ONLINE FIRST

This is a provisional PDF only. Copyedited and fully formatted version will be made available soon.

DISASTER AND EMERGENCY MEDICINE JOURNAL

Development and validation of heat wave hazard adaptation tool: a study protocol

Authors: Maryam Kiarsi, Mohammad Mahdi Doustmohammadi, Mohammad Reza Mahmoodi, Nouzar Nakhaee, Armin Zareiyan, Hamidreza Aghababaeian, Mohammadreza Amiresmaili

DOI: 10.5603/DEMJ.a2022.0038

Article type: Study protocol

Submitted: 2022-09-07

Accepted: 2022-11-22

Published online: 2022-11-30

[STUDY PROTOCOL]

DEVELOPMENT AND VALIDATION OF HEAT WAVE HAZARD ADAPTATION TOOL: A STUDY PROTOCOL

Maryam Kiarsi[1, 2], Mohammad Mahdi Doustmohammadi[3], Mohammad Reza Mahmoodi[4, 5], Nouzar Nakhaee[6], Mohammad Reza Mahmoodi[4, 5], Nouzar Nakhaee[6], Armin Zareiyan[7], Hamidreza Aghababaeian[1, 2], Mohammadreza Amiresmaili[3]

[1]Department of Medical Emergencies, Dezful University of Medical Sciences, Dezful, Iran

[2]Center for Climate Change and Health Research (CCCHR), Dezful University of Medical Sciences, Dezful, Iran

[3]Health in Disasters and Emergencies Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran

[4]Physiology Research Center, Institute of Neuropharmacology, Kerman University of Medical Sciences. Kerman, Iran

[5]Department of Nutrition, Faculty of Public Health, Kerman University of Medical Sciences. Kerman, Iran

[6]Health Services Management Research Center, Institute of Futures Studies in Health, Kerman University of Medical Sciences, Iran

[7]Public Health Department. Health in Emergencies and Disasters Department, Nursing Faculty, AJA University of Medical Sciences, Tehran, Iran

ADDRESS FOR CORRESPONDENCE:

Mohammadreza Amiresmaili, Health in Disasters and Emergencies Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran

e-mail: mohammadreza.amiresmaili@gmail.com, phone: +98 3431325396

ABSTRACT

INTRODUCTION: Global warming, climate change, temperature fluctuations, and increasing concern about their possible impacts on health have drawn the attention of scholars and academia around the world. Previous studies suggested heat waves can increase mortality and diseases, the demand for ambulances, hospitalization rates, and severe consequences, especially in vulnerable groups. The most effective measures can be taken by effective planning and providing practical solutions in the mitigation and preparedness stage to prevent and mitigate the effects of disasters. Given the absence of a tool to determine the level of adaptation in the world, this study aimed to identify the strategies to adapt to heat waves and develop a tool to measure the level of adaptation to heat waves.

MATERIAL AND METHODS: This exploratory sequential mixed methods (qualitative-quantitative) study was conducted in three phases. In the first phase, a qualitative study was carried out by conducting interviews with people affected by heat waves. The interview data were used to identify the themes related to adaptation to heat waves and the strategies to adapt to heat waves. In the second phase, a systematic review study was conducted to identify the strategies to adapt to heat waves in the world. Afterward, the data from the qualitative phase and systematic review were used to develop the items in the heatwave adaptation tool. Finally, in the third phase (the quantitative study), the psychometric properties of the developed tool were assessed using face validity, content validity, construct validity, and reliability indexes.

CONCLUSIONS: The developed tool can measure the level of adaptation behaviors of people against heat waves in different communities. Thus, an awareness of less adaptable and more vulnerable communities can contribute to conducting some mitigation and preparedness interventions in these communities.

KEY WORDS: climate change; heat waves; adaptation; tools

INTRODUCTION

Disasters pose severe threats to the life, development, and evolution of human society and disaster risk management requires a systematic process, including executive, and organizational decisions, other capacities to perform policies, strategies, and social capacity to reduce the negative effects and consequences of risks [1–3]. Unexpected incidents and disasters and the resulting damage are increasing due to environmental changes, economic, social, and political factors [3–6]. The excessive use of fossil fuels followed by the expansion of industrial activities has caused an increase in temperature and consequently global warming leading to visible climatic changes in different parts of the world [7]. According to the reports of the International Conference on Climate Change (ICCC), climate fluctuations have increased more than before and have caused phenomena such as unpredictable climate changes, including heat waves [8]. Thus, during the last 100 years, the average temperature on the planet has increased by 0.74 degrees Celsius. Projections show that compared to the period from 1850 to 1900, the average global temperature level until 2081–2100 is likely to increase by 1.0 and 1.8 degrees Celsius in the very low greenhouse gas emission scenario, 2.1 and 3.5 degrees Celsius in the medium greenhouse gas emission scenario, and 3.3 and 5.7 degrees Celsius under the high greenhouse gas emission scenario [9]. In addition, the frequency of extremely hot days will increase and the frequency of extremely cold days will decrease [9].

Global warming currently has significant and costly effects on societies, individual and public health, and the environment [10, 11]. According to previous studies, heat waves lead to an increase in deaths, heatstroke-related diseases, exacerbation of chronic diseases including cardiorespiratory diseases, and an increase in the need for emergency and ambulance services [7–9, 12–15]. Examining the effects of heat waves in the workplace also shows that many outdoor workers are at high risk of adverse health outcomes. In 2018, it was reported that 45 billion working hours were lost compared to the year 2000 due to the effects of the heat wave [16]. Exposure to daily heat during the hot season is a particular issue, especially for working people who cannot use air conditioning or other technical cooling methods [13, 17, 18].

These effects vary in various spatial and temporal patterns depending on the environmental, social, and economic situation of countries [19, 20]. While the frequency or magnitude of extreme weather events such as heat waves have increased, the population and assets at risk have also increased, and they are more vulnerable to these climatic changes. Therefore, the management of risks caused by climate-related disasters should be developed at any local and international scale, and disaster mitigation and preparedness strategies should be identified and offered [12, 21–23]. Adaptation to heat waves is one of these strategies used to reduce the consequences of heat waves [24].

