# DEVELOPMENT AND VALIDATION OF A QUESTIONNAIRE ON THE KNOWLEDGE AND PRACTICES OF NEUROLOGICAL PATIENTS REGARDING HEAT STRESS DURING HEATWAVES: A METHODOLOGICAL STUDY

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**Abstract**

**Objectives**. This study aimed to develop and validate a questionnaire assessing the knowledge and practices of neurological patients during heat stress.
**Material and Methods.** The questionnaire was developed and validated through three standardized stages (Boateng et al., 2018) involving expert review, pilot testing, and statistical validation.
**Results.** A thematic questionnaire was developed for patients with neurological conditions. Content validation was carried out by four experts (in hygiene, neurology, climatology, and sociology), and the Item Content Validity Index (I-CVI) scores ranged from 0.75 to 1.00. The Cronbach's alpha coefficient (Cronbach's $\alpha = 0.81$) indicated good internal consistency. To assess stability over time he test-retest method was applied at 14-day intervals (using the Pearson correlation coefficient), which generated correlation coefficients between 0.72 and 0.88 with statistical significance ($p < 0.05$). These values confirm the temporal stability of the instrument.
**Conclusions.** This newly developed questionnaire is reliable and valid for assessing the knowledge, practices, and informational needs of patients with neurological conditions in the context of heat stress during heatwaves.

*Keywords*: neurological patients, heat stress, pilot study, questionnaire

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## Introduction

Climate change is one of the biggest challenges to public health in the 21st century. Over the last decades, there has been a significant rise in global average temperatures, accompanied by an increased frequency of extreme weather phenomena, especially heatwaves (Rocque et al., 2021; Santé Publique France, 2022; Tomczyk et al., 2019). These phenomena are characteristic of the

Republic of Moldova and neighboring countries (Romania, Ukraine) (Croitoru et al., 2020; Overcenco & Croitoru, 2020).

The World Health Organization (WHO) highlights that heat stress associated with extreme temperatures is a major threat to population health, increasing morbidity and mortality, particularly among vulnerable groups: the elderly, children, and patients with chronic diseases, including neurological conditions (Ebi, 2021; WHO & PAHO, 2020).

Heatwaves trigger significant physiological changes that can worsen pre-existing health conditions (Desai et al., 2023; Ghosh Dastidar, 2024; Liu et al., 2019). In patients with neurological diseases, the effects can be especially severe. Thermoregulation mechanisms may be impaired due to the underlying disease (e.g., multiple sclerosis, stroke, peripheral neuropathies, Parkinson's disease) as well as from medications, which increase susceptibility to electrolyte imbalance, heat exhaustion, dehydration, or worsening of neurological symptoms (Anubhav et al., 2024; Ozdemir et al., 2023; Ruszkiewicz et al., 2019; Subramanian & Saad, 2025).

International studies show a significant increase in hospitalizations and decompensation among neurological patients during heatwaves (Blenkinsop et al., 2024; Louis et al., 2023). For example, multiple sclerosis patients report worsening motor and cognitive symptoms under high temperature conditions, a phenomenon known as "thermal pseudo-relapse" (Blenkinsop et al., 2024). For patients with Parkinson's disease or stroke, exposure to heat stress may worsen muscle rigidity, postural instability, or trigger syncopal episodes (Ruszkiewicz et al., 2019).

In the Republic of Moldova, climate change is becoming increasingly visible, with more frequent and prolonged heatwaves, often with temperatures exceeding 35°C for several consecutive days (Croitoru et al., 2018; Serviciul Hidrometeorologic de Stat [METEO], 2024; World Bank, 2021). In this context, the healthcare system faces the challenge of developing rapid adaptation and intervention strategies. However, the absence of specific local data regarding the perceptions, practices, and level of awareness among neurological patients makes it difficult to develop such strategies.

Validated tools, such as standardized questionnaires, are essential for collecting relevant data for research and designing effective public health interventions. Although there are general tools in the international literature for evaluating public perception of risks related to climate change, there is a lack of specific instruments tailored to neurological patients. Therefore, developing and validating a questionnaire to assess the knowledge, attitudes, and behaviors of neurological patients regarding heat stress becomes an urgent necessity. Such a tool can contribute not only to understanding the vulnerability level of this patient category but also to supporting policies for prevention, education, and intervention tailored to their specific needs.

