Chapter 3 / Capítulo 3

Habitability, territory, and sustainability: Interdisciplinary studies on housing, environment, and society in northwestern Mexico
ISBN: 978-9915-9966-6-0
DOI: 10.62486/978-9915-9966-6-0.Ch03
Pages: 31-44

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Urban heat island and psychological comfort in residential subdivisions of Mazatlán

Isla de calor urbana y confort psicológico en fraccionamientos de Mazatlán

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ABSTRACT

Urban heat shapes the habitability of residential subdivisions in hot cities, yet its psychological dimension is rarely measured. Using the preliminary data cut from the pilot survey of project FZ-HAB-0005 on the Factoriza UAS platform, this study described the initial behaviour of a fifteen-item scale with three dimensions, Perceived heat exposure, Well-being in the hot months and Adjustment of activities to heat, among residents of subdivisions in Mazatlán. With a cross-sectional design, 7 cases out of a target of 100 were analysed while data collection remained open; the analysis was limited to the perception component and included no temperature measurements. Descriptive statistics, Cronbach's alpha, McDonald's omega total and Spearman correlations between dimensions were estimated, and an exploratory factor analysis was attempted. Internal consistency was moderate for Perceived exposure (α = .636), higher for Adjustment of activities (α = .729; ω = .743, excluding one invariant item) and negative for Well-being (α = -.153). The factor analysis was not interpretable because the sample had fewer cases than items. Well-being and Adjustment of activities were negatively correlated (ρ = -.896), with a very imprecise estimate. Residents perceived their subdivision as hot, reported low well-being in summer and strongly adjusted their activities. The findings do not yet provide structural validity evidence and point to revisions of the instrument.

Keywords: urban heat island; perceived heat exposure; psychological well-being; heat adaptation

RESUMEN

El calor urbano condiciona la habitabilidad de los fraccionamientos de las ciudades cálidas, pero su dimensión psicológica rara vez se mide. Este estudio describió, en el corte preliminar del levantamiento piloto del proyecto FZ-HAB-0005 de Factoriza UAS, el comportamiento inicial de una escala de quince reactivos con tres dimensiones: Exposición percibida al calor, Bienestar en los meses de calor y Ajuste de actividades al calor, en residentes de fraccionamientos de Mazatlán. Con diseño transversal, se analizaron 7 casos de una meta de 100, con el levantamiento abierto; el análisis se limitó al componente de percepción y no incluyó mediciones de temperatura. Se estimaron descriptivos, alfa de Cronbach, omega total y correlaciones de Spearman entre dimensiones, y se intentó un análisis factorial exploratorio. La consistencia interna fue moderada en Exposición percibida (α = .636), más alta en Ajuste de actividades (α = .729; ω = .743, sin un reactivo invariante) y negativa en Bienestar (α = -.153). El análisis factorial no fue interpretable porque la muestra tiene menos casos que reactivos. Bienestar y Ajuste de actividades se correlacionaron en negativo (ρ = -.896), con una estimación muy imprecisa. Los residentes percibieron su fraccionamiento como caluroso, refirieron bajo bienestar en verano y ajustaron intensamente sus actividades. Los resultados no aportan todavía evidencias de validez estructural y orientan la revisión del instrumento.

Palabras clave: isla de calor urbana; exposición percibida al calor; bienestar psicológico; adaptación al calor

INTRODUCTION

Urban heat is no longer an exclusively climatic issue; it has become an everyday condition of habitability. The replacement of vegetation and natural soil with built surfaces, pavements and roofs alters the energy balance of cities and gives rise to the urban heat island, the phenomenon whereby urbanized areas record higher temperatures than their surroundings. In the hot-climate cities of northwestern Mexico, this condition is felt inside homes, in the streets and in the public spaces of the residential subdivisions where a large share of the population lives.

Research on the human consequences of heat has advanced rapidly. Recent systematic reviews have associated high temperatures and heat waves with an increased risk of mental and behavioral disorders (Li et al., 2023), with mental and neurological conditions in older adults (Byun et al., 2024), and with a decline in sleep quantity and quality (Chevance et al., 2024).

The proposed mechanisms include psychological stress, sleep disruption, fatigue, reduced physical exercise, social isolation, and loss of access to usual coping strategies (Baecker et al., 2025).

Beyond these health effects, the literature has documented that people adjust their daily lives to heat: they change their schedules, reduce outdoor activity and seek out cool spaces, although these responses depend on their resources and their perception of risk (Guzman-Colon et al., 2025; van de Kamp et al., 2026).

In Sinaloa, studies on urban heat have focused mainly on physical measurement. In Culiacán, Borbolla Gaxiola et al. (2024) characterized surface heat islands using satellite imagery and found that their intensity varies with the season and with land uses on the periphery; Barraza-Bracamontes et al. (2022) documented that residents of a social housing development described their homes as very hot.

For Mazatlán, by contrast, no instruments were identified that jointly measure perceived heat exposure in the housing development, well-being during the hot months, and the adjustment of daily activities, which are the three facets of the psychological experience of urban heat.

Project FZ-HAB-0005 of the Factoriza UAS platform set out to study the urban heat island and psychological comfort in residential developments (fraccionamientos) in Mazatlán. The project is registered with a mixed-methods design that envisages combining measurement of the thermal environment with a perception scale. This article reports only the perception component: the results of the first pilot survey of the Perceived Urban Heat and Well-being Scale, which consists of fifteen items organized into three dimensions, from a very small preliminary data cut. Its scope is therefore the initial review of the instrument, not the estimation of population parameters or the measurement of the heat island.

The overall objective was to describe the initial performance of a perceived urban heat and well-being scale in the preliminary data cut of its pilot survey with residents of housing developments in Mazatlán.

