	21
Hours Sleep	5h or less	164	19
	6h	295	33
	7h	311	35
	8h or more	119	13
Offspring	Yes	495	56
	No	394	44
Civil Status	Single	482	54
	Married	257	29
	Free Union	150	17
Alcohol Consume	No	362	41
	1-3 per month	458	52
	1-3 per week	63	06
	1-3 per day	6	01
Tobacco Consume	No	744	84
	1-3 per month	15	02
	1-3 per week	59	08
	1-3 per day	49	06
Cannabis Consume	No	827	93
	1-3 per month	32	04
	1-3 per week	18	02
	1-3 per day	12	01
Hospitalization due to COVID-19	No	844	95
	Yes	45	05

Table 1. Presents the sociodemographic data of the sample, including gender, age, education level, sleep hours, offspring status, civil status, and consumption habits related to alcohol, tobacco, and cannabis, as well as hospitalization history due to COVID-19. The data are presented as frequencies (N) and percentages (%).

Mean scores obtained in the Symptom Severity (SS) (M = 10.84, SD = 5.87) and Functional Disability (FD) (M = 2.49, SD = 2.83) subscales, as shown in Table 2, suggest moderate levels of symptom burden and functional disability. Values in the Overall Health (OH) subscale (M = 7.23, SD = 2.06) indicate that participants perceived their health as moderately good. Distribution analysis showed moderate positive skewness in the SS, FD, and Other Symptoms (OS) domains, whereas OH exhibited moderate negative skewness. Item-level analysis also revealed acceptable item means, standard deviations, and item-total correlations for SS and FD subscales, supporting the internal reliability findings presented in Table 2.

Table 2. Psychometric characteristics, scaling assumptions, and internal reliability of the C19-YRSm domains.

Domain	Item Means (Range)	Item SD (Range)	Item-Total Correlation (Range)	Scale Mean (SD)	Median (IQR)	Score Range	Skewness	Cronbach's Alpha
Symptom Severity (0–30)	0.06–1.49	0.27–1.01	0.28–0.67	10.84 (5.87)	10 (7–15)	0–30	0.30	0.87
Functional Disability (0–15)	0.04–0.59	0.25–0.89	0.45–0.75	2.49 (2.83)	2 (0–4)	0–15	1.50	0.82
Overall Health (0–10)	—	—	—	7.23 (2.06)	8 (6–9)	0–10	-0.95	—
Other Symptoms (0–25)	—	—	—	5.14 (4.06)	4 (2–7)	1–24	1.20	—

Table 2. The table presents mean scores, standard deviations (SD), medians (interquartile range, IQR), score ranges, and skewness for the Symptom Severity (SS), Functional Disability (FD), Overall Health (OH), and Other Symptoms (OS) subscales. Item-level statistics (item means, item SDs, item-total correlations) are presented as ranges across items for the SS and FD subscales. Internal consistency was evaluated using Cronbach's alpha, with values indicating acceptable reliability for SS and FD. Not applicable (—) indicates domains where item-level analysis was not conducted due to single-item structure or heterogeneity. N = 889 participants. C19-YRSm, modified COVID-19 Yorkshire Rehabilitation Scale.

Convergent Validity shown in Table 4 displays the correlation matrix among all domains (Symptom Severity, Functional Disability, Overall Health, Other Symptoms). Strong positive associations were found between SS and FD, and moderate positive associations were observed between SS and OS, and between FD and OS. OH showed a negative association with SS, FD, and OS.

Table 3. Correlation matrix C19-YRSm domains

Domains	Symptom Severity	Functional Disability	Overall Health	Other Symptoms
Symptom Severity	1.00	0.69	-0.47	0.60
Functional Disability	0.69	1.00	-0.39	0.52
Overall Health	-0.47	-0.39	1.00	-0.35
Other Symptoms	0.60	0.52	-0.35	1.00

Table 3 displays the correlation matrix for C19-YRSm domains, showing strong positive correlations between Symptom Severity (SS) and Functional Disability (FD), and moderate positive correlations between SS and Other Symptoms (OS), and FD and OS. Overall Health (OH) shows negative correlations with SS, FD, and OS. All correlations are significant ($p < 0.001$). Additionally, SS and FD scores increase with symptom severity, while OH decreases. N=889. C19-YRSm, modified COVID-19 Yorkshire Rehabilitation Scale.

Validity Between Groups: There was a linear increase in SS scores as the number of symptoms (OS subscale tertiles) increased from low to high severity. A similar pattern was observed for FD, whereas OH scores decreased as symptom count increased. All these results were statistically significant ($p < 0.001$).

Table 4. C19-YRSm domain scores by symptom burden.

Domain	*1* Low, N = 405	*1* Medium, N = 213	*1* High, N = 271	*2* p-value
Symptom Severity (0-30)	7.72 (5.07)	11.30 (4.58)	15.15 (5.00)	< 0.001
Functional Disability (0-15)	1.36 (1.94)	2.45 (2.40)	4.22 (3.35)	< 0.001
Overall Health (0-10)	7.81 (1.97)	7.20 (1.77)	6.39 (2.13)	< 0.001

Table 4 presents mean domain scores of the C19-YRSm by symptom burden, categorized as low, medium, and high based on the «Other Symptoms» domain. Scores for Symptom Severity and Functional Disability increase significantly as symptom burden rises, while Overall Health decreases.[1]Mean (Standard Deviation); [2]Kruskal-Wallis rank sum test with Dunn-sadak post hoc test. C19-YRSm, modified COVID-19 Yorkshire Rehabilitation Scale.