Adaptive behaviors can reduce adverse effects on health and various dimensions of individual and social life. However, adaptation strategies may include autonomous and planned adaptation [25]. Autonomous adaptation occurs without coordinated planning at the individual or social levels, and planned adaptation refers to deliberate policy actions with conscious interventions. Planned adaptation strategies should become a requirement to mitigate the adverse health effects and other consequences of extreme heat events. Heatwave adaptation assessments can address significant gaps in vulnerability and management of heat wave effects [26–29].

Research on disaster management shows that adaptation measures are closely related to risk reduction [30–33]. Adaptive measures are needed to reduce harm from heat waves at all levels and for all groups. To this end, some information is required about the current level of knowledge of the affected community and their adaptation methods against the heat wave. This information can be used as a guide for the necessity or non-necessity of interventions as well as the design of interventions [34]. In fact, when establishing adaptation policies for society, policymakers need to be aware of adaptive behaviors [35].

Although many research efforts have been taken in different parts of the world, none of the studies had used a standard tool to determine the level of adaptation of societies against heat waves, and there is no such tool, and sometimes the level of adaptation has been measured through questionnaires that were not psychometrically evaluated [36–39]. These restrictions make it difficult to draw a complete picture of current public adaptive behaviors [39, 40].

Besides, there have been severe heat waves in recent years in some parts of the world including Iran, especially in areas with a hot climate, such as Khuzestan Province. Thus, from a scientific point of view, natural hazards, including heat waves, which are currently increasing in intensity and rapidly fluctuating due to human actions, need to be managed following a disaster mitigation and preparedness approach. To this end, a tool is needed to measure the level of adaptation of the affected communities. Then, the resulting data can be used to formulate hazard mitigation and preparedness programs for less adaptive areas. Accordingly, one of the top priorities for managing the effects of natural hazards, including heat waves, is to determine the level of adaptation. Such information can help determine resources, facilities, and planning needed to improve adaptation. Moreover, the resulting information can be used to identify adaptation solutions in societies with a higher level of adaptability.

MATERIAL AND METHODS

Research design

This mixed methods (qualitative-quantitative) study was conducted in three consecutive phases (Fig. 1).

Phase 1: Identifying experiences of adaptation against heat waves (the qualitative study)

- **Objective:** This phase followed two objectives: Identifying adaptation strategies against heat waves and defining the concept of adaptation to heat waves (The phase was completed in 2020).
- **Research population:** The research population consisted of residents in Dezful and Ahvaz, who were selected from different age groups, occupations, and related offices and departments including the Department of Meteorology, Department of Agriculture Jihad, Department of Environment, Resources and Forestry, Municipality, and the universities of medical sciences in Dezful and Ahvaz.
- **Sampling:** The respondents were selected using purposive and convenience sampling with maximum dispersion. To achieve this goal, interviews were conducted with people from different occupations and different age groups, and the sampling process continued until the data saturation point.
- **Inclusion criteria:** Being a resident of Dezful or Ahvaz to have experience with heat waves, being 18 years old and above, the willingness to participate in research, and having the time to take the interview.
- **Exclusion criteria:** The unwillingness to participate in the study.
- **Ethical considerations:** The protocol for this study was approved by the Ethics Committee of Kerman University of Medical Sciences (1401.084. IR.KMU.REC).
- **Data collection instrument**: An interview guide form was used to collect data.

- **Data collection method:** The data were collected through semi-structured interviews.
- **Data analysis method:** MAXQDA 18 software was used to codify and analyze data. Colaizzi's seven-step method was used to analyze the data: First, each respondent's statements were recorded, transcribed, and read several times. Significant statements were underlined in the second step. In the third step, a general theme was extracted from each significant statement. In the fourth step, the extracted themes were categorized based on their similarities. In the fifth step, the identified categories were merged into a thorough description of the phenomenon in question, and more general categories were formed. In the last step, the findings were returned to the respondents and they reviewed and validated the findings [41].
- **Data validation (through supplementary interviews):** To ensure that the findings reflect the respondents' real experiences, the four criteria of credibility, dependability, confirmability, and transferability proposed by Lincoln and Guba were used [41].

Phase 2: Identifying solutions to adapt to heat waves in the world (A systematic review)

- **Objective:** The second phase of the study presented a systematic review of studies addressing adaptation to heat waves to discover and identify behaviors and strategies to adapt to heat waves in urban areas (This phase was completed in 2021).
- **Research population:** All English databases or reliable and accessible international databases including MBIS, Web of Science, PubMed, and Scopus, as well as Persian databases, including Iranian Research Institute for Information Science and Technology (IranDoc), Islamic World Science Citation Database (ISC), Iran Publications Database, and the Scientific Information Database (SID) were searched. The search strategy focused on three groups of keywords related to "adaptation" (adaptation, resilience, compatibility, damage reduction, resilient behavior, risk mitigation behaviors), "heat waves" (extremely hot weather and high temperatures), and "global warming and climate change".
- **Research sample:** The research sample included international documents, records, and articles focusing on adaptation measures against heat waves in Persian and English.
- **Inclusion criteria:** All articles whose full text was available, the articles that used suitable methods and data and proposed strategies for adapting to heat waves, the articles

in which heat waves were specifically addressed as a fundamental problem, and the articles on climate change that specifically addressed heat waves were included in this study.

- **Exclusion criteria:** Review articles, letters to editors, proceedings, specialized articles on adaptation to heat waves in animal husbandry, studies on cultivation of special plants and laboratory studies, genetics, and strategies for adaptation to urban heat islands excluding the effects of heat waves were excluded.
- **Research setting:** The articles were collected from libraries, universities, the Internet, and the national intranet.
- **Data collection instrument:** A data extraction form was used to collect data including the research methodology, title, first author, year of publication, research type, research procedure, sampling method, sample size, research setting, data collection instruments, results, and information related to heat wave adaptation solutions.
- **Data collection method:** A systematic review was conducted using the PRISMA 2020 Checklist. Endnote was used to store and organize the articles. After entering all the articles into the software, duplicate articles were identified and removed. Then, two researchers removed irrelevant titles by studying the titles and abstracts of the articles. Finally, after reviewing the full text of the articles, 58 articles were selected from a total of 1529 articles. The remaining 58 articles were individually screened based on the inclusion and exclusion criteria. After removing irrelevant articles, the full text of the remaining articles was searched. Then, the quality of each article was assessed based on a standard format separately by two researchers. In cases of disagreement between the researchers, a third researcher helped to select the most relevant cases. Afterward, the adaptation components and solutions were extracted from the articles using the data extraction form (first author, year of publication, country, results, etc.). After reviewing the results and extracting adaptation strategies, the extracted and classified adaptation strategies were validated through an individual survey of subject-matter experts and a panel of emergency health experts and professionals.
- **Data analysis strategy:** The results of qualitative and quantitative studies extracted through the systematic review were organized and reported in a table.