The specific objectives were, first, to describe the distribution of responses to each item; second, to estimate the internal consistency of each dimension using alpha and omega coefficients; third, to assess the feasibility of analysing the internal structure with the available sample size; and fourth, to explore the relationship among the scores of the three dimensions. The project did not state any hypotheses; therefore, the study is descriptive and exploratory in scope.

DEVELOPMENT

URBAN HEAT ISLAND AND PERCEIVED EXPOSURE

The urban heat island has been studied mainly with physical data: weather stations, sensor-equipped transects, and land surface temperature estimated by remote sensing. The latter approach can cover entire cities, but it reports the temperature of surfaces rather than that of the air people breathe or the temperature they perceive.

In Culiacán, analysis of satellite images from different seasons showed more intense surface heat islands in spring, owing to scarce rainfall, and, at certain times of the year, cool-island behavior associated with crops on the agricultural periphery; the authors themselves recommended comparing their results with in situ air temperature data and cautioned about the small number of weather stations in the city (Borbolla Gaxiola et al., 2024).

This finding indicates that the heat island does not behave the same way in every city or in

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

every season, and that its physical measurement is no substitute for the experience of those who live in it.

Perceived exposure refers to how residents assess the intensity of heat in their immediate surroundings. In Irbid, Jordan, a survey of apartment and single-family house residents covered perception of the neighborhood heat island and found that those living in apartments perceived a more intense heat island and rated tree shade and natural ventilation as less effective (Obeidat, 2026).

In Xi'an, China, most residents surveyed in urban parks felt that hot days affected their daily lives; housing type, occupation, and hours of outdoor work were associated with their perception of high temperatures (Zhang et al., 2023).

The instrument's Perceived Heat Exposure dimension captures this appraisal throughout the day and across the spaces of the housing development: intense heat during the day (R1), heat build-up in the streets in the afternoon (R2), persistence of heat at night (R3), the availability of cool places to spend time outdoors (R4, reverse-scored), and the sensation of heat from the pavement while walking (R5).

Nighttime heat deserves particular attention. Climate change and urbanization are raising both daytime and nighttime temperatures, and disrupted sleep is a plausible pathway linking heat to a range of adverse outcomes (Chevance et al., 2024). In Puerto Rico, a probability-based survey of adults found that exposure to nighttime heat was widespread and strongly associated with heat-related symptoms (Guzman-Colon et al., 2025). The systematic review cited above also showed that higher outdoor or indoor temperatures are generally associated with reduced sleep quantity and quality, with little evidence of rapid adaptation.

HEAT, WELL-BEING AND PSYCHOLOGICAL COMFORT

Psychological comfort in hot conditions encompasses more than thermal sensation: it includes mood, energy for activities, the ability to rest, and a sense of calm within one's own home. Epidemiological evidence supports this broad interpretation. The meta-analysis by Li et al. (2023) associated heatwaves and extreme temperatures with an increased risk of mental and behavioral disorders, and highlighted the usefulness of thermal indices that combine several meteorological factors.

In older adults, the review by Byun et al. (2024) found evidence of adverse effects of high temperatures and heat waves on mental and neurological conditions, with moderate overall certainty.

Studies combining systematic reviews with qualitative research have clarified the underlying mechanisms and vulnerability factors. Baecker et al. (2025) identified limited evidence on activation of the hypothalamic-pituitary-adrenal axis, psychological stress, reduced exercise, and sleep disruption; the focus groups added fatigue, health anxiety, loss of access to usual coping strategies, and social isolation.

In a subsequent study, Baecker et al. (2026) identified good physical health, social support and exposure to green spaces as protective factors, and added behavioral adaptive capacity, personal sensitivity to heat and inequalities in exposure. In Irbid, apartment residents reported greater perceived stress and poorer sleep quality than those living in houses; the author linked these differences more to perceived deficits in shade and ventilation than to housing type per se (Obeidat, 2026).

The Well-being During the Hot Months dimension captures these aspects, framed positively: feeling in good spirits during the hot season (R6), heat-related irritability (R7, reverse-scored), energy for activities in summer (R8), the ability to rest well on hot days (R9), and feeling calm inside the home (R10). After R7 is recoded, a higher score indicates greater well-being during the hot months.

ADJUSTMENT OF DAILY ACTIVITIES TO HEAT

People modify their behavior in response to heat. The most common strategies include using fans and air conditioning, staying indoors, and shifting daily schedules, but their adoption is limited by economic constraints and by risk perception. In Puerto Rico, fewer than half of the respondents perceived heat as a high risk to their health, and access to cooling was restricted by economic factors and by infrastructure instability (Guzman-Colon et al., 2025).

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

In the Netherlands, people of lower socioeconomic position adopted more protective behaviors during a heat wave, albeit mainly low-cost ones, whereas risk perception remained low across all groups (van de Kamp et al., 2026).

Adjusting activities is a double-edged strategy. On the one hand, it protects against exposure; on the other, it may reduce physical exercise, social contact and the use of public space, which are themselves resources for well-being (Baecker et al., 2025).

The availability of vegetation and cool spaces in the surrounding environment is associated with lower heat-related morbidity and mortality and with favorable effects on mental health (Nazish et al., 2024); residents of Xi'an recognized the cooling effect of green spaces and water (Zhang et al., 2023).

The Adjustment of activities to heat dimension includes changing the times for going out (R11), avoiding walking around the housing development at midday (R12), engaging in outdoor activities at any time of day (R13, reverse-scored), planning outings according to the temperature (R14), and spending more time indoors during the hot months (R15).

HOUSING AND RESIDENTIAL DEVELOPMENTS IN HOT CLIMATES

In housing developments, urban and architectural design shapes heat exposure through lot size, orientation, materials, vegetation and the proportion of paved surfaces.