Participants with a history of hospitalization for COVID-19 reported significantly higher scores on the Symptom Severity (SS) and Functional Disability (FD) subscales compared to participants who did not require hospitalization. In the SS subscale, hospitalized individuals had a mean of 15.33 (SD = 6.88), while those without a history of hospitalization had a mean of 10.60 (SD = 5.72; $p < 0.001$). Similarly, on the FD subscale, the mean score in the hospitalized group was 4.96 (SD = 4.28), in contrast to 2.26 (SD = 2.67) in the non-hospitalized group ($p < 0.001$).

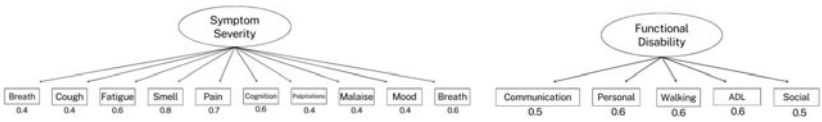
On the other hand, no significant differences were found in the perception of general health (OH) between both groups ($p = 0.09$). The mean score in the hospitalized group was 6.71 (SD = 2.26), while in the non-hospitalized group it was 7.26 (SD = 2.05).

Comparisons between groups were performed using the Mann-Whitney-Wilcoxon rank sum test. These results suggest that a history of hospitalization for COVID-19 could be associated with a greater burden of persistent symptoms and functional limitations in long-term recovery.

Factorial Structure

The results of the CFA showed an RMSEA of 0.72 (90% CI: 0.69 to 0.74) (Figure 1). The SRMR was 0.099, CFI was 0.919 and TLI was 0.914. Taking all four indices together, these indicated a reasonable model fit for the two-factor model. These factors were consistent with the interpretation of one factor measuring SS and the other measuring FD.

Figure 1. Factor structure of the modified COVID-19 Yorkshire Rehabilitation Scale Symptom Severity and Functional Disability subscales. ADL, Activities of Daily Living.



Discussion

This study aimed to translate, adapt, and validate the psychometric properties of the C19-YRSm. The results demonstrate that both the items and scales have satisfactory characteristics. These findings are consistent with previous validations in other populations, which have reported good internal consistency and convergent validity for the instrument. This further supports the psychometric properties of the C19-YRSm, with significant factors or domains such as SS (Symptom Severity), FD (Functional Disability), and OH (Overall Health). The scale's validation underscores its utility as an assessment tool for the specific condition of Long Covid. The design of the instrument allows patients to complete it independently, facilitating its use and monitoring by researchers or healthcare professionals.

Participant Profile

Regarding the participant profile in this sample, the vast majority were women (Bucciarelli et al., 2022; Davis et al., 2023). The proportion of women in this sample is notably high, which may be influenced by factors such as self-selection to participate in the study or the possibility that women are more likely to report persistent symptoms. This contrasts with studies that have found a more balanced gender distribution (Zhang et al., 2023).

Another relevant aspect is the high educational level of the participants in this study, with 74% having at least a university education. This figure is significantly higher than that observed in the general population in other studies, where more varied educational levels are reported (Chen et al., 2022). This factor may be related to greater health awareness and access to information about Long Covid, leading to higher participation in studies like this (Cohen & Van Der Meulen Rodgers, 2023).

Substance use patterns, such as alcohol, tobacco, and cannabis, were similar to those reported in other studies, although cannabis use was lower in this sample (García et al., 2023). This could be due to specific sociocultural factors in the Mexican population or a self-selection bias based on perceived substance use impacts on health.

Comparison with Other Validations

Regarding subscale results, higher mean scores were observed in SS (somatic symptoms), FD (functional disability), and OS (other symptoms) compared to other studies, suggesting that participants in this sample may be experiencing a greater degree of symptoms and functional disability. This variation could be due to differences in the population sample, such as the severity of the initial COVID-19 infection, access to healthcare, or genetic and lifestyle differences (Kabir et al., 2023).

When analyzing the means obtained in each subscale, this study reports higher mean scores in the SS, FD, and OS subscales and a lower mean score in OH compared to the psychometric analysis conducted by Smith et al. (2024) in the validation of the modified version. This implies greater impairment in functional capacity and a lower general health score. This could be related to the fact that the sample came from a Long Covid specialized clinic, and all participants met the diagnostic criteria for this condition, presenting signs and symptoms associated with Long Covid. This contrasts with the sample in this study, which included participants with a history of suspected or confirmed COVID-19, without necessarily meeting the criteria for Long Covid. Additional factors, such as ethnicity, sociodemographic factors, access to healthcare services, and timing of the instrument administration, may also play a role (Zhou et al., 2022).

