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Validation of a Scale to Measure the Perception of SARS-CoV-2 Vaccines Acceptance: The VAC-COVID-19 Scale

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ABSTRACT

Introduction: Since the announcement of the start of SARS-CoV-2 vaccines development, many myths and vaccine opponents have come to the fore. Therefore, in this scenario, it is imperative to have an instrument to assess the population perception of this subject matter.

Objective: To validate a scale to measure the perception of SARS-CoV-2 vaccines acceptance.

Methods: This is an instrumental and multicentre study, through which a list of possible reasons for whether or not people would be vaccinated was generated. After submitting them to 15 experts, a pilot survey was conducted virtually in a population of almost 3000 participants in the 24 regions of Peru. Descriptive statistics and the exploratory factor analysis (EFA) were conducted using the FACTOR program.

Results: The Kaiser-Meyer-Olkin (KMO) coefficient (KMO = 0.917) and the Bartlett's test of sphericity (3343.3; gl = 136; $p < 0.001$) were conducted. According to EFA results, two factors were found to explain 58.17% of the total variance. The fit indices show that the proposed model is adequate ($\chi^2 = 826.321$; df = 43; p = 0.001; RMR = 0.054; GFI = 0.952; AGFI = 0.927; CFI = 0.946; TLI = 0.931; and RMSEA = 0.078). Finally, Cronbach's α was found to be very satisfactory for the generated scale (α = 0.831; 95% CI = 0.82 – 0.84).

Conclusion: A simple and efficient scale was validated to assess positive and negative perceptions of SARS-CoV-2 vaccines (the VAC-COVID-19 scale), with a Cronbach's coefficient of 0.831.

Keywords: perception, mass vaccination, COVID-19 vaccines, SARS-CoV-2, validation, Peru

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has created a global public health emergency due to its rapid spread and significant morbidity and mortality. Several segments of the society have been affected, and so far the number of confirmed cases of the disease worldwide has already exceeded 90 million [1]. As a result, many pharmaceutical companies and countries set out to develop a vaccine to help put an end to the pandemic. Thus, some viable vaccines for mass vaccination against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) were developed in a very short time. Although the vaccination is urgent and the health systems of several countries can collapse at any time, its implementation and subsequent immunization are suffering some setbacks [2]. Moreover, there is the precedent that in situations such as this, the health sector often fails to carry out the vaccination process appropriately [3].

Another possible challenge in this context is the vaccine hesitation. Numerous studies conducted of Europe and North America on the population perception of vaccination have reported that greater acceptance of vaccines depends mainly on their safety and efficacy in clinical studies [4]. In addition, length of time of immunity, adverse effects, and the origin of the vaccine has been identified as the main factors associated

with increasing the likelihood of vaccination among the more vulnerable population [5]. Therefore, determining the number of patients who will reject SARS-CoV-2 vaccines could contribute greatly to clarifying whether collective immunization can be achieved [6].

It should also be noted that knowing the population perceptions of vaccination would be very useful for governments to implement effective campaigns and seek new strategies to achieve positive perception of vaccines [7,8]. Nevertheless, studies on vaccine perceptions, especially regarding SARS-CoV-2 vaccines are scarce in the literature. Furthermore, there are no scales or measuring instruments that can help us have a real approach to the population perception of the SARS-CoV-2 vaccination. In this study, we develop and validate a scale to measure the perception of SARS-CoV-2 vaccines acceptance.

METHODS

Study Type and Design

An instrumental, cross-sectional, analytical, and multicentric study was conducted in the 24 regions of Peru.

Population and Sample

First, a sample of 15 professionals with experience in the field of public health, a master's degree in related subjects (epidemiology, public health, or related research), specialization in related subjects (infectious diseases, immunology, internal medicine, or related field), or active in vaccination services (general practitioners, nurses, psychologists, communicators, etc.) were recruited.