In the Urbi Villa del Cedro housing development in Culiacán, Barraza-Bracamontes et al. (2022) combined a questionnaire with thermal, acoustic and lighting measurements and found that most of the dwellings fell within a comfort range calculated for the city, but that their occupants described them as very hot and kept the air conditioning running.

In Hermosillo, which has a hot, dry climate, Muñoz López et al. (2023) compared the energy consumption and emissions of the predominant type of social housing with those of a dwelling built in accordance with energy efficiency standards and found higher emissions in the former.

These findings suggest that the experience of heat in housing developments depends on the outdoor environment as well as on the thermal performance of the dwelling and on each household's resources for cooling or heating it. A perception instrument does not replace physical measurement, but it makes it possible to understand how heat is experienced and how it relates to well-being and to the organization of daily life. Given the cross-sectional design, the relationships between perceived exposure, well-being, and activity adjustment should be understood as associations rather than as dependencies.

METHODOLOGY

DESIGN

A quantitative, non-experimental, cross-sectional study with a descriptive and exploratory scope was conducted. The data correspond to survey wave LEV-0010, "Piloto fraccionamientos · Calor urbano y bienestar," of project FZ-HAB-0005 on the Factoriza UAS platform, and to the frozen dataset DST-0014, with a data cutoff date of 9 October 2026. This survey wave is an independent sample and the only one in the project. Although the project is registered under a mixed-methods approach, the present analysis is limited to the survey component.

POPULATION, SAMPLE, AND DATA CUTOFF

The survey population was defined as individuals aged 18 years or older living in residential subdivisions (fraccionamientos) of Mazatlán. The subdivisions were selected by the project lead; therefore, the selection was non-probabilistic. According to the Factoriza log, 19 individuals opened the questionnaire and 7 completed it; no cases were excluded on quality-control grounds, so 7 cases were analyzed (Table 2).

The analyzed data cut is preliminary: it comprises 7 cases out of a target of 100, and data collection was still open and in the field as of the cut-off date. With 7 cases for 15 items, the ratio is 0.5 cases per item, so the inter-item correlation matrix is not invertible. The adequacy of the data and the sample is the first condition that the methodological literature asks researchers to verify in item factor analysis (Ferrando et al., 2022; Goretzko et al., 2021).

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

INSTRUMENT

The Perceived Urban Heat and Well-Being Scale was administered. It comprises fifteen items with a five-point response format, ranging from Strongly disagree (1) to Strongly agree (5), organized into three dimensions of five items each: Perceived heat exposure (R1 to R5), Well-being during the hot months (R6 to R10), and Adjustment of activities to heat (R11 to R15).

Three items are reverse-worded: R4 ("In my housing development there are cool places to be outdoors"), R7 ("The heat puts me in a bad mood") and R13 ("I do my outdoor activities at any time of day"). These items are already recoded in the data matrix. After recoding, a higher score indicates greater perceived heat exposure, greater well-being during the hot months and greater adjustment of activities to the heat. Table 1 presents the code, dimension, wording and direction of each item.

Table 1. Structure of the instrument.

Code	Dimension	Item	Reverse
R1	Perceived heat exposure	In my neighborhood, the heat is intense during the day	No
R2	Perceived heat exposure	The streets in my residential subdivision build up heat in the afternoon	No
R3	Perceived heat exposure	At night, my neighborhood remains hot	No
R4	Perceived heat exposure	In my neighborhood there are cool places to spend time outdoors	Yes
R5	Perceived heat exposure	The pavement on my street feels very hot when I walk on it	No
R6	Well-being in the hot months	During the hot season, I feel in good spirits	No
R7	Well-being in the hot months	Heat makes me irritable	Yes
R8	Well-being during the warm months	In summer, I feel energetic enough for my activities	No
R9	Well-being during the hot months	I can rest well on hot days	No
R10	Well-being during the hot months	During the hot season, I feel at ease in my home	No
R11	Adjustment of activities to heat	I change my schedule to go out when it is cooler	No
R12	Adjustment of activities to heat	I avoid walking around my neighborhood at midday	No
R13	Adjustment of activities to heat	I do my outdoor activities at any time of day	Yes
R14	Adjustment of activities to heat	I plan my outings according to the day's temperature	No
R15	Adjustment of activities to heat	I spend more time indoors during the hot months	No

Note. Perceived Urban Heat and Well-Being Scale. Five-point response scale (Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree). Reverse-scored items have already been recoded in the delivered data matrix. Source: Factoriza UAS, project FZ-HAB-0005, survey LEV-0010, dataset DST-0014.

PROCEDURE

Responses were collected through the survey questionnaire administered on Factoriza UAS, which records explicit online informed consent before the first item and does not collect identifying data. Factoriza froze dataset DST-0014 with a cryptographic hash, generated the matrix with reverse-scored items recoded, and produced the descriptive, internal-consistency, and within-dimension correlation analyses (runs RUN-00066 to RUN-00072). The complementary analyses were performed using the data file and the item dictionary exported from the platform.

DATA ANALYSIS

In the first stage, Factoriza UAS calculated the mean, standard deviation, skewness, kurtosis, and percentages of responses at the extreme values of each item; the internal consistency of each dimension using Cronbach's alpha (Cronbach, 1951), with the corrected item-total correlation and alpha if item deleted; and the Pearson correlations between the items of each dimension, with 95% confidence intervals obtained through Fisher's transformation.

In a second stage, the program analisis_psicometrico.py, version 1.0, was run in Python 3.13.16 (Python Software Foundation, 2026), with NumPy 2.5.3 (Harris et al., 2020), SciPy 1.18.1 (Virtanen et al., 2020), and pandas 3.0.5. The program applies fixed, explicitly stated procedures, with no

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

manual intervention in the calculations, and excludes items with no variance from all analyses.