- **Developing the primary tool (research synthesis):** The heat wave adaptation tool was developed based on the findings of the qualitative phase and systematic review. In this phase, the primary codes extracted from the qualitative phase and the systematic review were categorized based on “adaptation solutions against heat waves”. Then, the items were individually re-examined, and the related categories were carefully identified. Similar items were merged and their relevance was assessed by experts and professors. Furthermore, after removing irrelevant items, an item bank was developed for further validation.

Phase 3: The validation of the heat wave adaptation tool:

- **Objective:** Validating the heat wave adaptation tool.
- **Research population:** People living in Dezful and Ahvaz.
- **Sampling:** The respondents were selected using cluster sampling from the residents in different districts of two cities of Dezful and Ahwar in proportion to their population. The population of Ahvaz was about three times that of Dezful. Ahvaz had eight districts and Dezful had four districts.
- **Inclusion criteria:** Being over 18 years old, resident, and the willingness to participate in the study.
- **Exclusion criteria:** Unwillingness to participate in the study.
- **Research setting:** Dezful and Ahvaz.
- **Data collection instrument:** A structured questionnaire was developed with items scored on a five-point Likert scale to assess the components of adaptation to heat waves.
- **Data collection method:** The respondents were selected using cluster sampling from both cities in proportion to their population. The number of respondents selected from Ahvaz was three times that of Dezful. Dezful had 4 districts. Thus, the number of respondents selected from this city was divided by 4 to determine the number of respondents in each district. The similar procedure was repeated for Ahvaz with 8 districts. To this end, the number of respondents selected from this city was divided by 8 to determine the number of respondents in each district. The questionnaires were completed through street

evaluations. For example, in a district with 3 streets, the questionnaires were divided by 3 and a questionnaire was completed for every three houses or shops in each street.

DATA ANALYSIS

Quantitative face validity assessment

At this phase, after explaining the objectives of the study, 10 respondents were asked to express their opinion regarding the comprehensibility of each item based on a five-point Likert scale (5 — totally comprehensible, 4 — somewhat comprehensible, 3 — moderately comprehensible, 2 — slightly comprehensible, and 1 — very incomprehensible). Afterward, the impact score of each item was calculated using the following formula:

$$\text{Impact Score} = \text{Frequency [\%]} \times \text{Importance}$$

Where frequency (percentage) refers to the number of people who gave a score of 4 or 5 to an item and importance is the average score of importance on the above Likert scale. If the impact score exceeds 1.5, the item will be considered suitable for further analysis [42]. However, the items with a score of less than 1.5 had a high level of difficulty and ambiguity.

Qualitative face validity assessment

Qualitative interviews were conducted with the same respondents who rated the items in the previous stage. They were asked to specify the reason(s) for the incomprehensibility of any item with a score of less than 1.5. Thus, using the feedback from the respondents, the problematic items were revised to make them more comprehensible.

Qualitative content validity assessment

Ten disaster and emergency experts qualitatively assessed the content validity of the checklist. They rated the items in terms of grammar, wording, clarity, classification and scoring, order and importance, and relevance. Afterward, the items were revised based on their feedback. However, no item was removed at this stage.

Quantitative content validity assessment

The content validity of the instrument was assessed quantitatively using the content validity ratio (CVR) and the content validity index (CVI):

A. Estimating the content validity ratio (CVR)

To calculate the CVR, the items were assessed by 10 experts using Lawshe's method. The experts were asked to determine whether each item operationally measured a theoretical construct or not. To this end, each item was rated on a 3-point scale (3 — necessary, 2 — useful but not necessary, and 3 — not necessary) [57]. The experts were different from the respondents surveyed in the qualitative content validity stage. The items with a minimum CVR of 0.62 were considered acceptable.

Table 1. Estimating CVR based on Lawshe's table [43] [please indicate table in text??]

Number of raters	Minimum acceptable CVR
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62
11	0.59
12	0.56
13	0.54
14	0.51
15	0.49
20	0.42
25	0.37
30	0.33
35	0.31
40	0.29

B. Estimating the content validity index (CVI)

Ten raters assessed the items to find out the extent to which they measured the intended construct. The raters scored the relevance of each item on a four-point Likert scale (1 — not relevant, 2 — somewhat relevant, 3 — relevant, and 4 — very relevant). The CVI value was calculated as the percentage of the acceptable score for each item scored 3 or 4 using the following formula [44]:

$$CVI = \frac{The\, number\, of\, raters\, giving\, a\, score\, of\; 3 \vee 4}{The\, total\, number\, of\, raters}$$

The items with a CVI score higher than 0.79 were considered relevant. The items with a CVI score of 0.79 to 0.70 were considered controversial and needed revision. Finally, the items with a CVI score of less than 0.70 were irrelevant and removed. Moreover, the item-level content validity index (I-CVI) was used to assess the quantitative content validity of each item. The scale-level content validity index (S-CVI) was also used to assess the content validity of the whole scale. I-CVI is a raw score. For example, a completely relevant item, which is scored 4 by 7 out of 10 raters has an I-CVI score of 0.7 [45]. S-CVI/average is called the average of I-CVI scores and was reported in the reviewed articles.

S-CVI/universal is a ratio of items of an instrument that were scored 3 and 4 by all raters in terms of relevance. It is a proportion of the items of a tool that are scored 3 or 4 in terms of the content by the raters [45]. Instrument developers often consider a value of 0.80 as the lowest acceptable requirement for S-CVI/average, but they propose an S-CVI score of 0.90 and above and an I-CVI score of 0.78. Furthermore, to increase the response accuracy, the probability of chance agreement (CP) in the responses to the items was first checked to reduce the probability that the respondents had reached an agreement about the instrument items by chance. To this end, the modified Cohen's kappa coefficient (K*) was calculated using the following formula as an indicator of the evaluators' agreement about the relevance or non-relevance of the item [46]:

$$k^* = \frac{\text{I-CVI} - p_c}{1 - p_c} \quad p_c = \left[\frac{N!}{A!(N-A)!}\right].5^N$$

$$k = \frac{\text{Proportion}_{\text{Agreement}} - \text{Proportion}_{\text{Chance agreement}}}{1 - \text{Proportion}_{\text{Chance agreement}}}$$

Where N is the number of raters and A is the number of agreements in terms of relevance.