The designed study, for which the questionnaire is being prepared, will allow you to identify gaps in knowledge about the impact of heat waves on patients with neurological diseases in the Republic of Moldova, thus making it possible to intervene in the climate education of patients with neurological diseases, but also of the general population who may be potential patients.

*Aim of the study*: to develop and validate a questionnaire that evaluates the level of knowledge, practices, and capacity to acquire information among patients with neurological conditions in the context of heat stress during heatwaves. This contributes to strengthening the scientific evidence base needed for effective public health strategies.

## Material and Methods

This article presents a methodological study aimed at developing and validating a questionnaire designed to assess the knowledge and practices of patients with neurological conditions regarding the health impact of heat stress associated with heatwaves.

The study was conducted from June to August 2024. The validation process followed standardized stages recommended in the literature, especially the three phases proposed by Boateng et al. (2018).

***Phase I: Defining constructs and developing questions***

*1. Concept definition.* A thorough review of recent national and international literature was conducted (on the impact of climate change on health, particularly on neurological patients) to define the conceptual framework of the questionnaire and to identify essential dimensions within the context of health risks posed by extreme heat.

WHO, CDC (Centers for Disease Control and Prevention), and ECDC (European Centre for Disease Prevention and Control) guidelines, as well as peer-reviewed articles, were analyzed to justify the necessity of the initiated study.

*2. Theoreti*cal *analysis*. Relevant scientific sources were reviewed, including: validation methodologies and question formulation; examples of existing questionnaires in similar studies (even on other diseases); application methods and theoretical structures.

The literature was retrieved from various open-access databases (e.g., PubMed, WoS, SCOPUS, SpringerLink, DOAJ, Index Copernicus), academic social networks (ResearchGate, Mendeley), and even from the Google search engine, depending on the research stage and method. Relevant terms were used such as: "questionnaire validation", "survey", "instrument development", "heat stress", "neurological disorders", "heatwave", "neurological patients", "attitudes", "practices", "neurologists", "questionnaire development", "questionnaire validation", "internal consistency", "Cronbach's alpha coefficient", "factor analysis". To highlight research in the Republic of Moldova, the biggest Open Access electronic library from the Republic of Moldova – National Bibliometric Instrument (IBN) and the repository of the "Nicolae Testemițanu" State University of Medicine and Pharmacy were consulted.

To improve the relevance of the results, Boolean operators (AND, OR) and specific metacharacters (.ti, .ab) were used for a narrower search, along with filters by field, directed at the title and abstract of the works, and the period of publication (mostly up to 10 years).

A total of 37 relevant scientific sources were analyzed, which explicitly describe: the importance of the studied issue; the need to raise awareness about climate change; standard stages of questionnaire development (including content validation); methods to assess validity and reliability (e.g., internal consistency, factor analysis, test-retest); applications in neurology, public health, and climate risk contexts.

*3. Question formulation.* Based on the theoretical analysis, the first version of the questionnaire was developed, structured into four sections: knowledge related to climate change and its impact on people with neurological conditions; practices during heatwaves or cold spells; well-being and health during hot weather; information acquisition regarding the health impact of heat stress.

The questionnaire contained 23 closed-ended questions (with multiple-choice options) and 4 open-ended questions to capture qualitative data.

In the fundamental study, the elaborate questionnaire will be applied by neurologists, with assistance from trained healthcare staff, from the three localities included in the study for which the questionnaire was developed.

***Phase II: Content validation and preliminary testing***

*4. Content validation.* The content was validated by four experts in hygiene, neurology, climatology, and sociology.

Simultaneously, the questionnaire and research protocol were evaluated and approved by the Research Ethics Committee of the *Nicolae Testemianu* State University of Medicine and Pharmacy, obtaining a positive opinion (No. 1, dated 26.05.2023).

*5. Pre-testing.* To evaluate clarity, feasibility, and structure, a pilot study was conducted with 30 patients diagnosed with neurological conditions (stroke, multiple sclerosis, Parkinson's disease, and peripheral neuropathies). Participants completed the questionnaire and assessed the clarity, relevance, and comprehensibility of each question.