The program estimated McDonald's omega total (McDonald, 1999/2013) for each dimension from a one-factor model, without reverse-scoring items; when any item correlates or loads negatively relative to the rest of its dimension, the program does not report omega because the coefficient is no longer interpretable.

It also attempted an exploratory factor analysis of the items that showed variance, preceded by an assessment of overall and per-item sampling adequacy (Lorenzo-Seva and Ferrando, 2021) and a test of sphericity, using parallel analysis to determine the number of factors, minimum residual extraction, and oblimin rotation.

Finally, it estimated the correlation between the mean dimension scores with Spearman's coefficient and its 95% confidence interval, using the Fisher transformation with the standard error from Bonett and Wright (2000).

The reference values for interpreting the psychometric indices are treated as guidelines rather than decision rules (Ferrando et al., 2022). No items were removed; the program flags problematic items and leaves the decision to the authors. Confirmatory factor analysis was not performed and is proposed as future work.

ETHICAL CONSIDERATIONS

Participation was voluntary and anonymous. Factoriza UAS records express informed consent online and does not collect names, email addresses or any other identifying data.

DECLARATION ON THE USE OF ARTIFICIAL INTELLIGENCE

During the preparation of this manuscript, the following were used: the Factoriza UAS platform, for data management and for descriptive, internal consistency and inter-item correlation analyses; a Python analysis program with fixed and validated procedures, for omega, exploratory factor analysis and inter-dimension correlations; and the Claude Opus language model (Anthropic), for running that program, assisted literature searching, drafting and assembling the document from the results. The authors reviewed, corrected and approved the entire text, verified every reference and take full responsibility for the content of the article.

RESULTS
SAMPLE COMPOSITION

Table 2 summarizes the flow of cases. Of the 19 individuals who opened the questionnaire, 7 completed it and were analyzed, with no exclusions for quality control. More than half of those who started the questionnaire did not complete it, a point that should be reviewed during field administration. All analyzed cases answered all fifteen items.

Table 2. Sample composition.

Indicator	Value
Individuals who opened the questionnaire	19
Completed questionnaires	7
Cases excluded by quality control	0
Cases analyzed	7
Items	15

Note. Survey "Piloto fraccionamientos · Calor urbano y bienestar" [Housing developments pilot · Urban heat and well-being] (LEV-0010); population: persons aged 18 years or older residing in housing developments in Mazatlán; territory: Mazatlán, Sinaloa, in housing developments selected by the project lead. Dataset DST-0014, fingerprint 98dfeee8c72e1b7e. Source: Factoriza UAS. Preliminary cut-off: n = 7 out of a target of 100, with the survey still open.

DESCRIPTIVE STATISTICS

Table 3 and Figure 1 present the descriptive statistics. The dimensions showed very different

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profiles. In Adjustment of activities to heat, all means were high: R15, spending more time indoors during the hot months, received the maximum response in all seven cases (*M* = 5.00, *SD* = 0.00), followed by R11, changing schedules to go out when it is cooler (*M* = 4.86, *SD* = 0.38), with 86% of responses at the maximum value; R12, avoiding walking around the housing development at midday (*M* = 4.57, *SD* = 0.53); R14, planning outings according to the temperature (*M* = 4.57, *SD* = 0.79); and R13 in its recoded version, which indicates that most respondents do not carry out their outdoor activities at just any time of day (*M* = 4.29, *SD* = 0.76).

In the Perceived Heat Exposure dimension, the means were also high for the direct items: R3, heat persisting at night (*M* = 4.29, *SD* = 0.76); R2, heat building up in the streets in the afternoon (*M* = 4.14, *SD* = 1.21); R5, hot pavement when walking (*M* = 4.00, *SD* = 1.41); and R1, intense heat during the day (*M* = 3.86, *SD* = 1.35). The distribution of R1 was skewed toward high values (skewness = -1.95) and showed high kurtosis (4.58), which is attributable to a single case that gave the minimum response.

The reverse-scored item R4 had a low mean in its recoded version (*M* = 2.14, *SD* = 1.35), with 43% of responses at the minimum value, indicating that a large proportion of respondents recognize that there are cool places to spend time outdoors in their neighborhood.

Means for Well-being during the hot months were low. Heat-related bad mood, in its recoded version (R7: *M* = 1.14, *SD* = 0.38), had 86% of responses at the minimum value; that is, most respondents strongly agreed that the heat puts them in a bad mood.

Feeling in good spirits during the hot season (R6: *M* = 1.29, *SD* = 0.49) and having energy for activities in summer (R8: *M* = 1.57, *SD* = 0.53) also received very low ratings, whereas resting well on hot days (R9) and feeling calm at home (R10) had intermediate means (*M* = 2.71 in both cases) and the greatest dispersion in the dimension (*SD* = 1.60 and *SD* = 1.25). Overall, this cross-section describes residents who perceive their housing development as hot, report low well-being during the hot months and substantially adjust their activities.

Table 3. Descriptive statistics for the items.

