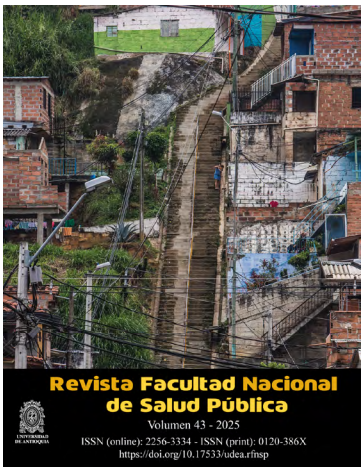

Title: Stairs
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Evidence of validity and reliability of the *Climate and Health Tool* (CHANT): Spanish language version adapted to tropical Latin America

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Objective: To culturally adapt and evaluate the internal structure (evidence of construct validity and internal consistency) of the CHANT scale in spanish, adapted to tropical Latin America, with health professionals from Costa Rica.
Methods: The study was observational and instrumental. The psychometric characteristics of validity (content and construct validity) and reliability of the instrument in Spanish in Costa Rica were analyzed. Data were collected from surveys of 229 health professionals, using snowball sampling stratified by regions of the territory. R-Studio software was used to determine Cronbach's alpha and confirmatory factor analysis.
Results: The internal consistency reliability, assessed by Cronbach's alpha, was 0.88. The five-subscale model was validated by confirmatory factor analysis goodness-of-fit tests (n = 229, Comparative fit index = 0.93; Mean square error = 0.06, Standardized mean square residual = 0.06; Normalized parsimony fit index = 0.74).
Conclusion: The Spanish language version of the T-CHANT shows evidence of construct validity and satisfactory reliability for measuring health professionals' awareness, motivation, concern, and behaviors at work and at home in relation to climate change and health.

---------*Keywords:* climate change, CHANT (Climate and Health Tool) survey, healthcare workers, psychometrics, instrument and test validatio.

* This study is part of the doctoral research project entitled “Planetary health literacy for health professionals considering climate change”, developed within the framework of the Doctorate in Natural Sciences for Development (DOCINADE), a joint program of the Instituto Tecnológico de Costa Rica, the Universidad Nacional and the Universidad Estatal a Distancia. The research project began in January 2023 and is currently underway.

Evidencia de validez y fiabilidad de la *Climate and Health Tool* (CHANT): versión en español adaptada a la zona tropical latinoamericana*

Resumen

Objetivo: Adaptar culturalmente y evaluar la estructura interna (evidencia de validez de constructo y la consistencia interna) de la escala CHANT en idioma español, adaptada a la zona tropical latinoamericana, con profesionales sanitarios de Costa Rica.
Métodos: El estudio fue observacional e instrumental. Se analizaron las características psicométricas de la validez (de contenido y de constructo) y la fiabilidad del instrumento en español en Costa Rica. Se recopilaron datos de encuestas realizadas a 229 profesionales de la salud, mediante muestreo de bola de nieve estratificada por regiones en el territorio. Se utilizó el programa R Studio para determinar el alfa de Cronbach, y el análisis factorial confirmatorio.
Resultados: La fiabilidad de la consistencia interna, evaluada mediante el alfa de Cronbach, fue de 0,88. El modelo de cinco subescalas fue validado mediante pruebas de bondad de ajuste del análisis factorial confirmatorio (n = 229, Índice de ajuste comparativo = 0,93; Error cuadrático medio = 0,06, Residuo cuadrático medio estandarizado = 0,06; Índice de ajuste de parsimonia normalizado = 0,74).
Conclusión: La versión T-CHANT presenta evidencia de validez de constructo y una fiabilidad satisfactoria para medir la concienciación, la motivación, la preocupación y los comportamientos en el trabajo y en el hogar de los profesionales sanitarios en relación con el cambio climático y la salud.

----------*Palabras clave:* cambio climático, encuesta CHANT (Herramienta Clima y Salud), personal de salud, psicometría, validación de instrumentos y pruebas.

Evidência de validade e confiabilidade da Ferramenta de Clima e Saúde (CHANT): versão em espanhol adaptada para a zona tropical latino-americana

Objetivo: Adaptar culturalmente e avaliar a estrutura interna (evidência de validade de construto e consistência interna) da escala CHANT em língua espanhola, adaptada à zona tropical latino-americana, com profissionais sanitários da Costa Rica.
Métodos: O estudo foi observacional e instrumental. Analisaram-se as características psicométricas da validade (de conteúdo e de construto) e a fiabilidade do instrumento em espanhol na Costa Rica. Coletaram-se dados de enquetes realizadas a 229 profissionais da saúde, por médio de amostragem de bola de neve estratificada por regiões no território. Foi utilizado o programa R Studio para determinar o alfa de Cronbach e a análise fatorial confirmatória.
Resultados: A fiabilidade da consistência interna, avaliada por meio do alfa de Cronbach, foi de 0,88. O modelo de cinco subescalas foi validado por meio de testes de bondade de ajuste da análise fatorial confirmatória (n = 229, Índice de ajuste comparativo = 0,93; Error quadrático médio = 0,06, Resíduo quadrático médio padronizado = 0,06; Índice de ajuste de parcimônia normalizado = 0,74).
Conclusão: A versão da T-CHANT apresenta evidência de validade de construto e uma fiabilidade satisfatória para mediar a conscienciação, a motivação, a preocupação e os comportamentos no trabalho e no lar dos profissionais sanitários em relação com a mudança climática e a saúde.