In contrast to the results reported in the validation in the Iranian population, where lower mean scores were found in the SS, FD, and OS subscales and a higher mean score in OH, indicating less functional impairment and better general health scores (Tamadoni et al., 2024). This may be related to a lower proportion of female participants, as other studies have reported that women tend to experience fewer short-term complications from COVID-19 but a higher proportion of long-term complications compared to male participants (Zhang et al., 2023).

It is also important to consider that most participants in this sample were not hospitalized (95%), which is consistent with trends observed in other studies where the majority of Long Covid cases did not require hospitalization (Kabir et al., 2023; Kustura et al., 2023). However, participants who were hospitalized showed significantly higher scores in the SS and FD subscales, aligning with literature indicating a greater symptom burden in

individuals with more severe acute illness (Zhou et al., 2022; Kustura et al., 2023).

Despite the timeframe, as the sample was collected between February and November 2023, some studies have reported the presence of moderate to severe disabling symptoms over extended periods. For example, in a Long Covid clinic study conducted by Sivan in 2024, symptoms were reported for periods ranging from 207 to 706 days, with an average of 408 days (Davis et al., 2023). The literature suggests that several mechanisms are involved in Long Covid symptomatology, including immune activation, autoantibodies, dysautonomia, endothelial damage, hypercoagulability, immune dysregulation, and viral persistence, which may overlap or occur individually or consecutively. This could explain the prolonged duration of symptoms (Davis et al., 2023).

Strengths and Limitations of the Study

This study presents several key strengths. First, a thorough and well-structured process of translating and culturally adapting the C19-YRSm instrument was carried out, following standard and multidisciplinary procedures, ensuring the validity of the process. Similar efforts have been highlighted in studies conducted in Turkey (Do an, 2024), Iran (Tamadoni et al., 2024), and Italy (Straudi et al., 2022), emphasizing the importance of cultural validation of instruments in different contexts. Additionally, the study included a large representative sample of 889 participants, providing a solid foundation for statistical analysis and enhancing the generalizability of the findings to the Mexican population. This is in line with research by Kabir et al. (2023), who highlight the need for large cohorts to better understand Long Covid. The validated C19-YRSm instrument has proven reliable and valid in various international contexts, demonstrating high internal consistency, as seen in the symptom severity and functional disability subscales, supporting its robustness in line with previous studies (Straudi et al., 2022; García et al., 2023; Do an, 2024; Tamadoni et al., 2024; Partiprajak et al., 2023; Kustura et al., 2023; Smith et al., 2024).

The complete statistical analyses, including confirmatory factor analysis and correlation tests, provide robust support for the psychometric properties of the instrument. Moreover, the clinical relevance of the study is significant, as it addresses a current and important issue—Long Covid—by providing a specific tool for assessing persistent symptoms and their impact on daily life. This is crucial for the care and rehabilitation of these patients, in line with recommendations proposed by Davis et al. (2023).

However, some limitations were identified. There is a gender bias in the sample, with 80% of participants being women, which may limit the generalization of the results to the male population and introduce bias in the interpretation of data related to Long Covid. This aligns with findings from previous studies in the Chinese population (Zhou et al., 2022), suggesting that gender differences may influence the prevalence and severity of Long Covid. Additionally, the fit indices for the confirmatory factor analysis were not optimal, indicating that the proposed factorial model does not fully align with the data, limiting the interpretability of the underlying dimensions, as discussed in the need for instrument improvements (Smith et al., 2024). Furthermore, the lack of geographic diversity in the sample raises questions about the representativeness of other regions within Mexico. Some studies highlight the importance of considering cultural and geographic diversity in instrument validation. Recruiting participants through social media may have introduced self-selection bias, where individuals with more severe symptoms or those more interested in the topic of Long Covid could be overrepresented (Tamadoni et al., 2024; Kustura et al., 2023). The cross-sectional design limits the ability to observe changes in symptom severity over time or evaluate the long-term impact of therapeutic interventions. Longitudinal research is recommended to better understand symptom evolution (Partiprajak et al., 2023). Finally, although the study focuses on the Mexican population, possible cultural differences that could affect the applicability of the C19-YRSm in other Spanish-speaking contexts are not explored. It would be advisable to conduct additional validations in other Latin American countries to broaden the generalization of the findings (Davis et al., 2023).

Conclusion

This study makes a valuable contribution to Long Covid research by translating, adapting, and validating the Modified Yorkshire Rehabilitation Scale (C19-YRSm) for the Mexican population. The results indicate that the

C19-YRSm has adequate psychometric characteristics, with good internal consistency and convergent validity, supporting its use as an assessment tool in various clinical and research contexts. The high prevalence of symptoms reported in our sample, especially among women and highly educated individuals, highlights the need for a more inclusive and culturally adapted approach to addressing Long Covid. Compared to international studies, our scores reveal a higher degree of severity and functional disability, which may reflect differences in the sample or the condition's severity across populations. The robustness of the cultural adaptation process and the significant representation of the sample strengthen the validity of our findings and suggest that the C19-YRSm is an effective tool for assessing prolonged symptoms in the Mexican population. These results may inform intervention strategies and improve the understanding of Long Covid, providing a solid foundation for future research and clinical applications.

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