Item	M	SD	Skewness	Kurtosis	Floor	Ceiling
R1	3.86	1.35	-1.95	4.58	14%	29%
R2	4.14	1.21	-1.15	-0.06	14%	57%
R3	4.29	0.76	-0.60	-0.35	14%	43%
R4	2.14	1.35	0.80	-1.28	43%	29%
R5	4.00	1.41	-0.99	-1.20	29%	57%
R6	1.29	0.49	1.23	-0.84	71%	29%
R7	1.14	0.38	2.65	7.00	86%	14%
R8	1.57	0.53	-0.37	-2.80	43%	57%
R9	2.71	1.60	0.98	-0.86	14%	29%
R10	2.71	1.25	0.74	1.49	14%	14%
R11	4.86	0.38	-2.65	7.00	14%	86%
R12	4.57	0.53	-0.37	-2.80	43%	57%
R13	4.29	0.76	-0.60	-0.35	14%	43%
R14	4.57	0.79	-1.76	2.36	14%	71%
R15	5.00	0.00	—	—	100%	100%

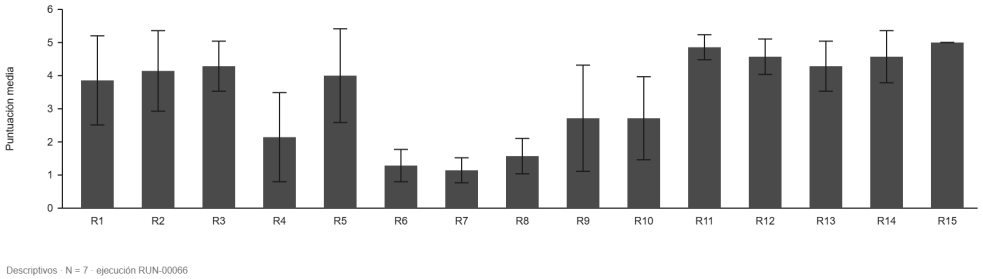
Note.N = 7. Floor and ceiling indicate the percentage of responses at the minimum and maximum values. R15 showed no variation; therefore, its skewness and kurtosis cannot be calculated. The item-total correlation column across the fifteen items is omitted because it combines three dimensions; the item-total correlation by dimension is presented in Table 4. Run RUN-00066 of Factoriza UAS. Preliminary cutoff: n = 7 out of a target of 100, with data collection still open.

INTERNAL CONSISTENCY

Table 4 summarizes the item analysis by dimension computed with Factoriza, and Table 5 presents the coefficients from the complementary software. Perceived heat exposure had α = .636 in both calculations; omega is not reported because R1 correlated negatively with the rest of the dimension (*r* = -.014), and removing this item would raise alpha to .774. R5 (hot pavement) was the most consistent item (.769), followed by R2 (.502) and R3 (.482).

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

Figure 1. Mean scores by item with one-standard-deviation bars.



Within the dimension, the highest correlation was between R2 and R5 (*r* = .873, 95% CI [.350, .981], *p* = .010), followed by R3 and R5 (*r* = .780, 95% CI [.064, .966], *p* = .039), which suggests that heat accumulation in the streets, the persistence of heat at night, and hot pavement form a common core of perceived exposure.

Well-being during the hot months showed a negative alpha, α = -.153, in both calculations. Three of its five items correlated negatively with the rest of the dimension: R7, heat-related bad mood (-.455), R10, calmness at home (-.116), and R9, rest on hot days (-.109); R8 (.263) and R6 (.125) had positive but low correlations. None of the correlations among the items of this dimension had a confidence interval that excluded zero. Given this pattern, the total Well-being score does not represent a common attribute in this cohort and should not be interpreted as such.

Adjustment of activities to heat had α = .683 in the Factoriza calculation with all five items, and α = .729 with ω = .743 in the complementary program, which excluded R15 because it lacked variation. That exclusion explains the difference between the two values: the program's value matches the alpha-if-item-deleted for R15 reported by Factoriza (.729). R13 was the most consistent item (.955), followed by R14 (.700) and R12 (.417), whereas R11 (changing schedules for going out) had a low correlation (.104). The correlations of R13 with R14 (r = .801, 95% CI [.120, .969], *p* = .031) and with R12 (*r* = .766, 95% CI [.031, .963], *p* = .045) were the highest in the dimension.

Table 4. Item analysis by dimension.

Dimension	Item	Corrected item-total r	α if item deleted
Perceived heat exposure	R1	-.014	.774
Perceived heat exposure	R2	.502	.527
Perceived heat exposure	R3	.482	.575
Perceived heat exposure	R4	.415	.571
Perceived heat exposure	R5	.769	.342
Well-being during the hot months	R6	.125	-.267
Well-being during the hot months	R7	-.455	.065
Well-being during the hot months	R8	.263	-.402
Well-being during the hot months	R9	-.109	.000
Well-being during the hot months	R10	-.116	.000
Adjustment of activities to heat	R11	.104	.734
Adjustment of activities to heat	R12	.417	.642
Adjustment of activities to heat	R13	.955	.286
Adjustment of activities to heat	R14	.700	.485
Adjustment of activities to heat	R15	—	.729

Note.N = 7. Scale from 1 to 5; reverse-scored items R4, R7, and R13 are shown recoded. Run RUN-00066 of Factoriza UAS. Preliminary data cut: n = 7 out of a target of 100, with data collection still open.

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

Table 5. Internal consistency by dimension.

Dimension	Items	n	α	ω	Remark
Perceived heat exposure	5	7	.636		Reverse-scored items: R1; ω not interpretable
Well-being during the hot months	5	7	-.153		Items keyed in the opposite direction: R7, R9, R10; ω not interpretable
Adjustment of activities to heat	4	7	.729	.743	

Note.N = 7. The corrected item-total correlation excludes the item itself from the total of its dimension. Cronbach's α for each full dimension (5 items each): Perceived heat exposure = .636 (run RUN-00067); Well-being during the hot months = -.153 (RUN-00069); Adjustment of activities to heat = .683 (RUN-00071). In Adjustment of activities, R15 showed no variance, so its item-total correlation cannot be calculated. When the mean inter-item covariance is negative, alpha is no longer bounded between 0 and 1, which explains the negative value for Well-being during the hot months. Source: Factoriza UAS, Tables 4, 6, and 8 of the package, combined without modifying values. Preliminary data cut: n = 7 out of a target of 100, with data collection still ongoing.