----------*Palavras-chave:* mudança climática, enquete CHANT (ferramenta de clima, saúde e enfermagem), pessoal de saúde, psicometria, validação de instrumentos e testes.

Introduction

Climate change represents a significant threat to public health, as several studies have pointed out [1-3]. Despite this reality, many Latin American countries, including Costa Rica, lack comprehensive assessments in the health sector, limiting the ability to implement improvement actions [4]. From the perspective of planetary health, which encompasses both human well-being and the integrity of natural systems [5], climate change emerges as a force that is pushing some of the planet's environmental situations to the limit [6].

Climate change is defined as a global phenomenon, characterized by a significant and sustained rise in the average temperature of the planet, as well as by long-term changes in weather patterns, with potentially severe consequences for the environment, biodiversity and human societies [7].

Climate change impacts health and well-being in various ways: increasing unmet basic needs, escalating the prevalence of zoonotic diseases, altering epidemiological patterns due to extreme weather events, reducing food availability by disrupting agricultural production, and raising the incidence of cardiovascular and respiratory conditions.

In addition, the economic stability of countries and the capacity of health systems to respond resiliently to emerging collective needs are compromised.

Addressing these health needs is intrinsically linked to the United Nations Sustainable Development Goals (SDGs), as mentioned by Fallah *et al.* [8], particularly SDG 3 (Good health and well-being), SDG 12 (responsible consumption and production) and SDG 13 (climate action), as well as promoting partnerships for the achievement of these goals (SDG 17).

According to McKinnon *et al* [9], health professionals must expand their roles beyond clinical care to actively promote planetary sustainability, given the current complexities of the world. This involves addressing emerging public health demands driven by climate change and recognizing planetary effects on various human activities [10].

Camacho and Jaimes [12] note that pro-environmental attitudes and behaviors can help minimize environmental risk factors and enable health professionals to perform effectively inreal and changing situations. Therefore, assessing these attitudes and behaviors is crucial to determining whether professionals are prepared to address the emerging needs of human and planetary health caused by climate change [10] Conversely, if some gaps are identified, some proposals to foster these competences should be established.

Environmental education plays a crucial role in the practice of health personnel to promote sustainability and climate action. As highlighted by Álvarez-García *et al* [11], specific knowledge, practices and attitudes are required to address the issue of planetary health education.

Environmental knowledge involves understanding the foundations that guide individual attitudes and behaviors towards the environment. In this sense, *environmental attitudes* can be considered indicators of people's ecological behavior, as they reflect personal patterns based on values, beliefs, perceptions, and awareness regarding the need to protect, preserve, or improve the natural environment [13, 14].

These attitudes, however, are not directly observable or measurable in isolation, but are interpreted through their components [14]. These include: the *cognitive component*, which encompasses knowledge and beliefs about environmental issues; the *affective component*, which refers to feelings or emotions towards the attitude object; and the *behavioral component*, which includes predispositions or intentions to act in relation to that object. Analyzing these components enhances our understanding of environmental behavior and the factors that condition it.

Attitudes are closely related to behavior, as they can influence both collective and individual behaviors. Consequently, a positive attitude often results in favorable behaviors towards the environment, which makes it possible to infer and measure the behavioral component from observations.

However, some studies [14-16] report that the link between attitudes and behaviors does not ensure that these behaviors are put into practice, since the correlations of the studies give results that are usually low, which motivates the analysis of mediating or moderating variables. The influence of sociodemographic (gender, ethnicity, age, income, educational level, etc.), methodological (design and type of research), contextual (physical, social, political and economic environment), psychosocial (influences related to the social environment and individual psychological processes) and cognitive (knowledge, beliefs, selective attention, perceptions, etc.) factors that may influence the magnitude or direction of this relationship are studied.

In addition to these, there are other intervening elements that affect the relationship between attitudes and behaviors. These refer to the degree of information that people have about the specific actions they should take to guide their behavior, as well as their knowledge about possible strategies to solve specific problems [15,16]. This includes both understanding environmental actions and having the necessary skills to implement them. Assessing this knowledge, along with attitudes and practices provides a foundation for designing literacy programs, aimed at health professionals, for the construction of the necessary capacities in the face of the climate crisis.

In the search for a tool to assess knowledge, attitudes and behaviors related to climate change and health, the CHANT (Climate and Health Tool) survey emerged as a suitable instrument [17,18]. This tool was chosen thanks to its sound theoretical basis and to its development from conceptual models integrating climate change, health and determinants [17]. Furthermore, data collected using this tool supports the design of educational interventions. These interventions can later inform the development of a literacy strategy, as proposed in the doctoral research project mentioned earlier, as recommended by its authors Winquist *et al* [19].