Also, a non-random sample of 30 respondents was selected for a pilot phase (prior to the general survey) and another non-random sample of 3000 participants from the 24 regions of Peru was used for the application of the general survey. The participants were recruited through social media, email, and phone calls. Our samples were composed of students, workers, and retirees. Although the samples were non-random, every effort was made to ensure that they adequately represented each group of the study.

We included all participants who were over 18 years of age, and who completed the survey correctly (ended the survey) and agreed to participate voluntarily in the study. Participants who lived outside the country in the last six months (considering the date of invitation to participate in the study), or who had COVID-19 complications and not completed the entire survey were excluded (16 exclusions). Finally, the study sample consisted of 2984 participants.

Procedures and Instrument

Item development

The research team carried out an exhaustive bibliographic search in databases with Spanish and English articles, in addition to consultation to experts in the field. An initial list with 19 items to the survey was obtained, which was divided into two groups of 13 and six items each, including reasons for 'whether or not' the participants would be vaccinated, respectively. Each item had five possible Likert-type responses: strongly disagree, disagree, neither disagree nor agree, agree, and strongly agree.

Scale development

The next steps included substantive validation (through the evaluation of the 15 experts in the field), form validation (by the 30 participants of the pilot phase), and general survey (with the participation of almost 3000 people). For the substantive validation, the experts gave their assessments through a validation sheet that included the following indicators: representativeness, clarity, and relevance. In each stage, several suggestions were taken into consideration, and necessary changes were made, with the final scale having only 11 items.

Due to the serious socio-epidemiological situation, especially in the northern regions of Peru, we decided that all steps of the research would be done virtually, using the SurveyMonkey, Inc. (San Mateo, California, USA). This platform was chosen due to the possibility of having the option of receiving only one response for each respondent (with filtering for only one response for each item). All of this was developed during the month of December 2020.

Statistical Analysis

Descriptive analysis and the exploratory factor analysis (EFA) were conducted using the FACTOR program. The mean, standard deviation, asymmetry, and kurtosis of each one the 19 initial items of the scale were analyzed. The value +/- 2 was adopted to the coefficient of asymmetry and kurtosis [9]. The Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) coefficient were used for this purpose. EFA was performed using robust ordinary least squares, with an oblique promin rotation. The parallel analysis suggested the existence of two factors [10].

We used the statistical program AMOS (version 21) to estimate the confirmatory factor analysis (CFA) models. The goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), the Tucker-Lewis index (TLI), and the comparative fit index (CFI) were analyzed based on the structural equation modelling (SEM). Moreover, the the root mean square error of approximation (RMSEA) and the root mean square error (RMR) were calculated following the criteria proposed by Hu and Bentler [11], who indicated that the GFI, AGFI, TLI, and CFI values should be higher than 0.9 and the RMSEA value lower than 0.08. Reliability and confidence intervals were determined using the Statistical Package for Social Sciences (SPSS) version 12 (SPSS Inc., Chicago, IL, USA).

Ethics

The project was developed in accordance with the international ethical and methodological guidelines. It was approved by the committee of Norbert Wiener Private University with registration number 306-2020. The consent for participation was obtained at the beginning of the survey, and only the responses of the professionals who agreed to participate in the study were considered eligible.

RESULTS

Table 1 shows the calculation of the mean, standard deviation, asymmetry, and kurtosis (descriptive statistics) of the 19 initial items of the VAC-COVID-19 scale. Item 15 has the highest average score (M = 2.92), while item 12 the highest dispersion (SD = 1.28). The asymmetry and kurtosis values of all items do not exceed the range +/- 2 [9]. On the other hand,