Table 2. Estimating I-CVI and K values [please indicate table in text??]

Number of raters	Items scored 3 or 4	I-CVI	K
3	3	1.00	1.00
3	2	0.67	0.47
4	4	1.00	1.00
4	3	0.75	0.67

5	5	1.00	1.00
5	4	0.80	0.76
6	6	1.00	1.00
6	5	0.83	0.81
6	4	0.67	0.57
7	7	1.00	1.00
7	6	0.86	0.85
7	5	0.71	0.65
8	8	1.00	1.00
8	7	0.88	0.88
8	6	0.75	0.72
9	9	1.00	1.00
9	8	0.89	0.89
9	7	0.78	0.76

Then, the Cohen's kappa coefficient was estimated with the number of agreements on relevance (1-CVI) and the probability of chance agreement. Cohen's kappa coefficient is interpreted as follows:

1. Cohen’s kappa coefficient of 0.40 to 0.59 shows a poor agreement.
2. Cohen’s kappa coefficient of 0.60 to 0.74 shows a good agreement.
3. Cohen’s kappa coefficient of greater than 0.74 shows perfect agreement.

The items that met the third requirement (K* > 0.74) were kept and the other items were removed [42, 45]. In the present study, all I-CVI, PC, and K* values were calculated.

Construct validity

Exploratory factor analysis was run to ass the construct validity of the instrument. In exploratory factor analysis, the researcher does not have any presuppositions about the number or nature of the variables, and as the name suggests, it is exploratory. Thus, this analysis allows the researcher to discover the main constructs needed to generate a theory or model from a relatively large set of latent constructs in a set of questions. In exploratory factor analysis, the researcher does not have any presumptions about the factors or constructs in the instrument. However, the goal is to find out what the constructs in the instrument are like and under which factor or group each item is placed [47].

Prerequisites for running exploratory factor analysis

- **Sample size:** Comrey and Lee's scale was used to estimate the sample size in this study. Comrey and Lee proposed a graded scale of sample size for scale development: 100 — poor, 200 — fair, 300 — good, 500 — very good, and 1000 — excellent [39]. Therefore, in the present study, the estimated number of respondents required for factor analysis was 403 people.
- **The communality of the variables:** The communality of the variables explains the percentage of variance that a variable has in all factors. Thus, it can be considered a reliable indicator. A high communality of the variables shows that the sample size is adequate. In the communality of the variables table, items with a communality value of less than 0.2 are removed by exploratory factor analysis [48]. In this table, there was no communality of less than 0.2.
- **Overdetermination:** The minimum required number of variables for each extracted factor was 3 variables. The factors with less than 3 variables are considered weak and unstable [49].
- **Factor loading**: In this study, the minimum acceptable factor loading for the presence of an item in a factor was 0.3, which was calculated using the following equation [50]:

  $CV=5.152 \div \sqrt{(n-2)}$

  Where CV is the number of extractable factors and n is the sample size [50].
- **Normality:** Factor analysis is more powerful for the data that have a normal distribution. The assumption of normality was checked by univariate distribution based on skewness of ± 3 and kurtosis of ± 7 [51]. The determinant value was estimated as 0.58 using multivariate distribution.
- **Correlation:** Another prerequisite was the existence of a correlation between variables [49]. Following a strict approach, the minimum required correlation is 0.3 [45]. However, based on a moderate view, regardless of the r value, only the items whose correlation value was above 0.05 were removed [42, 49]. In the present study, p-value was used as a measure of correlation which was significant for all items.

- **Missing values:** If some respondents did not answer some items, the missing data should be taken into account so that they do not affect the desired estimates [42].
- **Sampling adequacy:** The size of sampling adequacy is shown in the anti-image diameter of the correlation matrix. Here, the variables with a measurement accuracy of less than 0.5 were removed (FLD, 2000). In the SPSS output, two Bartletts and Kaiser-Meyer-Olkin (KMO) values are estimated as the indicators of sampling adequacy. The KMO value should be above 0.5 for each item. Besides, the result of Bartlett's test should be significant [52, 53]. In the present study, both the KMO and KMO values were estimated for each item. Bartlett's values were found to be significant.

Data extraction

In SPSS software, there are seven data extraction models [50]. In this study, exploratory factor analysis was performed using the maximum likelihood method.

Determining the number of factors

In this study, two criteria, i.e. scree plot (Cattel, 1996) and Kaiser's (1960) criteria were used to determine the number of factors.

- **Scree plot:** A scree plot is used to replace the variance of each component in the data and also to determine the effective number of factors that can be extracted. In this plot, the eigenvalues are drawn on the horizontal axis and the number of factors on the vertical axis. The factors in this plot are selected visually and wherever the plot fails, the factors that are placed before it, are known as suitable factors [42]. In this study, the scree plot was used as the main criterion, which obtained three factors.
- **Eigenvalue**: If there are several variables and a composite variable is created by adding them, this variable will have a dispersion that is directly related to the dispersion of the responses given to each variable. Since variables with a larger variance have a greater effect on the composite variance, it is necessary to standardize the variables before summing them, or in other words, calculate the Z score. In factor analysis, this value is called the eigenvalue. Only factors with an eigenvalue of 1 or greater are considered for significance, and factors with eigenvalues of less than one are discarded [54]. Keyser's values estimated through the eigenvalues for three extracted factors were 3.09, 2.78, and

2.04, respectively. Thus, the eigenvalues for all three extracted factors were obtained above 1.

The rotation of the extracted factors

Through rotation, the variables that are placed on more than one factor are mainly assigned to one factor [55]. The common rotation techniques are direct oblimin and promax. Direct oblimin tries to simplify the mathematic structure and output, while promax is useful on larger datasets due to its speed. Promax ultimately leads to a higher correlation between factors and achieving a simple construct (Gorsuch, 1983) [42]. In this study, Promax rotation was used. Then, after substituting the items in three extracted factors, the factors were named and their reliability was checked.