INTERNAL STRUCTURE

The planned exploratory factor analysis could not be estimated in an interpretable manner, and its results are not presented in tables.

With 7 cases and 14 items showing variance, the correlation matrix is not invertible; consequently, the overall measure of sampling adequacy and the item-level sampling adequacy could not be calculated, and the numerical value that the software returns for the sphericity test depends on a near-zero determinant and is not interpretable. Parallel analysis suggested two factors, but with fewer cases than items, this solution is unsupported. These results are reported in the reproducibility appendix, but they provide no evidence about the dimensionality of the instrument and should not be cited as such.

RELATIONSHIP BETWEEN THE DIMENSIONS

Table 6 presents the Spearman correlations among the mean scores of the three dimensions, based on 7 cases. The relationship between Well-being during the hot months and Adjustment of activities to heat was negative, with an interval that excluded zero, ρ = -.896, 95% CI [-.989, -.282], *p* = .006: those who reported greater adjustment of their activities also reported lower well-being.

The intervals for the other two relationships did not exclude zero: Perceived exposure and Activity adjustment, ρ = .648, 95% CI [-.297, .952], *p* = .116, and Perceived exposure and Well-being, ρ = -.639, 95% CI [-.950, .309], *p* = .122. Because the Well-being score had a negative alpha, its correlation with the other dimensions should be interpreted with particular caution, and with 7 cases the width of the intervals indicates a very imprecise estimate.

Table 6. Correlations between dimensions.

Dimension pair	n	ρ	IC 95 %	p
Perceived heat exposure and well-being during the hot months	7	-.639	[-.950, .309]	.122
Perceived Heat Exposure and Adjustment of Activities to Heat	7	.648	[-.297, .952]	.116
Well-being in the hot months and Adjustment of activities to heat	7	-.896	[-.989, -.282]	.006

Note. α = Cronbach's alpha; ω = McDonald's omega total from a one-factor minimum residual model, without reverse-scoring items. Complete cases per dimension. Source: Prepared by the authors using analisis_psicometrico.py 1.0 (Python 3.13.16), dataset DST-0014_FZ_HAB_0005. R15, which showed no variance in the data cut, was excluded from the calculation; therefore, Adjustment of Activities to Heat was estimated with 4 items. Preliminary data cut: n = 7 of a target of 100, with data collection ongoing.

DISCUSSION OF RESULTS

The purpose of this study was to describe the initial performance of a scale of perceived urban heat and well-being among residents of housing developments in Mazatlán. The central finding is uneven across dimensions.

Perceived Heat Exposure showed moderate internal consistency, which would increase

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

without R1; Activity Adjustment to Heat showed the highest consistency of the three, although one of its items had no variance; and Well-being During the Hot Months did not behave as a scale.

With 7 cases, all coefficients are provisional: the simulation literature on alpha and omega coefficients has relied on much larger samples (Malkewitz et al., 2023), and the internal structure could not be estimated.

The descriptive profile is consistent with the literature on the experience of heat in hot cities. The perception of intense heat in the streets, at night, and on the pavement matches Irbid residents' assessment of the heat island in their neighborhood (Obeidat, 2026) and the description of homes in a Culiacán housing development as very hot (Barraza-Bracamontes et al., 2022).

The high ratings given to nighttime heat are relevant because nighttime exposure has been associated with heat-related symptoms (Guzman-Colon et al., 2025) and with poorer sleep quality (Chevance et al., 2024).

That most participants acknowledged the existence of cool places to spend time outdoors, even as they avoided walking at midday, suggests that these places are not sufficient to sustain outdoor activity during the hottest hours of the day. These correspondences are descriptive: the study did not measure the temperature of the housing developments, so perceptions cannot be linked to the physical intensity of the heat island.

The low well-being scores, particularly heat-related irritability and lack of energy in summer, are consistent with the mechanisms described in the literature, such as psychological stress, fatigue, and sleep disruption (Baecker et al., 2025), and with epidemiological evidence linking extreme heat to an increased risk of mental and behavioral disorders (Li et al., 2023).

However, the dimension did not show internal consistency. One possible explanation is that it combines items describing mood states, such as good spirits and bad mood, with items that depend on housing conditions, such as resting well and feeling calm at home, which could vary with the availability of air conditioning.

The literature shows that access to fans and air conditioning depends on economic resources (Guzman-Colon et al., 2025), so two people with the same discomfort from the heat could rest very differently at home. This hypothesis cannot be tested with the available data because the questionnaire did not record home climate control.

The reverse-scored items did not show a single pattern. R13, in Activity Adjustment, was the most consistent item in its dimension. R4, in Perceived Exposure, had a positive item-total correlation (.415), whereas R7, in Well-being, correlated negatively with the remaining items (-.455).

Scales with items keyed in both directions require more careful reading, and a proportion of respondents respond inconsistently to the positively and negatively worded items of the same dimension (Steinmann et al., 2022); detecting these responses can appreciably reduce wording effects (García-Batista et al., 2021).

For R7, almost all responses were concentrated on a single value, which reduces its variance and makes any correlation unstable, so its behavior could reflect this lack of variation more than the reverse wording.

The negative correlation between Well-being and Activity adjustment, the only one with an interval that excluded zero, is consistent with the idea that modifying daily life because of the heat has costs for well-being, through reduced exercise, social contact and use of public space (Baecker et al., 2025), but also with the reverse interpretation, whereby those who feel worst in summer are the ones who shelter the most.