Table 1. Preliminary analysis of the items on the VAC-COVID-19 scale

Variable	M*	DS†	A‡	K§	h**
Item 1	0.77	1.027	1.187	0.583	0.552
Item 2	1.213	1.217	0.607	-0.746	0.665
Item 3	0.614	0.903	1.514	1.875	0.496
Item 4	1.003	1.136	0.898	-0.168	0.646
Item 5	0.575	0.884	1.747	2.945	0.564
Item 6	0.775	0.978	1.218	0.893	0.464
Item 7	0.911	1.014	0.996	0.308	0.494
Item 8	1.801	1.282	-0.015	-1.204	0.379
Item 9	2.112	1.173	-0.393	-0.69	0.379
Item 10	1.484	1.215	0.316	-0.929	0.638
Item 11	1.608	1.259	0.238	-1.073	0.329
Item 12	1.704	1.289	0.184	-1.123	0.432
Item 13	1.754	1.228	0.076	-0.984	0.329
Item 14	2.789	1.082	-0.826	0.114	0.692
Item 15	2.929	1.024	-1.059	0.827	0.797
Item 16	2.905	0.998	-1.025	0.923	0.778
Item 17	2.4	1.136	-0.311	-0.682	0.402
Item 18	1.867	1.187	0.141	-0.925	0.171
Item 19	2.421	1.185	-0.409	-0.656	0.24

* Mean; † Standard Deviation; ‡ Asymmetry coefficient; § Kurtosis coefficient; ** Communalities.

Table 2. Exploratory factor analysis of the VAC-COVID-19 scale

#	Items	F1*	F2†
1	I think they are going to insert electronic chips/transistors to control my brain.	0.665	
2	I think SARS-CoV-2 vaccines are part of the plan of a large company that created COVID-19.	0.814	
3	I think that some SARS-CoV-2 vaccines can come from a former communist republic (like Russia), which may result in influences on communist thinking.	0.641	
4	I think COVID-19 is an invention of the World Health Organization (WHO) or other similar institutions.	0.793	
5	I think COVID-19 does not exist. It is an invention.	0.691	
6	I have already been infected with SARS-Cov-2 and I do not think the vaccine is necessary.	0.621	
7	I think the pandemic is already ending.	0.705	
8	I do not know what and how the vaccines have been made.	0.654	
9	SARS-CoV-2 vaccines can cause side effects or adverse effects.	0.65	
10	I think they want to try the vaccines on us.	0.798	
11	I do not think I belong to a risk group.	0.619	
12	A healthy life is enough to fight disease.	0.688	
13	I do not trust in my health care system (including health care personnel).	0.608	
14	I want to get back to the life I had before the pandemic.		0.844
15	SARS-CoV-2 vaccines should contribute to improving the health of my family or loved ones.		0.945
16	I think SARS-CoV-2 vaccines should contribute to improving the health of the community/population.		0.897
17	I do not want to wear personal protective equipment anymore (masks).		0.626
	Variance percentage	44.27%	13.09%
	Inter-factor correlation		
	F1*	1	
	F2†	0.391	1

* F1 = Factor 1 = Reasons for not receiving vaccination; † F2 = Factor 2 = Reasons for receiving vaccination.

items 17 and 18 ("I would be vaccinated only if it is a requirement for work/study" and "if the vaccination is done at home") have communalities lower than 0.30, so they were not considered in the EFA.

Exploratory Factor Analysis (EFA)

An EFA was performed and the scale items were saturated in two factors. Results of the KMO coefficient (KMO = 0.917) and the Bartlett's test of sphericity (3343.3; gl = 136; $p < 0.001$) were acceptable and significant. The parallel analysis, unweighted least squares, and oblique promin rotation methods were used. The parallel analysis method suggested that two factors be retained. The rotated solution of the 17 items explains 58.17% of the total variance. Factor 1 (reasons for not receiving vaccination) explains 44.27% of the variance, while Factor 2 (reasons for receiving vaccination) 13.09%. All items present saturation greater than 0.60.

Confirmatory Factor Analysis (CFA)

Table 3 shows the CFA results based on the internal structure of the VAC-COVID-19 scale. The results of the original model showed that goodness-of-fit was poor. Therefore, items 8 and 9 were eliminated in accordance with the modification indices, and the model was not satisfactory. Items 6 and 7 were eliminated in the second re-specification, showing a variation in the goodness-of-fit indices; however, the model was still not satisfactory. In the third re-specification, items 10 and 11 were eliminated and thus an acceptable factor structure model was found.