Reliability analysis

Reliability refers to the degree of stability and internal consistency of the results produced by a tool in repeated and multiple measurements. Thus, it is associated with the credibility and repeatability of a tool. There are several methods to assess the reliability of an instrument, specifically the test-retest method and internal consistency [56]. In this study, the reliability of the instrument was assessed using the test-retest method and internal consistency. Internal consistency was evaluated using Cronbach's alpha and average inter-item correlation (AIC). The α values greater than 0.7 were acceptable. An AIC of 0.2 to 0.4 was considered to indicate good internal consistency. Then, the instrument was re-administered to check its consistency [57]. The ICC values were interpreted as follows: Less than 0.4 (poor reliability), 0.4–0.6 (moderate reliability), 0.6–0.8 (good reliability) and 0.8–1 (perfect reliability) [58]. The final instrument was administered to 30 persons. It was re-administered after 14 days to the same persons with the same conditions. Then, the scores obtained in these two stages were compared using the correlation coefficients.

DISCUSSION

Although many research efforts have been taken in different parts of the world, none of the studies had used a standard tool to determine the level of adaptation of societies against heat waves, and there is no such tool, and sometimes the level of adaptation has been measured through questionnaires that were not psychometrically evaluated [36–39]. Most studies have highlighted the increased frequency and length of heat waves and their harmful effects on health [7, 8, 59–65]. Thus, governments and related officials should pay more attention to heat waves and seek effective solutions for greater adaptation and damage mitigation measures. These measures can reduce the human and financial consequences of heat waves. Accordingly, the tool developed in the study focused on adaptation solutions. Thus, the tool can measure the adaptation level against heat waves in different regions. The outcomes can be used to formulate effective adaptation interventions and solutions.

Using the findings from the qualitative phase of the study and the data from the interviews, the themes related to adaptation and adaptation solutions and strategies were extracted. Overall, two themes of “adaptive paradigm” and “adaptive strategies” were extracted. Each theme was divided into two main categories and several subcategories. For example, the main category of “governance measures” was divided into four subcategories, including managerial and research subcategories. In the systematic review, eleven strategies for adaptation to heat waves including education and awareness raising, green infrastructure, and critical infrastructure were identified. The items in the instrument were formed by merging the obtained codes. Afterward, the psychometric properties of the tool were assessed. The items were placed into three factors that play a significant role in adaptation to heat waves.

Most of the studies on adaptation to heat waves have tried to discover individual behaviors, including effective adaptive behaviors against heat waves such as adequate hydration, paying attention to daily weather forecasts, modifying lifestyle, using air conditioners and fans, frequent showering, reducing the duration of outdoor activities, paying attention to health protection guidelines, reducing and changing the level of physical activity, paying attention to the type of clothing, doing things in the early hours of the day, going to parks, canopies, and swimming pools, and using balconies in the cool hours of the day [30, 39, 66–70].

In addition to individual adaptive behaviors, organizing national programs to cope with the effects of heat waves is very important and improves the level of societal adaptation [71]. Moreover, managers and policymakers need to have a good perception of the dangers of heat waves [72]. Concerning individual planning, people must improve their knowledge by receiving information to protect themselves to formulate individual plans for adaptive behaviors. The heat wave adaptation tool was developed based on heat wave adaptation strategies used both in the affected society and around the world.

Limitations

Lack of face-to-face access to all study participants due to time interference with the COVID-19 pandemic was one of the main limitations in the qualitative phase of the research, so other communication methods were used, including phone conversations. Another limitation of the qualitative study was the bias in the analysis and interpretation of the results, which was maximized by adopting strategies such as examining qualitative data in different stages of analysis with some participants and research colleagues. One of the limitations in the implementation of the quantitative study parts of the research was the non-cooperation of some participants due to not having enough time to participate in the study, which was attempted by sending the questionnaire at a time determined by themselves and setting a longer response deadline and explaining the value of the participants' opinions. In the process of building the tool, we improved the process of participation in this study. Another limitation was the use of all dimensions of the society; because the qualitative study in the present research was conducted on the people of the society, the resulting tool was designed based on the individual dimension of people's adaptive behaviors.

CONCLUSIONS

The tool developed in this can direct the attention of senior health managers to preparedness against heat waves. Thus, they can identify the areas with less adaptation to heat waves, meet their needs by implementing damage mitigation programs, and help them avoid the economic, social, physical, and psychological effects of heat waves. The main contribution of the present study was that it addressed the concept of adaptation to heat waves using a combination of inductive and analogical methods. Besides, this is the first study in Iran to develop and validate a tool for assessing adaptation to heat waves. The developed tool can help planners in the Ministry of Health and researchers to evaluate the level of adaptation in different regions and formulate plans of action to reduce the consequences of heat waves.

Acknowledgments

The authors would like to express their gratitude to the officials of Kerman University of Medical Sciences and all the experts participating in this study.

Funding

This paper was extracted from a doctoral dissertation approved by the scientific committee of Kerman University of Medical Sciences (code: 1401.084. IR.KMU.REC). This research project was financed by the Kerman University of Medical Sciences.

Conflict of interest

The authors declared no conflict of interest.