The cross-sectional design does not allow us to distinguish between the two, and the lack of consistency in Well-being means that this correlation must be treated as a signal for the definitive analysis rather than as a finding. The concentration of Activity Adjustment responses at high values, with no variation in R15, also indicates that adjustment to heat is almost universal in this group, which limits the instrument's ability to discriminate between individuals.

Finally, response quality should be reviewed before the final analysis, because in small samples careless or inconsistent response patterns can markedly distort correlations (Ward and Meade, 2023).

CONCLUSIONS

The study met its objective within the scope permitted by a preliminary data cut of 7 cases. In its pilot data collection, the perceived urban heat and well-being scale of project FZ-HAB-0005 showed moderate internal consistency for Perceived heat exposure (α = .636), higher consistency for Adjustment of activities to heat (α = .729 and ω = .743 without the invariant item R15), and a

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

negative coefficient for Well-being during the hot months (α = -.153).

The exploratory factor analysis could not be estimated in an interpretable way because the sample had fewer cases than items. The relationship between Well-being and Activity adjustment was negative, with an interval that excluded zero, but the lack of internal consistency of Well-being precludes interpreting this relationship. The results do not yet provide evidence of structural validity, but they describe residents who perceive their housing development as hot, report low well-being during the hot months, and make intensive adjustments to their activities.

The limitations are substantial. The sample of 7 cases, against a target of 100 and with only 0.5 cases per item, precludes estimation of the internal structure and renders all statistics unstable. In addition, data collection was still ongoing, and more than half of those who started the questionnaire did not complete it.

The residential developments were selected by the project lead; no information is available on the respondents, the type of housing, or air conditioning, and one of the items showed no variation. The physical component of the mixed-methods pathway is not part of the analyzed data, so the study did not measure the urban heat island; its results refer only to perception. The cross-sectional design precludes establishing dependence relationships. In addition, no confirmatory factor analysis was performed.

Several decisions for the authors follow from these results. The first is to review the Well-being dimension during the hot months and to assess whether mood states should be separated from conditions of rest and tranquility at home. The second is to review R1 in Perceived exposure and the case with contradictory responses.

The third is to assess whether R15 and R11 retain discriminatory capacity in a larger sample, or whether they should be reworded to reduce the concentration of responses at the maximum value. The fourth is to verify the recoding of R4, R7, and R13. The fifth is to record the type of dwelling, the available climate control, and the administration period. None of these decisions was made in the present analysis, which retains the original fifteen items.

For future work, we propose completing data collection up to the planned target, repeating the exploratory factor analysis when the number of cases permits, and then evaluating the resulting structure through confirmatory factor analysis in an independent sample.

The physical component of the mixed-methods approach, involving measurements of air and surface temperature in the housing developments studied, would make it possible to relate perception to heat island intensity, as recommended by studies that point to the lack of in situ measurements (Borbolla Gaxiola et al., 2024). An instrument with documented validity evidence would allow vegetation, shade and the design of Mazatlán's housing developments to be directed toward the well-being of their residents, in line with the evidence on the role of green spaces in coping with heat (Nazish et al., 2024).