However, no validated or feasible Spanish-language version of the CHANT survey was available, and adaptation to the Central American context was necessary. Therefore, the objective of the study was to culturally adapt and evaluate the internal structure (evidence of construct validity and internal consistency) of the Spanish version of the T-CHANT scale, adapted for the tropical Latin American region, with health professionals from Costa Rica. This tool will contribute to strengthen professional competencies and to better prepare the health sector to face the challenges derived from climate change in the tropics.

Methods

This section outlines the design of the study, population and sample, the sampling procedure, the data collection technique and the instrument used, including the corresponding modifications. The procedure followed for the processing and data statistical analysis is also described.

Study design

The study follows a cross-sectional observational, instrumental design [20], aimed at analyzing the psychometric characteristics of the adapted instrument. A quantitative approach was used to conduct the statistical evaluation.

The study was carried out in three phases: the first phase consisted of the adaptation of the existing Spanish translation and subsequent cultural adaptation; the second phase included data collection; and then, during the third phase, the statistical evaluation of the internal structure was carried out, evaluating the evidence of construct validity and internal consistency of the T-CHANT scale.

Population, type of sampling and sample

The study population consisted of *health professionals*, defined as those with specific training and education in disciplines dedicated to preventing or treating a disease as well as promoting health or improving the health of humans and animals [21].

A non-probabilistic convenience sampling method was used, employing a stratified snowball technique in Costa Rica, from a key person across regions: Central, Pacific, Huetar Norte, Brunca, Chorotega, and Huetar Atlántica.

Based on methodological recommendations for factor analysis, a minimum sample size of 220 participants was established [22]. There were 246 participants; however, 229 people with complete responses were included in the confirmatory analysis.

The sample inclusion criteria were: 1) voluntariness of participation, 2) practice of a health profession, 3) active practice of the profession in Costa Rica.

The sample had a diverse distribution in terms of age, sex and profession (see Table 1). Most of the participants were aged 30-39 years of age, representing 49% of the sample. There was a higher proportion of women, accounting for 63% of the participants. Regarding the profession, most of the participants come from the discipline of nursing. The predominant academic level among the participants is bachelor's degree, with 67% of the total sample, followed by master's degree, representing 28%.

Table 1. Absolute and relative frequency of participants (n = 229).

Variable		n (%)*
Age group (years)	20-29	26 (15)
	30 -39	87 (49)
	40- 49	40 (22)
	50- 59	19 (11)
	60 or older	7 (3)
	Unknown	50
Sex	Male	66 (37)
	Female	112 (63)
	No answer	1 (0)
	Unknown	50
Occupation	Nursing	62 (35.4)
	Pharmacy	7 (4.0)
	Medicine	32 (18.3)
	Microbiology	4 (2)
	Nutrition	3 (1.7)
	Dentistry	26 (14.9)
	Other health professional	14 (8.0)
	Psychology	3 (1.7)
	Therapies	3 (1,.7)
	Social work	19 (10.9)
	Veterinary	2 (1.1)
	Unknown	54

Variable		n (%)*
Academic degree	Baccalaureate	1 (0.6)
	Doctorate	4 (2.2)
	Bachelor's degree	120 (67)
	Master's degree	49 (28)
	Technician	4 (2.2)
	Unknown	51

* Percentages were calculated excluding blank responses, categorized as "Unknown".

Data collection technique and instrument

The first stage involved the linguistic adaptation of the Spanish-translated version of the instrument, adjusting it to the most commonly used and comprehensible expressions, lexicon and idiomatic uses for the local population [23]. This process aimed to ensure the cultural relevance and clarity of the instrument. Subsequently, a pilot test was carried out, with the participation of a group of health professionals, who qualitatively evaluated the items of the instrument, providing suggestions and observations that allowed the content validity to be strengthened.

Data collection was carried out between January and May 2024, through the virtual platform QualtricsXM, provided by Washington State University. The questionnaire was distributed via e- mail, and the researcher had explicit authorization from the first author of the instrument for its use.

The second phase involved the statistical analysis of the data obtained to assess reliability and construct validity, which is described in the section "Statistical processing and analysis".

Instrument

The tool used was the Spanish version of the CHANT survey. This questionnaire assesses awareness, motivation, concern, work behaviors and home behaviors among health professionals [17]. The original scale, developed in 2017, through expert interviews, is based on a five-factor model with 22 Likert-scale items (rated from 1 to 5). It also includes sociodemographic variables and additional questions covering experience, optimism and communication. The composition of the complete instrument is presented in Annex 1.

Psychometric evaluations were previously conducted in 2019 and 2021. ; the five subscales demonstrated acceptable reliability , with Cronbach's alpha coefficients ranging from 0.67 to 0.91. The instrument has been translated into Spanish, Portuguese and Italian, and its reliability has been evaluated in English [19] and Korean [23]. In addition, it has been used in studies mainly in the United States [24,25]. The Spanish version adapted to the Latin American tropical region was named T-CHANT.