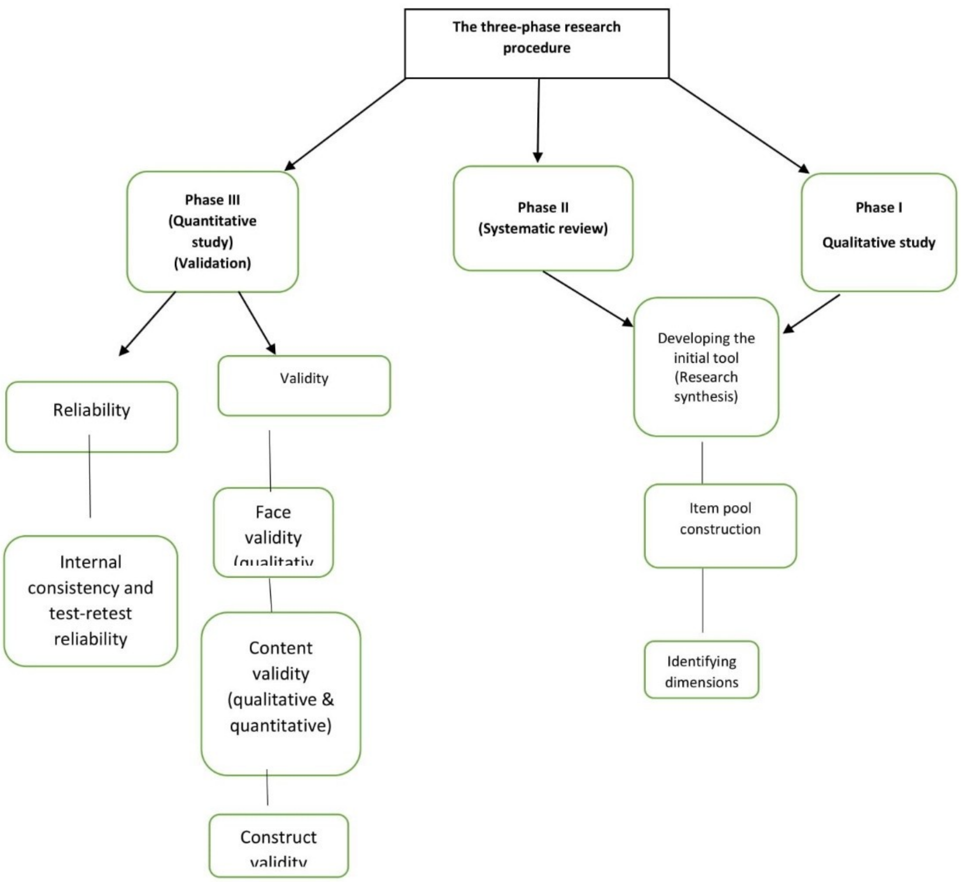

FIGURE 1. The steps taken to conduct the study

REFERENCES

1. Kaviani F, Aliakbari F, Sheikhbardsiri H, et al. Nursing Students' Competency to Attend Disaster Situations: A Study in Western Iran. Disaster Med Public Health Prep. 2022; 16(5): 2044–2048, doi: 10.1017/dmp.2021.263, indexed in Pubmed: 34802484.

2. Rezaei F, Maracy M, Yarmohammadian M, et al. Hospitals preparedness using WHO guideline: A systematic review and meta-analysis. Hong Kong J Emerg Med. 2018; 25(4): 211–222, doi: 10.1177/1024907918760123.

3. Sheikhbardsiri H, Yarmohammadian MH, Khankeh H, et al. An operational exercise for disaster assessment and emergency preparedness in south of Iran. J Public Health Manag Pract. 2020; 26(5): 451–456, doi: 10.1097/PHH.0000000000000815, indexed in Pubmed: 32732718.

4. Khademipour G, Nakhaee N, Anari SM, et al. Crowd simulations and determining the critical density point of emergency situations. Disaster Med Public Health Prep. 2017; 11(6): 674–680, doi: 10.1017/dmp.2017.7, indexed in Pubmed: 28554341.

5. Sheikhbardsiri H, Doustmohammadi MM, Mousavi SH, et al. Qualitative study of health system preparedness for successful implementation of disaster exercises in the Iranian context. Disaster Med Public Health Prep. 2022; 16(2): 500–509, doi: 10.1017/dmp.2020.257, indexed in Pubmed: 33023696.

6. Sheikhbardsiri H, Khademipour G, Davarani ER, et al. Response capability of hospitals to an incident caused by mass gatherings in southeast Iran. Injury. 2022; 53(5): 1722–1726, doi: 10.1016/j.injury.2021.12.055, indexed in Pubmed: 35027219.

7. Baldwin JW, Dessy JB, Vecchi GA, et al. Temporally compound heat wave events and global warming: an emerging hazard. Earth's Future. 2019; 7(4): 411–427, doi: 10.1029/2018EF000989.

8. Lee S, Lee E, Park MS, et al. Short-term effect of temperature on daily emergency visits for acute myocardial infarction with threshold temperatures. PLoS One. 2014; 9(4): e94070, doi: 10.1371/journal.pone.0094070, indexed in Pubmed: 24770787.

9. Arias P, Bellouin N, Coppola E, et al. Climate Change 2021: The Physical Science Basis. Contribution of Working Group14 I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Technical Summary. 2021.

10. Beigli F, Lenci R. Underground and semi underground passive cooling strategies in hot climate of iran. Underground and semi underground passive cooling strategies in hot climate of Iran. 2016; 5(3): 1–12.

11. Mann ME. Do global warming and climate change represent a serious threat to our welfare and environment? Soc Philosph Policy. 2009; 26(2): 193–230.

12. Chirico F, NJIjoer M, et al. New and Old Indices for Evaluating Heat Stress in an Indoor Environment: Some Considerations. Comment on Kownacki, L.; Gao, C.; Kuklane, K.; Wierzbicka, A. Heat Stress in Indoor Environments of Scandinavian Urban Areas: A Literature Reviewew. Int J Environ Res Public Health. 2019; 16(8).

13. Lundgren Kownacki K, Gao C, Kuklane K, et al. Heat stress in indoor environments of scandinavian urban areas: A literature review. Int J Environ Res Public Health. 2019; 16(4): 560, doi: 10.3390/ijerph16040560, indexed in Pubmed: 30769945.

14. Dhimal M, Chirico F, Bista B, et al. Impact of air pollution on global burden of disease in 2019. 2021; 9(10): 1719.

15. Chirico F. Comments on "Climate Change and Public Health: A Small Frame Obscures the Picture". New Solut. 2018; 28(1): 5–7, doi: 10.1177/1048291117752463, indexed in Pubmed: 29310508.

16. Watts N, Amann M, Arnell N, et al. The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. Lancet. 2018; 391(10120): P1836–P1878, doi: 10.1016/S0140-6736(19)32596-6.

17. Chirico F, Magnavita N. The significant role of health surveillance in the occupational heat stress assessment. The significant role of health surveillance in the occupational heat stress assessment. 2019; 63(2): 193–4.

18. Magnavita N, Chirico F. New and emerging risk factors in occupational health. Applied Sciences. 2020; 10(24): 8906, doi: 10.3390/app10248906.

19. Papadakis G, Chalabi Z, Khare S, et al. Health protection planning for extreme weather events and natural disasters. Am J Disaster Med. 2018; 13(4): 227–236, doi: 10.5055/ajdm.2018.0303, indexed in Pubmed: 30821337.

20. Organization WH. The work of WHO in the Eastern Mediterranean Region: annual report of the Regional Director 2015. World Health Organization. Regional Office for the Eastern Mediterranean; 2016. Report No.: 9290221690.

21. Field CB, Barros V, Stocker TF, Dahe Q. Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change: Cambridge University Press; 2012.