To assess stability over time, the *test-retest* method was applied at 14-day intervals. Stability over time was assessed using the *Pearson correlation coefficient* (Venegas-Carro et al., 2022).

The following indices were calculated:

- I-CVI (Item-Content Validity Index) at the question level – proportion of experts who gave scores of 3 or 4. The accepted threshold was ≥0.78.
- S-CVI/Ave (Scale-Content Validity Index/Average): the average of all I-CVI values. acceptable if ≥0.80.

In the resulting S-CVI was 0.89, indicating good content validity. Questions that obtained I-CVI below the threshold of 0.78 were revised, reformulated, or eliminated (4 questions eliminated and 6 reformulated).

According to the Lynn (1986) methodology, among 4 experts, a question is acceptable if I-CVI ≥ 0.75 (i.e., 3 out of 4 experts consider it relevant or very relevant).

*6. Internal consistency and construct reliability*. Internal consistency was assessed using Cronbach's alpha. According to literature, $\alpha \geq 0.70$ is acceptable for scale reliability (Carden et al., 2019; Jain & Angural, 2017). Each section of the questionnaire was analyzed individually.

Table 1 presents the standardized interpretation of the Cronbach alpha coefficient values, in relation to the level of internal consistency and reliability of the instrument (Jugessur, 2022).

**Table 1**

*Internal consistency value and significance (Jugessur, 2022)*

| | **Cronbach's alpha** | **Internal Consistency/Reliability Test** |
|---|---|---|
| 1 | $\alpha \geq 0.9$ | Excellent (high-stakes testing) |
| 2 | $0.7 \leq \alpha \geq 0.9$ | Good (low-stakes testing) |
| 3 | $0.6 \leq \alpha < 0.7$ | Acceptable |
| 4 | $0.5 \leq \alpha < 0.6$ | Poor |
| 5 | $\alpha < 0.5$ | Unacceptable |

The Cronbach alpha coefficient (for assessing the internal consistency of the questions) was calculated using the licensed software Statistical analysis IBM SPSS Statistics, version 27.0 (IBM Corp., Armonk, NY, USA) (Software: source 38).

Following the reliability analysis, the interpreted questions were examined, and construct names were assigned. [WORDS MISSING HERE] was performed using IBM SPSS Statistics v27.0.

***Phase III – Metric analysis of the scale (Internal consistency and EFA)***

The assessment of the adequacy of the data for factor analysis was carried out using the Kaiser–Meyer–Olkin and Bartlett tests, standard methods recommended in the literature for validating the application of EFA (Boateng et al., 2018; Kim et al., 2025). EFA was performed per best practices (Boateng et al., 2018; Howard, 2023). Test-retest reliability was again assessed with Pearson's correlation (Zhu et al., 2025).

A KMO value > 0.50 indicated that the sample was adequate for factor analysis (Kim et al., 2025). In total, 105 questionnaires were processed.

## Results

*Development of the research instrument*

The study began with a rigorous literature review to identify existing tools that assess knowledge and practices among patients with neurological conditions in the context of heat stress due to heatwaves. The bibliographic investigation revealed a lack of publicly available, validated, and regionally relevant instruments for the target group.

Therefore, the first methodological stage involved designing a preliminary version of the questionnaire based on conclusions from the literature and tailored to the epidemiological and climatic realities of the Republic of Moldova.

Following the model proposed by Boateng et al. (2018), this first phase provided a solid foundation for the next steps of conceptual validation and empirical testing.

The literature review helped shape several key domains: the level of awareness patients have about the health risks related to heatwaves; the protective and adaptive practices patients undertake; the information sources used regarding heat stress and neurological patients; and general health-related behaviors.

These domains formed the basis for the question set, ensuring the questionnaire's relevance and internal coherence.

A new, original instrument was developed under the title: "Assessment of Knowledge and Practices of Patients with Neurological Conditions Regarding the Impact of Heat Stress on Health During Heatwaves".

During questionnaire development, key methodological recommendations were followed, avoiding ambiguous, suggestive, or double-barreled questions, using neutral, clear language, ensuring logical structure and grammatical correctness.