Statistical processing and analysis

Following the methodology used by Winquist et al. [19], a confirmatory factor analysis (CFA) was conducted based on the hypothesized five-factor model. The instrument's structure was assessed using CFA [26], along with Cronbach's alpha to evaluate internal consistency [27]. CFA tests the validity of the model by comparing it with empirical data and analyzing goodness of fit [28]. The phases included: 1) model specification, 2) identification, 3) parameter estimation, 4) model fit assessment, 5) interpretation, and 6) specification, grounded in theory and previous exploratory factor analysis [29].

All statistical analyses were conducted using R version 4.3.3 [30]. and RStudio version 2024.4.0.735 [31]. The libraries semPlot version 1.1.6 [32], gt version 0.10.1 [33] and gtsummary version 1.7.2 [34] were also used for the creation of figures and tables with standardized results. For each T-CHANT item, the mean, standard deviation, skewness and kurtosis were calculated.

Five recommended performance indicators [28,35] were analyzed in the goodness of fit assessment. These include the following indicators that, according to Manzano [36], provide the necessary information to assess a model:

χ^2 (chi-squared): A p-value > 0.05 indicates a good fit, supporting the null hypothesis that model errors are zero. However, results are sensitive to sample size [37].

Comparative Fit Index (CFI): comparing in a general way the estimated five- factor model with the null model is important, as this indicates independence between the variables studied [28]. Values close to one indicate the extent to which the specified model is better than the null model; however, values >0.80 are acceptable [38].

Root Mean Square Error Approximation (RMSEA) *Index*: estimates how well the model fits the population [36]. Values < 0 indicate good fit; however, values up to 0.10 can be accepted, but an indicator close to zero is desirable [36-38].

Standardized Root Mean Square Residual (SRMR): indicates whether the proposed theoretical model fits the empirical data. The value can vary between 0 and 1, where a lower value indicates a better model fit. Results < 0.08 suggest good fit [35].

Parsimony Normed Fit Index (PNFI): this index adjusts the NFI indicator as a function of the degrees of freedom and evaluates the relationship between the quality of the fit and the complexity of the model, penalizing more complex models [39]. The NFI threshold varies between 0 and 1, where values close to 1 indicate a better fit [38,39].

Cronbach's alpha was used to measure the internal consistency and reliability of each factor, considering a score of 0.70 or higher as adequate [27,28,40].

Ethical considerations

This research study was conducted in accordance with the provisions of the Costa Rican Biomedical Research Regulatory Law [41], as well as in compliance with the ethical principles contained in applicable international treaties and declarations, including as the Declaration of Helsinki [42]. The study protocol was evaluated and approved by the Scientific Ethical Committee of the NationalUniversity (Oficio UNA-CECUNA-OFIC-067-2024), guaranteeing respect for the rights, dignity and well-being of the participants.

Prior to data collection, all participants provided informed consent, confirming their voluntary participation and the confidentiality of their responses.

Results

This section presents the main findings of the process to demonstrate the validity and reliability of the instrument. It begins with a summary of modifications made to the original tool, followed by an analysis of the scale's reliability using relevant statistical methods. Lastly, the goodness-of-fit of the T-CHANT scale is presented, confirming the adequacy of its factor structure for the target health professional population.

#2 Adjustments to the original instrument

A comprehension verification process was conducted with a team of experts in health research, as outlined in the "Methods" section, with the aim of ensuring semantic clarity and cultural relevance of the statements in the national context.

This process included both individual and group review of the items, focusing on linguistic appropriateness, familiarity of terminology for the target population, and consistency with the underlying theoretical construct.

Cultural adaptation primarily was applied to items related to diseases. The original version referenced infectious pathologies prevalent in the United States; these were modified to include climate-sensitive infectious diseases common in tropical regions. For example, in the "Awareness" factor, the item was adapted to: "Climate change increases the possibility of adverse health conditions, such as heat stroke, asthma exacerbation, dengue fever or others".

Likewise, the item related to emissions generated by the health system, which originally referenced the U.S. context, was reformulated to: "The health system is responsible for approximately 5% of the total global greenhouse gas emissions that contribute to global warming", in order to represent the sector in global terms and not a particular country.

Regarding items addressing personal experiences and the frequency of observation of certain events, the response option was modified to: "Vector-borne disease, such as dengue, zika, chikungunya, malaria, among others", to better align with local epidemiological conditions (see Annex 1).

In addition, the sociodemographic questions were adapted to the national context, specifically in the variables "basic profession", "academic degree" and "ethnic group", and the variable "canton of residence" was incorporated.[†] The final question on affiliation to the "Alliance of Nurses for Healthy Environments" association was removed as it was not applicable.

All other items remained unchanged, retaining the wording of the original version of the instrument.

Summary measures of the T-CHANT instrument

The symmetry of the data was specified, where a value between− 0.5 and 0.5 indicates an approximately symmetrical distribution; values between ±0.5 and ±1.0 , indicate a slight symmetry, and higher values indicate considerable asymmetry [36]. Results reveal asymmetry in the factors "concern" and "motivation", as well as in two items under "work behaviors" (see Table 2). Regarding kurtosis, most items demonstrated leptokurtic distributions, indicating a high concentration of extreme values.

Reliability analysis of the scale

Regarding reliability, the scores per factor analyzed through Cronbach's alpha indicate that the construct is sufficiently measured, although there are some exceptions with results below the acceptable threshold (0.70).