https://doi.org/10.62486/978-9915-9966-6-0.Ch03

REFERENCES

Baecker, L., Iyengar, U., Del Piccolo, M. C., y Mechelli, A. (2025). Impacts of extreme heat on mental health: Systematic review and qualitative investigation of the underpinning mechanisms. *The Journal of Climate Change and Health*, *22*, Artículo 100446. https://doi.org/10.1016/j.joclim.2025.100446
Baecker, L., Khan, M., Iyengar, U., Tadayon, A., y Mechelli, A. (2026). Extreme heat and mental health: Systematic review and qualitative investigation of risk and protective factors. *Psychological Medicine*, *56*, Artículo e219. https://doi.org/10.1017/S0033291726105169
Barraza-Bracamontes, C., Íñiguez-Ayón, Y. P., Íñiguez-Sepúlveda, C. D., y Bojórquez-Morales, G. (2022). Habitabilidad de la vivienda social. Caso: Fraccionamiento Urbi Villa del Cedro, Culiacán, Sinaloa. *Revista de Ciencias Tecnológicas*, *5*(4), 387–406. https://doi.org/10.37636/recit.v54387406
Bonett, D. G., y Wright, T. A. (2000). Sample size requirements for estimating Pearson, Kendall and Spearman correlations. *Psychometrika*, *65*(1), 23–28. https://doi.org/10.1007/BF02294183
Borbolla Gaxiola, C., Osuna Gallardo, M. G., y Zazueta Medina, L. R. (2024). Caracterización de las islas de calor urbanas superficiales en una agrociudad. El fenómeno de isla de frío urbano en Culiacán, México. *Quivera. Revista de Estudios Territoriales*, *26*(2), 73–90. https://doi.org/10.36677/qret.v26i2.22970
Byun, G., Choi, Y., Foo, D., Stewart, R., Song, Y., Son, J.-Y., Heo, S., Ning, X., Clark, C., Kim, H., Michelle Choi, H., Kim, S., Kim, S.-Y., Burrows, K., Lee, J.-T., Deziel, N. C., y Bell, M. L. (2024). Effects of ambient temperature on mental and neurological conditions in older adults: A systematic review and meta-analysis. *Environment International*, *194*, Artículo 109166. https://doi.org/10.1016/j.envint.2024.109166
Chevance, G., Minor, K., Vielma, C., Campi, E., O'Callaghan-Gordo, C., Basagaña, X., Ballester, J., y Bernard, P. (2024). A systematic review of ambient heat and sleep in a warming climate. *Sleep Medicine Reviews*, *75*, Artículo 101915. https://doi.org/10.1016/j.smrv.2024.101915
Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555
Ferrando, P. J., Lorenzo-Seva, U., Hernández-Dorado, A., y Muñiz, J. (2022). Decalogue for the factor analysis of test items. *Psicothema*, *34*(1), 7–17. https://doi.org/10.7334/psicothema2021.456
García-Batista, Z. E., Guerra-Peña, K., Garrido, L. E., Cantisano-Guzmán, L. M., Moretti, L., Cano-Vindel, A., Arias, V. B., y Medrano, L. A. (2021). Using constrained factor mixture analysis to validate mixed-worded psychological scales: The case of the Rosenberg Self-Esteem Scale in the Dominican Republic. *Frontiers in Psychology*, *12*, Artículo 636693. https://doi.org/10.3389/fpsyg.2021.636693
Goretzko, D., Pham, T. T. H., y Bühner, M. (2021). Exploratory factor analysis: Current use, methodological developments and recommendations for good practice. *Current Psychology*, *40*(7), 3510–3521. https://doi.org/10.1007/s12144-019-00300-2
Guzman-Colon, B., Guido, Z., Amaya-Ardila, C. P., Cabrera-Rivera, L. T., y Méndez-Lázaro, P. A. (2025). Heat risk perception and vulnerability in Puerto Rico: Insights for climate adaptation in the Caribbean. *International Journal of Environmental Research and Public Health*, *22*(8), Artículo 1197. https://doi.org/10.3390/ijerph22081197
Harris, C. R., Millman, K. J., van der Walt, S. J., Gommers, R., Virtanen, P., Cournapeau, D., Wieser, E., Taylor, J., Berg, S., Smith, N. J., Kern, R., Picus, M., Hoyer, S., van Kerkwijk, M. H., Brett, M., Haldane, A., Fernández del Río, J., Wiebe, M., Peterson, P., . . . Oliphant, T. E. (2020). Array programming with NumPy. *Nature*, *585*(7825), 357–362. https://doi.org/10.1038/s41586-020-2649-2
Li, D., Zhang, Y., Li, X., Zhang, K., Lu, Y., y Brown, R. D. (2023). Climatic and meteorological exposure and mental and behavioral health: A systematic review and meta-analysis. *Science of the Total Environment*, *892*, Artículo 164435. https://doi.org/10.1016/j.scitotenv.2023.164435
Lorenzo-Seva, U., y Ferrando, P. J. (2021). MSA: The forgotten index for identifying inappropriate items before computing exploratory item factor analysis. *Methodology*, *17*(4), 296–306. https://doi.org/10.5964/meth.7185
Malkewitz, C. P., Schwall, P., Meesters, C., y Hardt, J. (2023). Estimating reliability: A comparison of Cronbach's α, McDonald's ωt and the greatest lower bound. *Social Sciences & Humanities Open*, *7*(1), Artículo 100368. https://doi.org/10.1016/j.ssaho.2022.100368
McDonald, R. P. (2013). *Test theory: A unified treatment*. Psychology Press. https://doi.org/10.4324/9781410601087 (Obra original publicada en 1999)
Muñoz López, M. T., Gutiérrez Sánchez, L. M., y Quintana Pacheco, J. (2023). De lo ideal a lo real en eficiencia energética de la vivienda tipo interés social: caso Hermosillo, Sonora, México. *Contexto. Revista de la Facultad de Arquitectura de la Universidad Autónoma de Nuevo León*, *17*(26), 51–70. https://doi.org/10.29105/contexto17.26-373
Nazish, A., Abbas, K., y Sattar, E. (2024). Health impact of urban green spaces: A systematic review of heat-related morbidity and mortality. *BMJ Open*, *14*(9), Artículo e081632. https://doi.org/10.1136/bmjopen-2023-081632
Obeidat, B. (2026). Dwelling form and heat-related well-being in a semi-arid city: A cross-sectional survey of apartment and detached-house residents in Irbid, Jordan. *Journal of Urban Health*, *103*(1), 182–200. https://doi.org/10.1007/s11524-025-01056-w
Python Software Foundation. (2026). *Python* (Versión 3.13.16) [Software]. https://www.python.org/
Steinmann, I., Strietholt, R., y Braeken, J. (2022). A constrained factor mixture analysis model for consistent and inconsistent respondents to mixed-worded scales. *Psychological Methods*, *27*(4), 667–702. https://doi.org/10.1037/met0000392
van de Kamp, E., Schneider, F., Daanen, H., y Huynen, M. (2026). Comparing heatwave experiences, behaviors, and risk perceptions across high-risk populations in the Netherlands: A cross-sectional survey study. *The*

Journal of Climate Change and Health, *29*, Artículo 100689. https://doi.org/10.1016/j.joclim.2026.100689
Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., Burovski, E., Peterson, P., Weckesser, W., Bright, J., van der Walt, S. J., Brett, M., Wilson, J., Millman, K. J., Mayorov, N., Nelson, A. R. J., Jones, E., Kern, R., Larson, E., . . . Vázquez-Baeza, Y. (2020). SciPy 1.0: Fundamental algorithms for scientific computing in Python. *Nature Methods*, *17*(3), 261–272. https://doi.org/10.1038/s41592-019-0686-2
Ward, M. K., y Meade, A. W. (2023). Dealing with careless responding in survey data: Prevention, identification, and recommended best practices. *Annual Review of Psychology*, *74*, 577–596. https://doi.org/10.1146/annurev-psych-040422-045007
Zhang, T., Huang, R., Yang, M., Lin, G., Ma, X., Wang, X., y Huang, Q. (2023). Perceptions of the health risk from hot days and the cooling effect of urban green spaces: A case study in Xi'an, China. *Frontiers in Public Health*, *11*, Artículo 1211164. https://doi.org/10.3389/fpubh.2023.1211164

https://doi.org/10.62486/978-9915-9966-6-0.Ch03