The fit indices show that the proposed model is adequate. Also, the correlations between Factors 1 and 2 were significant. In summary, the model of 11 items distributed in two factors is satisfactory (**Figure 1**).

Table 3. Goodness-of-fit indices of factorial models of the VAC-COVID-19 scale

Goodness-of-fit indices	Original (17 items)	Model 1 (15 items)	Model 2 (13 items)	Model 3 (11 items)
CMIN	3548.99	2300.548	1629.663	826.321
df	118	89	64	43
p	<0.001	<0.001	<0.001	<0.001
CMIN/df	30.069	25.849	25.463	19.217
RMR	0.085	0.075	0.077	0.054
GFI	0.843	0.893	0.914	0.952
AGFI	0.797	0.856	0.878	0.927
CFI	0.853	0.891	0.910	0.946
TLI	0.830	0.871	0.891	0.931
RMSEA	0.099	0.091	0.091	0.078

CMIN= Chi-square goodness-of-fit index; df= Degrees of freedom; p= p-value; CMIN/df= Chi-square divided by the df value; RMR= Root mean square error; GFI= Goodness-of-fit index; AGFI= Adjusted goodness-of-fit index; CFI= Comparative fit index; TLI= Tucker-Lewis index; RMSEA= Root mean square error of approximation.

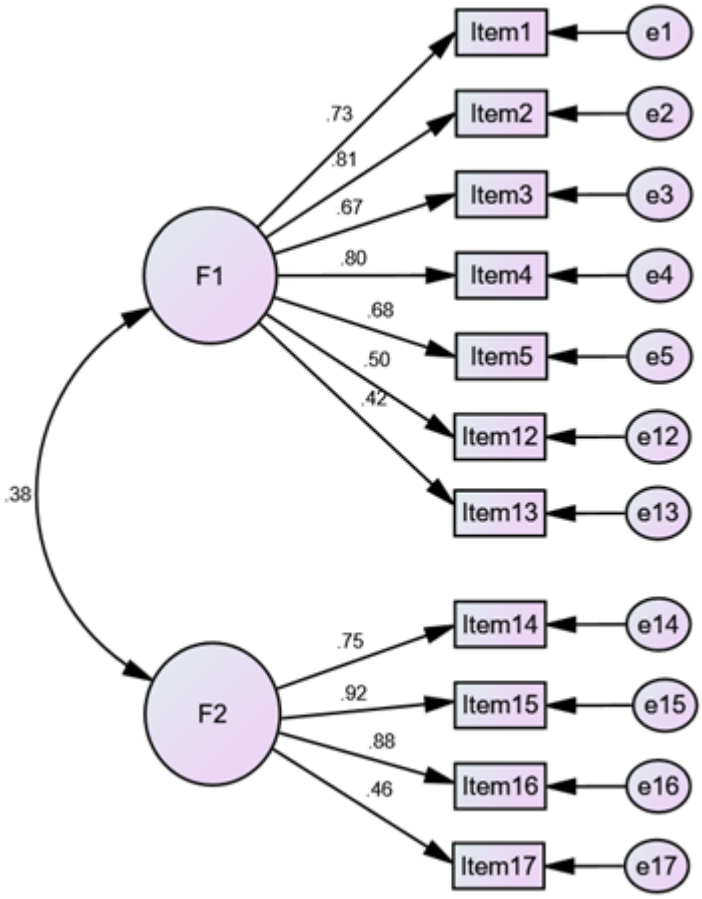

Figure 1. Final model of the VAC-COVID-19 scale

Table 4. Cronbach's α for the VAC-COVID-19 scale and its factors

	Number of items	Cronbach's α	95% Confidence Interval
Factor 1	7	0.834	0.82 – 0.84
Factor 2	4	0.837	0.82 – 0.84
Total Scale	11	0.831	0.82 – 0.84

Reliability

The reliability of the scale was estimated with Cronbach's coefficient α [12]. We evidence that the general structure (α = 0.831; 95% CI= 0.82 – 0.84) and all the factors of the scale (Factor 1: α = 0.834; 95% CI = 0.82–0.84 and Factor 2: α = 0.837; 95% CI = 0.82–0.84) are adequate. **Table 4** shows the estimate of reliability for both the scale and its factors, whose reliability coefficients are above higher 0.8 (the acceptable cut-off point is ≥ 0.70), indicating that the VAC-COVID-19 scale is reliable.