The psychometric instrument presents satisfactory levels of reliability for the following factors: awareness (Cronbach's alpha = 0.82), concern (Cronbach's alpha = 0.87), motivation (Cronbach's alpha = 0.90) and behaviors at home (Cronbach's alpha = 0.73). However, the factor behaviors at work has a Cronbach's alpha of 0.69, which is below the acceptable standard. In addition, when analyzing the overall test scores, a Cronbach's alpha of 0.88 was obtained (see Table 3).

[†] The political division of Costa Rica consists of provinces, cantons and districts.

Table 2. Descriptive statistics and factor loadings of the items of the 5-factor T-CHANT model (n = 229).

	Descriptive		Factor loadings				
Question	Mean (SD)	Asymmetry/Curtosis	Level of consciousness	Concern	Motivation	Behaviors at home	Behaviors at work
The planet has warmed considerably since the 1850s, resulting in climate change	4.0 (1.0)	−1.0/0.7	0.65				
The warming causing climate change is mainly caused by human behaviors that emit greenhouse gases (GHGs) into the atmosphere (such as the use of gas and coal for electricity and heat buildings, fuel for transportation, and modern agriculture)	4.2 (0.9)	−1.1/0.7	**0.78**				
The healthcare sector contributes about 5% of the total global greenhouse gas emissions that fuel global warming.	2.7 (1.3)	0.2/− 1.2	0.53				
Climate change raises the risk of negative health outcomes , such as heat stroke, asthma exacerbations, dengue fever and others	4.1 (1.1)	−1.2/0.7	**0.80**				
Certain vulnerable populations, such as the very young or elderly, and other at-risk groups (homeless or poor, communities of color, etc.), are more likely to suffer from adverse health effects of climate change.	4.0 (1.1)	−1.1/0.7	**0.81**				
Health effects	4.3 (0.9)	**−1.6/3.1**		**0.78**			
Economic impacts (e.g. rebuilding after natural disasters, health care costs, etc.)	4.1 (1.0)	−1.1/1.1		**0.78**			
General impact on you, your family, or someone you know today	4.0 (1.0)	−1.0/0.7		**0.78**			
Overall impact on future generations	4.4 (0.9)	**−1.9/3.2**		**0.75**			
Changes to the planet (other species, forests, oceans, etc.)	4.5 (0.7)	**−2.1/5.8**		**0.72**			
I want to change my practice to help reduce GHG contributions	4.0 (1.1)	−1.0/0.3			0.75		
I want to teach my patients/clients/community members how climate change affects health	4.0 (1.1)	−1.2/1.0			0.94		
I want to prepare for the effects of climate change on health in my workplace	4.1 (.,1)	−1,3/1.2			0.92		

	Descriptive		Factor loadings				
Question	Mean (SD)	Asymmetry/Curtosis	Level of consciousness	Concern	Motivation	Behaviors at home	Behaviors at work
Using non-fossil fuel-based energy sources (e.g., wind or solar power, geothermal, carbon offsets, etc.)	2.2 (1.3)	0.7/− 0.9				0.30	
Conserving energy (e.g., using low consumption appliances, maintaining moderate temperatures, turning off lights, etc.)	4.1 (0.9)	−0.9/1.1				0.68	
Consuming less gasoline (driving fuel-efficient vehicles, reducing unnecessary trips, cycling and walking, etc.)	3.4 (1.1)	−0.3/− 0.7				0.68	
Reducing waste (buying less, reusing more, recycling and composting more)	3.9 (1.0)	−0.6/− 0.3				**0.78**	
Choosing foods that require fewer resources to grow/produce (local, seasonal, less animal products, less packaging)	3.3 (1.1)	−0.3/− 0.5				0.69	
Saving energy (turning off lights and electronic devices, etc.)	4.0 (0.9)	−0.9/0.6					**0.73**
Commuting to work using active transportation (cycling, walking), shared or public transport	2.8 (1,4)	0.2/− 1.3					0.52
Reducing waste (plastic, paper, clothing, clinical materials, etc.)	3.8 (1.0)	−0.6/− 0.1					**0.76**
Ask those in charge of your workplace to support policies, products or processes that emit fewer greenhouse gases (GHGs)	2.8 (1,3)	0.1/− 1.1					0.52

SD: Standard deviation.

Table 3. Cronbach's alpha by factor and overall (n = 229)

Factor	Cronbach's alpha	Mean	Standard deviation	Skewness	Kurtosis
Awareness	0.82	3.81	1.23	−0.89	−0.16
Concern	0.87	4.26	0.93	−1.45	2.12
Motivation	0.90	4.02	1.08	−1.16	0.86
Behavior at home	0.73	3.36	1.26	−0.45	−0.80
Behaviors at work	0.69	3.36	1.30	−0.41	−0.95
Global result	0.88	3.76	1.22	−0.83	−0.25

Evidence of construct validity by confirmatory factor analysis

Whether the items accurately reflect the theoretical constructs they aim to measure, CFA was conducted to test hypotheses about the factor structure based on existing theory [19]. The results of the factor loadings, variances and covariances are presented in Figure 1.