22. Khademipour G, Sheikhbardsiri H. Disaster risk assessment of primary healthcare facilities in South East of Iran: a study with approach of disaster risk reduction. Disaster Emerg Med J. 2022; 7(1): 11–20, doi: 10.5603/demj.a2022.0002.

23. Molavi-Taleghani Y, Ebrahimpour H, Sheikhbardsiri H. A proactive risk assessment through healthcare failure mode and effect analysis in pediatric surgery department. J Compr Pediat. 2020; 11(3), doi: 10.5812/compreped.56008.

24. Akompab DA, Bi P, Williams S, et al. Awareness of and attitudes towards heat waves within the context of climate change among a cohort of residents in Adelaide, Australia. Int J Environ Res Public Health. 2012; 10(1): 1–17, doi: 10.3390/ijerph10010001, indexed in Pubmed: 23343978.

25. Sahebi A, Yousefi A, Abdi K, et al. The prevalence of post-traumatic stress disorder among health care workers during the COVID-19 pandemic: an umbrella review and meta-analysis. Front Psychiatry. 2021; 12: 764738, doi: 10.3389/fpsyt.2021.764738, indexed in Pubmed: 34867550.

26. Huang C, Barnett AG, Xu Z, et al. Managing the health effects of temperature in response to climate change: challenges ahead. Environ Health Perspect. 2013; 121(4): 415–419, doi: 10.1289/ehp.1206025, indexed in Pubmed: 23407064.

27. Huang C, Vaneckova P, Wang X, et al. Constraints and barriers to public health adaptation to climate change: a review of the literature. Am J Prev Med. 2011; 40(2): 183–190, doi: 10.1016/j.amepre.2010.10.025, indexed in Pubmed: 21238867.

28. He Y, Ma R, Ren M, et al. Public health adaptation to heat waves in response to climate change in China. Ambient temperature and health in China. Springer. 2019: 171–190.

29. Sheikhbardsiri H, Afshar PJ, Baniasadi H, et al. Workplace violence against prehospital paramedic personnel (city and road) and factors related to this type of violence in iran. J Interpers Violence. 2022; 37(13-14): NP11683–NP11698, doi: 10.1177/0886260520967127, indexed in Pubmed: 33107378.

30. Liu T, Xu YJ, Zhang YH, et al. Associations between risk perception, spontaneous adaptation behavior to heat waves and heatstroke in Guangdong province, China. BMC Public Health. 2013; 13: 913, doi: 10.1186/1471-2458-13-913, indexed in Pubmed: 24088302.

31. Nejadshafiee M, Nekoei-Moghadam M, Bahaadinbeigy K, et al. Providing telenursing care for victims: a simulated study for introducing of possibility nursing interventions in disasters. BMC Med Inform Decis Mak. 2022; 22(1): 54, doi: 10.1186/s12911-022-01792-y, indexed in Pubmed: 35236344.

32. Nobakht S, Shirdel A, Molavi-Taleghani Y, et al. Human resources for health: A narrative review of adequacy and distribution of clinical and nonclinical human resources in hospitals of Iran. Internat J Health Plan Manag. 2018; 33(3): 560–572, doi: 10.1002/hpm.2510.

33. Sheikhbardsiri H, Raeisi A, Khademipour G. Domestic violence against women working in four educational hospitals in iran. J Interpers Violence. 2020; 35(21-22): 5107–5121, doi: 10.1177/0886260517719539, indexed in Pubmed: 29294832.

34. Rauf S, Bakhsh K, Abbas A, et al. How hard they hit? Perception, adaptation and public health implications of heat waves in urban and peri-urban Pakistan. Environ Sci Pollut Res Int. 2017; 24(11): 10630–10639, doi: 10.1007/s11356-017-8756-4, indexed in Pubmed: 28283973.

35. Ardalan A, Rajaei MH, Masoumi G, et al. 2012-2025 Roadmap of I.R.Iran's Disaster Health Management. PLoS Curr. 2012; 4: e4f93005fbcb34, doi: 10.1371/4f93005fbcb34, indexed in Pubmed: 22953239.

36. Laranjeira K, Göttsche F, Birkmann J, et al. Heat vulnerability and adaptive capacities: findings of a household survey in Ludwigsburg, BW, Germany. Climatic Change. 2021; 166(1-2), doi: 10.1007/s10584-021-03103-2.

37. van Loenhout JA, Vanderplanken K, Kashibadze T, et al. Heatwave-protective knowledge and behaviour among urban populations: a multi-country study in Tunisia, Georgia and Israel. BMC Public Health. 2021; 21(1): 834, doi: 10.1186/s12889-021-10865-y, indexed in Pubmed: 33931063.

38. Meerow S, Ladd K. Planning for extreme heat: A national survey of US planners. J American Plan Ass. 2022; 88(3): 319–334.

39. Ban J, Shi W, Cui L, et al. Health-risk perception and its mediating effect on protective behavioral adaptation to heat waves. Environ Res. 2019; 172: 27–33, doi: 10.1016/j.envres.2019.01.006, indexed in Pubmed: 30769186.

40. Spence A, Poortinga W, Butler C, et al. Perceptions of climate change and willingness to save energy related to flood experience. Nature Climate Change. 2011; 1(1): 46–49, doi: 10.1038/nclimate1059.

41. Sigaroodi AE, Nayeri ND, Rahnavard Z, et al. Qualitative research methodology: phenomenology. J Holist Nurs Midwifery. 2012; 22(2): 56–63.

42. Ebadi A, Zarshenas L, Rakhshan M, et al. Principles of scale development in health science. Tehran: Jame. ; 2017.

43. LAWSHE CH. A quantitative approach to content validity. Personnel Psychol. 1975; 28(4): 563–575, doi: 10.1111/j.1744-6570.1975.tb01393.x.

44. Hosseini Z, Ghorbani Z, Ebn Ah. Face and content validity and reliability assessment of change cycle questionnaire in smokers. J Mashhad Dental School. 2015; 39(2): 147–154.

45. Broder HL, McGrath C, Cisneros GJ. Questionnaire development: face validity and item impact testing of the Child Oral Health Impact Profile. Community Dent Oral Epidemiol. 2007; 35 Suppl 1: 8–19, doi: 10.1111/j.1600-0528.2007.00401.x, indexed in Pubmed: 17615046.