DISCUSSION

The attempts to develop an effective SARS-CoV-2 vaccine have been proceeding rapidly and collaboratively worldwide. However, the existence of a possible level of distrust regarding this vaccine (manufactured by different laboratories) makes it necessary to know how the population perceives it, and thus to understand the doubts and the real confidence in the new vaccines [13,14]. Therefore, we validated this scale (VAC-

COVID-19) in response to the proliferation of many myths and beliefs about the possible adverse effects of immunizations [15]. Our survey is broad in scope and effective and will serve to have a deeper perspective on SARS-CoV-2 vaccination, as well as for further studies, with the ability to contrast the pros and cons based on scientific evidence [16].

The first factor of the study is related to reasons for the population not accepting to be vaccinated against SARS-CoV-2. Its respective items allow us to know the reasons for existing myths at the global level, including possible negative influences of powerful groups, the question on the origin of the vaccine (repercussions according to the country that developed it), among other information related to anti-vaccination movements— mainly transmitted by social networks and the media, which have broadly and quickly disseminated information without considering their accuracy and veracity [17]. Moreover, in the first factor, questions were also asked about the trust that the population has in the health organizations and systems, including the World Health Organization, since in many countries there is a degree of mistrust on their own health systems and vaccination programs [18]. Therefore, using the knowledge gained from answering these questions, it becomes possible to help guide the health authorities to develop specific strategies to increase the trust of the population in SARS-CoV-2 vaccines. A good example of this has occurred in Chile, where there is the highest rate of trust in vaccination with respect to the influenza vaccination program in Latin America; due to its population have higher knowledge and perception levels about influenza risks [19].

The second factor consists of four items about the most important reasons as to why the population should receive SARS-CoV-2 vaccination. The answers to these questions are very important to know, as they also should help authorities in the development of more effective public health strategies against the COVID-19 pandemic. In this context, a major current concern is the return to activities of daily living (as before the pandemic), since the confinement can lead to several negative health consequences, such as stress, anxiety, and fear [20-22]. It is worth remembering that many people have been away from their families and other loved ones. Furthermore, many people are no longer properly using personal protective equipment; despite the fact that the mask protects, its use has caused some dermatological problems, including acne, contact dermatitis, ulcers, and erosions [20].

It should also be noted that the present survey mainly aims to measure the willingness of general population to receive SARS-CoV-2 vaccination, with acceptable Cronbach's alpha values ($\alpha = 0.831$). In 2016, Shapiro et al developed a scale that measures vaccine conspiracy beliefs regarding human papillomavirus (HPV) vaccine with the participation of 1427 Canadian parents. This 7-items scale obtained a reliable Cronbach's alpha ($\alpha = 0.937$). However, such scale had a higher inter-factor correlation (0.82) [23] than the scale developed by us (0.391). On the other hand, in 2017, Forster et al validated a scale that assesses HPV vaccination knowledge, involvement in the vaccine decision-making, self-efficacy with regard to getting the vaccine, and fear and anxiety about vaccination. In this case, the developed scale has three sections and each of them was validated obtaining Cronbach's alpha values ($\alpha = 0.60, 0.79, 0.79$) lower [24] than ours.

One of the limitations of our study was that it cannot be extrapolated to the entire Peruvian population, since the sample selection was not randomized. Therefore, although the present research has been conducted in all the regions of Peru, the fact of we used a non-random type of sampling meant that the study cannot be extrapolated, for example, to the rural population. Another limitation is the absence of concurrent validity assessment. We strongly recommend that in future studies this assessment is carried out. Moreover, we suggest further validations on this issue.