Acceptable relationships between the items and the factors of the tool are evident, as most show moderate to high values. Regarding the variances, most of the results indicate a remarkable variability in responses, suggesting that the items are adequately capturing the differences in the construct evaluated, and the associated error is relatively low in all cases. Similarly, the results show a *p-value* < 0.001, indicating that the variability observed in the items is not attributable to chance.

When examining the covariances between the factors, all relationships are positive and significant. This provides robust evidence that the observed relationships between the factors are not due to chance and that the factors are correlated within the population studied.

Goodness of fit

Table 4 summarizes the results of the most common indicators reported in the literature: chi-squared, degrees of freedom, comparative fit index, confidence interval, mean squared error approximation, normalized mean squared residuals, and parsimonious index. As shown, each indicator meets the expected thresholds described in the Methods section.

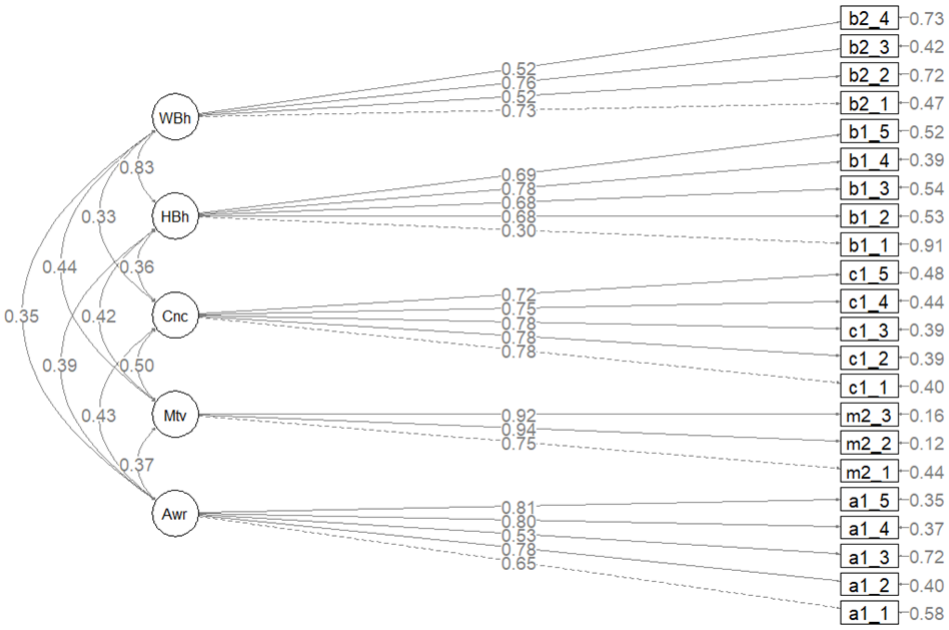

Figure 1 Plot of the confirmatory factor analysis of subscales and T-CHANT factors. The latent factors are: WBh: Work behaviors; HBh: Home behaviors; Cnc: Concern; Mtv: Motivation; and Awr: Awareness.

Table 4. Goodness of fit indices for the pentafactorial model of T-CHANT

Model	χ^2	df	*p*-value	CFI	RMSEA	90 %CI RMSEA	SRMR	PNFI
Observed	377.05	199	<0.001	0.93	0.06	0.05-0.07	0.06	0.74
Expected*	-	-	>0.05	>0.90	<0.06	-	<0.08	>0,.0

*According to the literature cited.

χ^2: Chi squared; df: Degrees of freedom; CFI: comparative fit index; CI: confidence interval; RMSEA: root mean square error approximation; SRMR: normalized root mean square residuals; PNFI: parsimonious index.

Discussion

The T-CHANT subscales model demonstrates high internal consistency reliability, as measured by Cronbach's alpha [41], showing satisfactory levels in the factors of conscientiousness, concern, motivation and behaviors at home. Behaviors at work falls slightly below the acceptable limit (Cronbach's alpha = 0.69), which can be interpreted as questionable in terms of reliability. However, this value is not far from the ideal threshold generally accepted in the literature [27,28,40].

Ferrando *et al* [39] suggest several possible causes for such a result: 1) the items may not be sufficiently related or redundant in their content; 2) they may reflect different aspects of the construct instead of a single cohesive factor; and 3) a small number of items may have a lower score. In this case, option 3) may be applicable, since the "work behaviors" factor is composed of a limited number of items. Although this size may influence the reliability coefficient, it is also relevant to consider that two of these items present factor loadings of 0.52, which could be contributing additionally to the observed result.

The resulting factor loadings show an acceptable relationship. Except for the latent factor "Work behaviors" and the item "Use energy sources not based on fossil fuels", which suggests a weak association (0.30). The literature suggests that items with loadings below 0.40 should be modified or removed, which applies to item 16 in this factor [43]. Notably, Jung et al. [23] found similar results, suggesting that this factor should be re-evaluated, as its performance has been suboptimal since the instrument's development in 2021. Despite this, all factor loadings are statistically significant, meaning they significantly contribute to their respective constructs.