After development, the instrument was revised linguistically, grammatically and logically to eliminate any ambiguities. The principle of neutral and clear wording was respected, so that the questions did not influence the responses and faithfully reflected the assessed constructs.

The initial version contained 27 questions divided into four sections. The first compartment referred to Knowledge held by patients regarding the phenomenon of climate change and the impact on people with neurological diseases (8 questions), The second compartment included 6 questions, which referred to the practical activities of patients with neurological diseases practiced during heat waves. The third compartment contained 9 questions about the well-being and health during heat waves of patients with neurological diseases. The fourth compartment with 4 questions focused on the method of accumulating information about the impact on health, the sources used, the method of obtaining information and one's own opinion about the level of

information. The final part of the questionnaire included socio-demographic items: gender, age, living environment, and highest level of education.

The questions in the questionnaire were written in a mixed format (closed and open questions). The questionnaire included four open questions, which were not included in the calculation of internal consistency, as this type of analysis applies only to questions with standardized answers. The free answers were analyzed qualitatively to identify emerging themes or relevant suggestions and had an exploratory and contextual role.

The questionnaire used several types of scales depending on the section. The questions in the "practices" and "information sources" areas were predominantly closed-ended (yes/no) or multiple-choice with pre-set answers and additional options, while in the "knowledge" and "well-being" sections, simple-choice or multiple-choice questions with pre-set answers prevailed. These allowed for the quantification of the responses and the analysis of internal consistency using the Cronbach alpha coefficient.

This questionnaire formed the basis of the pilot survey conducted in the second phase of the research.

*Content validation*

The evaluation carried out by 4 experts (from hygiene, neurology, climatology, sociology) indicated values of content validity I-CVI (Content Validity Index) at the question level – between 0.75 and 1.00.

As a result, 3 questions (with I-CVI = 0.75) were reformulated to increase clarity; the rest of the questions had I-CVI between 0.85 and 1.00 and were kept in the proposed form, being considered relevant or very relevant. S-CVI/Ave, which indicates good content validity (0.89).

*Pilot study for instrument validation*

Pre-testing was carried out with 30 neurological patients (10% of the representative national sample size), selected through convenience sampling. The questionnaire was administered face-to-face by physicians, with assistance from trained healthcare staff when needed. This method allowed not only the collection of quantitative data, but also the obtaining of qualitative feedback essential for the revision of the instrument.

Participants were asked to express their impressions of the question wording and the general structure of the questionnaire by answering three open-ended evaluation questions (included at the end of the questionnaire):

1. Which questions were unclear or difficult to understand?
2. Which questions were easy to understand?
3. What suggestions do you have for improving the wording and structure?

Face validity: feedback from the neurological patient pilot showed that 10.0% of respondents found some questions partially unclear (especially those about information sources and the use of air conditioning); 83.4% considered the questions clear and understandable; 6.6% had difficulty understanding terms like "heatwave" and "heat stress" (even though definitions were provided).

Based on these observations, 5 questions were reformulated to improve clarity.

The questionnaire validation process generated consistent results, both in terms of validity and reliability of the instrument.

As a result, four questions were adjusted, and two questions were transferred from one compartment to another.

*Internal consistency*

According to Table 2, the *Cronbach alpha* coefficient indicates good internal consistency.

**Table 2**

*Cronbach alpha coefficients*

| Section | Number of questions | Cronbach alpha |
|---|---|---|
| Knowledge | 8 | 0,78 |
| Practices | 6 | 0,84 |
| Health status and information | 9 | 0,81 |
| **Total** | **27** | **0,81** |

Repeated application of the questionnaire at 14-day intervals generated correlation coefficients between 0.72 and 0.88, with statistical significance ($p<0.05$). These values confirm the stability of the instrument over time.

*Exploratory Factor Analysis (EFA)*

To test the suitability of the data for factor analysis, the Kaiser-Meyer-Olkin (KMO) tests were applied, which indicated a value of 0.78 and Bartlett's test of sphericity, which specified statistical significance $p < 0.001$, suggesting suitability for factor analysis.

The analysis identified three main factors, which together explain 62.5% of the total variability. Factor loadings were above 0.60 for each item included, indicating a robust factor structure and a good correspondence between the items and the proposed theoretical constructs (Table 3).