In conclusion, the VAC-COVID-19 scale is a valid and reliable instrument of public health to measure the perception of SARS-CoV-2 vaccines acceptance. This scale can be very useful to determine the reasons why different populations adhere or not to the vaccination, in order to help propose adequate and effective strategies to advance vaccination coverage rates.

Author contributions: All authors have sufficiently contributed to the study, and agreed with the results and conclusions.

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Declaration of interest: CRM and **OR-L** work in the institution which financed the research.

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APPENDIX

Items of the final survey (from **Table 2**) written in English (**Table A1**), Spanish (**Table A2**), and Portuguese languages (**Table A3**).

Table A1. Items in English

I shouldn't get SARS-CoV-2 vaccines because…
1. I think they are going to insert electronic chips/transistors to control my brain.
2. I think SARS-CoV-2 vaccines are part of the plan of a large company that created COVID-19.
3. I think that some SARS-CoV-2 vaccines can come from a former communist republic (like Russia), which may result in influences on communist thinking.
4. I think COVID-19 is an invention of the World Health Organization (WHO) or other similar institutions.
5. I think COVID-19 does not exist. It is an invention.
12. A healthy life is enough to fight disease.
13. I do not trust in my health care system (including health care personnel).
I should get SARS-CoV-2 vaccines because…
14. I want to get back to the life I had before the pandemic.
15. SARS-CoV-2 vaccines should contribute to improving the health of my family or loved ones.
16. I think SARS-CoV-2 vaccines should contribute to improving the health of the community/population.
17. I do not want to wear personal protective equipment anymore (masks).

Table A2. Items in Spanish

No debería ponerme las vacunas contra el SARS-CoV-2 porque…
1. Pienso que me van a insertar chips/transistores electrónicos para controlar mi cerebro.
2. Pienso que las vacunas contra el SARS-CoV-2 son parte del plan de una gran empresa que creó el COVID-19.
3. Pienso que algunas vacunas contra el SARS-Cov-2 pueden provenir de una antigua república comunista (como Rusia), resultando en influencias en el pensamiento comunista.
4. Pienso que el COVID-19 es un invento de la Organización Mundial de la Salud (OMS) u otras instituciones similares.
5. Pienso que el COVID-19 no existe, es un invento.
12. Una vida saludable es suficiente para combatir las enfermedades.
13. No confío en mi sistema de salud (incluído el personal de salud).
Debería ponerme las vacunas contra el SARS-CoV-2 porque …
14. Quiero regresar a mi vida de antes de la pandemia.
15. Las vacunas contra el SARS-CoV-2 deben contribuir a mejorar la salud de mi familia o seres queridos.
16. Las vacunas contra el SARS-CoV-2 deben contribuir a mejorar la salud de la comunidad/población.
17. No quiero seguir usando equipos de protección personal (mascarillas)

Table A3. Items in Portuguese

Eu não deveria tomar as vacinas contra o SARS-CoV-2 porque...
1. Eu penso que elas vão inserir chips/transistores eletrônicos para controlar meu cérebro.
2. Eu penso que as vacinas contra o SARS-CoV-2 fazem parte do plano de uma grande empresa que criou a COVID-19.
3. Eu penso que algumas das vacinas contra o SARS-CoV-2 podem vir de uma ex-república comunista (como a Rússia), o que deve resultar em influências no pensamento comunista.
4. Eu penso que a COVID-19 é uma invenção da Organização Mundial da Saúde (OMS) ou de outras instituições similares.
5. Eu penso que a COVID-19 não existe, é uma invenção.
12. Uma vida saudável é o suficiente para combater as doenças.
13. Não confio no meu sistema de saúde (incluindo os profissionais de saúde).
Eu deveria tomar as vacinas contra o SARS-CoV-2 porque…
14. Quero voltar para minha rotina anterior à pandemia.
15. As vacinas contra o SARS-CoV-2 devem contribuir para melhorar a saúde da minha família ou entes queridos.
16. As vacinas contra o SARS-CoV-2 devem contribuir para melhorar a saúde da comunidade/população.
17. Não quero continuar usando equipamentos de proteção individual (máscaras).