Furthermore, the five-factor model demonstrates good data fit, as it meets the assumptions commonly reported in the literature [36-39]. This confirms the construct validity of the scale, indicating that the items adequately measure the theoretical factors proposed by Schenk *et al* [17].

When comparing the goodness-of-fit of the model with previous validations in other languages, similar results to those obtained by Winquist *et al* [19] are observed. However, it is worth mentioning that, in Korean research, the K-CHANT proposal achieves better indices by eliminating two of the initial items [25]. Regarding RMSEA values, some authors accept values below 0.05, while others suggest considering a good fit with values below 0.06 [35,38,40]. Therefore, the interpretation of the value obtained will depend on the criteria adopted for its interpretation; in this case, the second option was selected.

One limitation of the analysis is the treatment of Likert-type items as continuous variables under the assumption of multivariate normality.

. Both the original five-factor model and the prior validations adopted this approach, so this methodology is maintained to ensure the comparability of the results. However, a sensitivity analysis using the polychoric matrix and treating the items as ordinal was conducted. This analysis showed that the significance of the factor loadings was maintained, and improvements were observed in the goodness of fit indicators. However, to implement it, it was necessary to collapse the two lower categories of the "concern" factor, to ensure at least one observation in each category of the scale, which departs from the original design. It is recommended that future studies address the analysis of items as ordinal variables with a larger sample size.

The T-CHANT survey is a reliable and robust instrument fo assessing awareness, concern, motivation, and climate-related behaviors at home and in the workplace among healthcare workers. From a planetary health perspective, these findings can support climate literacy initiatives within the health sector. It is anticipated that the results obtained through the application of this instrument at the institutional, local and national levels can contribute to the development of public and environmental health programs and policies, as well as to the training and continuing education of health personnel in Costa Rica. Given the similar regional context, this

instrument could also be suitable for use in other Central American and Spanish-speaking Caribbean countries

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The authors declare that they have no conflicts of interest.

Declaration of responsibility

It is declared that the views expressed are the responsibility of the authors and not of the institutions in which they work.

Declaration of contribution by authors

Ericka Murillo devised, posed, formulated and justified the research question, based on a literature search; she worked on drafting the manuscript and the discussion. *Diego Leal* led the statistical analysis and discussion, as well as the revision of the manuscript for publication.

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Annex. Climate and health tool adapted to the tropics (T-CHANT).

Distribution of items.

Sociodemographic:

D1 Select your base profession.

- Dentistry
- Nursing
- Medicine
- Pharmacy
- Social work
- Psychology
- Professional therapy (physical, respiratory, occupational, speech)
- Microbiology
- Veterinary medicine
- Nutrition
- Other healthcare professional

D2 If not listed above, please specify your profession

D3 This question is about educational level; select the highest academic degree obtained.

- Bachelor's degree
- Master's degree/ Specialist degree
- Doctorate
- Post-doctorate
- Baccalaureate

D4 How many years have you worked as a health professional?

Options 0 to +45.

D5 What is your current professional role?

- Direct patient care
- Community/Public health
- Administration/Leadership
- Quality/Research
- Faculty/Teaching
- Retired
- Student

D6 What is your primary professional field?

- Hospital / Acute care
- Ambulatory care
- Long-term care
- Community setting
- College or educational institution
- Institute/University
- Government sector
- Non-profit organization
- Business/Entrepreneur
- Retired
- Other

D7 Please complete this sentence: I identify myself as

- Male
- Female
- Transgender
- Other
- I prefer not to answer D8 What is your ethnic background?
- Afro-descendant
- Asian
- Indigenous
- Caucasian/White
- Prefer not to answer Other

D9 What is your current age?

D10 Enter the name of the canton of the country in which you reside.

D11 Anonymous code (if provided)

Aw1 Awareness

A1. Please indicate your level of familiarity with the following evidence-based statements.

- A1_2 The warming which causes climate change is due in large part to human behaviors which add greenhouse gases (GHGs) to the atmosphere (such as use of gas and coal to create electricity and heat buildings, fuel for transportation, and modern agriculture)
- A1_3 Healthcare sector contributes about 5% of the total global greenhouse gas emissions linked to climate change.
- A1_4 Climate change increases the risk of negative health outcomes, such as heat stroke, asthma exacerbation, dengue fever or others.
- A1_ 5 Vulnerable populations such as the very young or elderly, and other at-risk groups (homeless, low-income, minorities, etc.), experience more adverse health impacts due to climate change.

Scaling points

1. Not at all familiar
2. Slightly familiar
3. Somewhat familiar
4. Relatively familiar
5. Extremely familiar

A2 I have heard about climate change from these sources (select all that apply)

Options

a. Print media
b. TV news
c. Social media
d. Internet
e. Professional courses
f. Professional organizations
g. Friends or family
h. Other:
i. Never heard of climate change

Ex1 Experience

How often have you noticed the following climate-related events in your area?

a. Extreme heat
b. Heavy precipitation
c. Droughts
d. Flooding
e. Hurricanes and storm surges
f. Wildfires Scale points
1. Never
2. Rarely
3. Occasionally
4. Frequently
5. Very often

Ex2b For this group, how often are you seeing these conditions?
Myself/Family/People I know:
Statements

- Respiratory problems, such as asthma, allergies, or worsening chronic obstructive pulmonary disease.
- Vector-borne disease, such as dengue, zika, chikungunya, malaria, among others.
- Extreme heat illness
- Physical trauma related to severe storms or fires.
- Mental health problems such as depression, stress, anxiety, or trauma.