46. Polit DF, Beck CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. Res Nurs Health. 2006; 29(5): 489–497, doi: 10.1002/nur.20147, indexed in Pubmed: 16977646.

47. Williams B, Onsman A, Brown T. Exploratory factor analysis: A five-step guide for novices. Australasian J Paramed. 2010; 8(3), doi: 10.33151/ajp.8.3.93.

48. Samitsch C. Data Quality and its Impacts on Decision-Making: How Managers can benefit from Good Data. Springer, 2014 .

49. Yong A, Pearce S. A beginner's guide to factor analysis: focusing on exploratory factor analysis. Tutorials Quant Meth Psychol. 2013; 9(2): 79–94, doi: 10.20982/tqmp.09.2.p079.

50. Munro D, Hazard B, Aroian KJ. Statistical Methods for Health Care Research. Lippincott Williams & Wilkins 2005.

51. Guba EG, Lincoln YS. Competing paradigms in qualitative research. Handbook of qualitative research. In: Denzin NK, Lincoln YS. ed. Handbook of Qualitative Research. Sage Publications, Thousand Oaks 1994: 105–117.

52. Malhotra NK. Questionnaire design and scale development. In: Grove R, Vriens M. ed. The handbook of marketing research: Uses, misuses, and future advances. Thousand Oaks, CA: Sage Publications 2006: 83–94.

53. Kaiser H. An index of factorial simplicity. Psychometrika. 1974; 39(1): 31–36, doi: 10.1007/bf02291575.

54. Preacher KJ, Zhang G, Kim C, et al. Choosing the optimal number of factors in exploratory factor analysis: a model selection perspective. Multivariate Behav Res. 2013; 48(1): 28–56, doi: 10.1080/00273171.2012.710386, indexed in Pubmed: 26789208.

55. Rummel R. Applied factor analysis, Evanston, IL: Northwestern Univer. Press. ; 1970.

56. Gliem JA, Gliem RR. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales2003: Midwest Research-to-Practice Conference in Adult, Continuing, and Community.

57. Sharif Nia H, Mohammadinezhad M, Allen KA, et al. Psychometric evaluation of the Persian version of the spiritual well-being scale (SWBS) in Iranian patients with cancer. Palliat Support Care. 2022; 20(1): 113–121, doi: 10.1017/S1478951521000407, indexed in Pubmed: 33958021.

58. McGraw K, Wong SP. Forming inferences about some intraclass correlation coefficients. Psychological Methods. 1996; 1(1): 30–46, doi: 10.1037/1082-989x.1.1.30.

59. Schaffer A, Muscatello D, Broome R, et al. Emergency department visits, ambulance calls, and mortality associated with an exceptional heat wave in Sydney, Australia, 2011: a time-series analysis. Environ Health. 2012; 11(1), doi: 10.1186/1476-069X-11-3, indexed in Pubmed: 22273155.

60. Egondi T, Kyobutungi C, Rocklöv J. Temperature variation and heat wave and cold spell impacts on years of life lost among the urban poor population of Nairobi, Kenya. Int J Environ Res Public Health. 2015; 12(3): 2735–2748, doi: 10.3390/ijerph120302735, indexed in Pubmed: 25739007.

61. Gasparrini A, Armstrong B. The impact of heat waves on mortality. Epidemiology. 2011; 22(1): 68–73, doi: 10.1097/EDE.0b013e3181fdcd99, indexed in Pubmed: 21150355.

62. Oudin Åström D, Schifano P, Asta F, et al. The effect of heat waves on mortality in susceptible groups: a cohort study of a mediterranean and a northern European City. Environ Health. 2015; 14: 30, doi: 10.1186/s12940-015-0012-0, indexed in Pubmed: 25889290.

63. Xu Z, Etzel RA, Su H, et al. Impact of ambient temperature on children's health: a systematic review. Environ Res. 2012; 117: 120–131, doi: 10.1016/j.envres.2012.07.002, indexed in Pubmed: 22831555.

64. Turner LR, Connell D, Tong S. The effect of heat waves on ambulance attendances in Brisbane, Australia. Prehosp Disaster Med. 2013; 28(5): 482–487, doi: 10.1017/S1049023X13008789, indexed in Pubmed: 23981779.

65. Turner LR, Connell D, Tong S. Exposure to hot and cold temperatures and ambulance attendances in Brisbane, Australia: a time-series study. BMJ Open. 2012; 2(4), doi: 10.1136/bmjopen-2012-001074, indexed in Pubmed: 22773538.

66. McCall T, Beckmann S, Kawe C, et al. Climate change adaptation and mitigation – a hitherto neglected gender-sensitive public health perspective. Climate Develop. 2018; 11(9): 735–744, doi: 10.1080/17565529.2018.1529551.

67. Mehiriz K, Gosselin P, Tardif I, et al. The effect of an automated phone warning and health advisory system on adaptation to high heat episodes and health services use in vulnerable groups-evidence from a randomized controlled study. Int J Environ Res Public Health. 2018; 15(8), doi: 10.3390/ijerph15081581, indexed in Pubmed: 30046018.

68. Lao J, Hansen A, Nitschke M, et al. Working smart: An exploration of council workers' experiences and perceptions of heat in Adelaide, South Australia. Safety Science. 2016; 82: 228–235, doi: 10.1016/j.ssci.2015.09.026.

69. Alaci DS. Promoting climate change adaptation in developing countries: the urban planning opportunities in resilience building. Climate Change Manag. 2017: 323–344, doi: 10.1007/978-3-319-49520-0_20.

70. Lane K, Wheeler K, Charles-Guzman K, et al. Extreme heat awareness and protective behaviors in New York City. J Urban Health. 2014; 91(3): 403–414, doi: 10.1007/s11524-013-9850-7, indexed in Pubmed: 24297476.

71. Alberini A, Gans W, Alhassan M. Individual and public-program adaptation: coping with heat waves in five cities in Canada. Int J Environ Res Public Health. 2011; 8(12): 4679–4701, doi: 10.3390/ijerph8124679, indexed in Pubmed: 22408596.

72. Akompab D, Bi P, Williams S, et al. Engaging stakeholders in an adaptation process: governance and institutional arrangements in heat-health policy development in Adelaide, Australia. Mitigation Adapta Strat Glob Change. 2013; 18(7): 1001–1018, doi: 10.1007/s11027-012-9404-4.