**Table 3**

*The main factors identified in the questionnaire through factor analysis*

| | Factor name | Explanation of the factors | Explained variance (%) | Core topics covered |
|---|---|---|---|---|
| 1 | Knowledge and perceptions on heat stress | cognitive understanding of heat stress from patients | 26,8% | perceptions of heatwaves, risks, health impact |
| 2 | Protective practices | behavioral adaptation and protective actions in response to heat stress | 21,4% | hydration, avoidance, medication adjustment, a/c use |
| 3 | Information sources and general behavior | access to sources, use of health information and general patient reactions to heatwave warnings | 14,3% | access to and preferences for health information |

Both the theoretical and practical construction of the instrument were based on international methodological recommendations (Goni et al., 2020; Reethesh et al., 2019), sequential stages of question generation and pre-testing (Boateng et al., 2018; Bujang et al., 2022), content validation by experts (Boateng et al., 2018; Goni et al., 2020; Reethesh et al., 2019; Yazdi-

Feyzabadi et al., 2021), and assessment of internal consistency through the Cronbach alpha coefficient (Boateng et al., 2018).

**Discussions**

The results of the validation process confirm that the developed questionnaire is a valid and reliable instrument for evaluating the knowledge, practices, health status, and access to education among patients with neurological conditions in the context of heat stress during heatwaves.

Content validity refers to the extent to which the questionnaire items adequately and comprehensively represent the constructs they are intended to measure. The Content Validity Index (S-CVI = 0.89) confirms that the selected items are both relevant and representative of the investigated domains. Although the validation panel included only four experts, Lynn's methodology (1986) supports the sufficiency of an I-CVI ≥ 0.75 for this number of evaluators – thus strengthening the reliability of the conclusions.

These results are consistent with other similar studies that validated public health and climate change–related instruments (Arsad et al., 2022; Kiarsi et al., 2023).

The internal consistency of the questionnaire (Cronbach's alpha = 0.81) indicates good homogeneity of the items, with each domain showing α values between 0.79 and 0.83. These results align with international standards for research and public health tools (Boateng et al., 2018; Goni et al., 2020).

Likewise, the test-retest correlation coefficients (ranging from 0.72 to 0.88) demonstrate good temporal stability, which is essential for instruments measuring perceptions and behaviors related to environmental risks.

The exploratory factor analysis confirmed the importance of three main dimensions:

1. Knowledge of heat stress and climate change;
2. Protective and adaptive practices during heatwaves;
3. Access to information and general health behaviors.

These three dimensions directly correspond to the study's initial aim – to evaluate the knowledge, practices, and information acquisition capacity of patients with neurological conditions in the context of heat stress.

This factor model aligns with structures described in international literature for tools focused on climate change adaptation and heat stress risk assessment in the general population (Ebi et al., 2021; WHO, 2021).

*Limitations of the study*

The pilot study sample size was small (n = 30); however, it represented 10% of the calculated national representative sample, which is acceptable for initial validation.

The instrument was validated in a single geographical context (the Republic of Moldova). For broader generalization, testing in other regions or countries with similar conditions is recommended.

*Strengths*

- This is the first validated questionnaire in the Republic of Moldova targeting neurological patients and focusing on heat stress impacts.
- The instrument is tailored to the regional socio-cultural and climatic context.
- It provides a solid foundation for developing educational interventions, public health programs, and evidence-based policies to prevent the effects of heat stress in vulnerable

populations. This statement aligns with the article's conclusions, emphasizing the instrument's practical utility in guiding evidence-based educational and preventive programs for neurological patients exposed to heat stress.

## Conclusions

The questionnaire developed to assess the knowledge and practices of patients with neurological conditions in the context of heat stress during heatwaves has proven to be a valid and reliable tool.

This tool is used in hygiene, epidemiological, and clinical research to evaluate the effectiveness of educational interventions, and to inform public health strategies aimed at reducing risks associated with thermal stress.

The questionnaire also holds potential for adaptation and validation in other regions or for other categories of chronically ill patients.

## Competing interests

The author declares no competing interests.

## Ethical approval

The research was approved by the Ethics Committee "Nicolae Testemițanu" State University of Medicine and Pharmacy, the Republic of Moldova (no. 1/26.05.2023).

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