Scale points
1. Never
2. Rarely
3. Occasionally
4. Frequently
5. Very often

Ex2c For this group, how often are you seeing these conditions?
People I read or hear about, but don't know personally

- Respiratory problems, such as asthma, allergies, or worsening chronic obstructive pulmonary disease.
- Vector-borne disease, such as dengue, zika, chikungunya, malaria, among others.
- Extreme heat illness
- Physical trauma related to severe storms or fires.
- Mental health problems such as depression, stress, anxiety or trauma.

Scale points
1. Never
2. Rarely
3. Occasionally
4. Frequently

Cnc Concern
C1 How concerned are you about the following, as they relate to climate change? Please indicate how true the following statements are for you.
Statements

- C1_1 Health-related consequences
- C2_2 Financial impacts (rebuilding after storms or fires, treatment/health costs, etc.)
- C1_3 Overall impacts on you and your family, or someone you know today.
- C1_4 Overall impacts to future generations
- C1_5 Changes to the planet (other species, forests, oceans, etc.)

Scale points
1. Not at all
2. Slightly
3. Somewhat
4. Relatively
5. Extremely

Motivation
M1 How optimistic are you that humans will:
Please indicate how true the following statements are for you.
Statements

- M1_1 They will adequately prepare for the impacts of climate change.
- M1_2 Will prevent climate change.

Scale points
1 Not at all
2 Somewhat
3 Possibly
4 Very
5 Extremely
6 Not applicable

M2 The health sector contributes approximately 5% of global greenhouse gases (GHG). Please indicate how true the following statements are for you.
Statements

- M2_1 I want to change my practice to reduce GHG contributions.
- M2_1 I want to teach patients/clients/community members about how climate change impacts health.
- M2_3 I want to prepare for health impacts due to climate change in my workplace.

Scale points
Very untrue for me Somewhat untrue for me
1. Neutral
2. True for me
3. Very true for me
4. Not applicable

M3 The following are reasons I am motivated to address climate change: (Check all that apply)
Options:

1. Personal connection to nature
2. Religion/faith/spirituality
3. Health concerns
4. Economic costs
5. Social justice/inequality
6. Concern for the future
7. Clean air and water
8. Property loss
9. Increased climate severity
10. Worse forest fires
11. Infectious disease
12. Rising sea levels
13. My family
14. To help create healthy communities
15. To live within my ecological footprint
16. To protect the planet
17. Professional obligation
18. To reduce the climate impacts of my work and workplace
19. Not applicable - I am not motivated to take action
20. Other:

M4 The following are reasons I do NOT address climate change to the extent I would like: (Check all that apply)
Options:

1. Fear of losing job
2. National security
3. It costs too much
4. It overwhelms me
5. It is too complex
6. Humans cannot reduce climate change
7. I don't know enough about climate change
8. I don't know what to do
9. Political influences
10. I have more important concerns
11. It is not convenient
12. I prefer to spend my time on other important issues
13. I am too busy
14. I don't feel confident enough to act
15. Not applicable - I do address climate change to the extent that I would like to.
16. Does not apply - I do not want to and am not interested in addressing climate change.
17. Other

Behavior

B1 How often do you perform in the following behaviors at home? Statements

- B1_1 Use non-fossil fuel-based energy sources (such as buying wind or solar energy, geothermal, buying energy offsets, etc.)
- B1_2 Conserve energy (such as use energy efficient appliances, keep moderate temperature settings, turn off lights and electronics, etc.)trips, bike-walk, etc.)
- B1_4 Reduce waste (buy less, reuse more, recycle and compost more)
- B1_5 Choose foods that require fewer resources to grow/produce (local, seasonal, less animal products, less packaged).

Points of scale

1. Never
2. Rarely
3. Sometimes
4. Often
5. Always

B2 How often do you carry out these habits at work: (if you do not work or volunteer in a professional setting, please ignore this question)?
Statements

- B2_1 Conserve energy (such as turning off lights and electronics, etc.)
- B2_2 Commute to work using active (bike, walk), shared, or public transportation B2_3 Reducing waste (plastic, paper, linen, clinical tools, etc.)
- B2_4 Ask your workplace leaders to support policies, products or procedures that create fewer greenhouse gases.

Scale points

1. Never
2. Rarely
3. Sometimes
4. Often
5. Always

B3 How often do you communicate (in person, by phone, email, mail, etc.) about climate change and health with these groups or individuals?
Statements

- Professionally (co-workers, patients, clients)
- Personally (friends, family, neighbors)
- Elected officials or community leaders

Points of scale

1. Never
2. Annually
3. 2-3 times a year
4. Monthly
5. Weekly

F1 Is there anything else you would like to add?