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Sheltered from the heat? How tents and shade covers may unintentionally increase air temperature exposures to unsheltered communities

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ABSTRACT

Objective: Heat vulnerability and homelessness are central public health concerns in cities globally, and public health implementation should address these two challenges in tandem to minimize preventable heat-related morbidity and mortality. Populations facing unsheltered homelessness use tents (or similar shelters) with shading features to minimize sun and heat exposure. This study evaluates the efficacy of different tent cover (shading) materials and how they moderate the in-tent air temperature (T_{air}) exposures of tent users during extreme summer conditions.

Study design: Within-tent T_{air} monitoring using Kestrel Drop devices occurred across three full typical summer days in Phoenix, Arizona in July 2022.

Methods: In-tent T_{air} were statistically compared between six small side-by-side identical tents with different cover materials (control (no cover), mylar, white bedsheet, tarp, sunbrella fabric, aluminum foil), as well as with ambient T_{air}.

Results: Using any tent resulted in higher daytime in-tent T_{air} than ambient T_{air}. Further, compared to a control tent, the T_{air} within tents shaded with sunbrella, tarp, and white bedsheet had significantly higher T_{air} at all times (2.36 °C, 2.46 °C, and 1.11 °C higher T_{air}, respectively), controlling for T_{air} and day/night.

Conclusion: Adding cover materials over tents may increase heat risk to an already vulnerable population at certain times of the day. Higher in-tent T_{air} is attributable to the reduced ability for heat and vapor to escape, largely due to reduced ventilation (mixing). Local authorities and welfare associations should reconsider using unventilated tents for shading and promote more widespread, ventilated tents and shade to ensure that prevention efforts do not further marginalize the most vulnerable. Future work should incorporate more comprehensive measurements of solar radiation to quantify overall heat stress for exposure reduction techniques.

1. Introduction

Those experiencing unsheltered homelessness[a] are highly predisposed to severe outdoor conditions exacerbated by intrinsic socio-demographic attributes, making them highly susceptible to hazards [1–3]. For instance, those experiencing homelessness have a 17.5-year shorter life span than the general populace, thus it is critical to align public health interventions with the unique challenges of those experiencing homelessness [4]. Specifically, extreme heat events and outdoor heat exposures are central public health concerns [5–9]. In Maricopa County, Arizona, the homeless population—both unsheltered and sheltered[b] —accounted for approximately 59.7 % and 42.4 % of the total heat-related deaths for 2020 and 2021, respectively [10]. In 2020, a staggering 2.3 % of the known homeless population of Maricopa County died due to heat-related causes. Moreover, Longo et al. [11] found that the population experiencing homelessness faces 241 % higher heat stress than college students in Phoenix, Arizona. These statistics demonstrate the disproportionate heat-health outcomes among people experiencing homelessness, and any public health intervention strategy must be inclusive and comprehensive to address drivers of differential health outcomes, especially for populations underrepresented and marginalized in research. Accordingly, this study examines the effectiveness of

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[a] Unsheltered homeless refers to populations sleeping on the streets or places not meant for human habitation [34].
[b] Sheltered homeless refers to populations staying in emergency shelters, transitional housing, or safe haven programs [34].

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tents and tent covers as a public health intervention strategy in modifying the in-tent thermal experience of people experiencing homelessness.

Factors amplifying the heat susceptibility of the unsheltered homeless include the prevalence of chronic ailments, higher rates of respiratory disorders, mental illnesses, sheltering in high-risk urban areas, inequitable policies and practices, and greater heat exposure [12–14]. Within Maricopa County, the point-in-time count of those experiencing homelessness showed a higher rate of increase of unsheltered (34 %) versus sheltered (9 %) people between 2020 and 2022, translating to increased heat risks as communities experiencing homelessness are unable to avoid direct heat exposure [7,15]. Globally, homelessness constitutes a public health challenge [16]; thus, it is crucial to investigate how certain public health interventions address the specific needs of disproportionately vulnerable groups toward strengthening subsequent public health strategies.

Climate projections indicate an increasing trend of extreme heat intensity, magnitude, and duration of heat events, which could mean a higher predisposition in the homeless community [17,18]. Climate change exacerbates heat vulnerability, especially among the socially disadvantaged, translating to increased cases of heat-related morbidity and mortality. These risks compound the vulnerability of the unsheltered homeless, amplifying heat susceptibility [19,20–22]. Therefore, there is a compelling need to understand the effectiveness of adaptation and/or mitigation strategies embraced by people experiencing homelessness. Attempts to bridge health disparities must also consider homelessness to obtain tangible solutions, as public health cannot be disassociated from the larger socioeconomic context [1,9,23,24].

The co-occurrence of heat vulnerability and homelessness remains understudied and has received minimal academic and policy interest. Heat events manifest as a multiplicity of outcomes ranging from health deterioration, decreased physical and mental well-being, increased financial challenges, mobility impairment, and impediments to social services [25,26]. In this regard, differential implications of heat exist [1,8], which are less understood yet could have profound implications on institutional and individual response strategies. People experiencing homelessness are not well represented in disaster health planning [7], and the response/mitigation measures instituted fail to reflect their heat-hazard context [27,28]. Many response plans adopt a 'treatment first model'[c] instead of a 'housing first model'[d] [17,23,29].

Moreover, current heat alerts fail to reach the unsheltered homeless population, meaning that the nature of heat-hazard response could lead to maladaptation [1]. For instance, the homeless prevention program only served 676 individuals and families in Phoenix for the financial year 2022, yet the total number of people experiencing homelessness was 9,026, indicating that a large proportion of the most at-risk population is highly exposed to the extremely hot summer conditions [30]. More so, the legal and social invisibility associated with homelessness excludes them from conventional databases resulting in policy stigmatization, inefficiencies, and inconsideration [31,32]. Therefore, it is imperative to specifically study such marginalized groups. One strategy often used to help minimize heat exposure for unsheltered communities during the hot summer months involves providing tents of various types, and adding more material as shade to reduce sun exposure. However, the effectiveness of such a strategy in safeguarding against heat exposure has not been examined.

Accordingly, this study evaluates the efficacy of different tent cover (shading) materials and how they moderate the air temperature of tent users during extreme summer conditions in Phoenix, Arizona. Results act as a means of informing targeted responses for the most vulnerable population. The study deviates from merely quantifying sociodemographic dimensions of vulnerability to demonstrating situational factors affecting thermal exposure in unhoused communities and providing next steps and recommendations.

2. Methods

2.1. Study site, data collection, experiment setup

Phoenix, located in the Sonoran Desert (33.44 N, 112.02 W), experiences extreme heat in the summer (June–August) with average minimum and maximum daily temperatures of ~83 °F (28.3 °C) and ~107 °F (41.6 °C), respectively (2010–2020 period) [33]. Despite these extreme conditions, the point-in-time counts of the people experiencing homelessness indicated a 22 % (total count of 9026) increase for 2022 compared to 2020. The sheltered homeless count was 3997 (9 % increase), while the unsheltered homeless were 5029 (34 % increase) [34]. Although the human services campus (a partnership of organizations with a shared goal of ending homelessness) served approximately 12, 180 individuals in 2022, the unsheltered homeless numbers continue to rise across the area while they remain highly vulnerable to hazards given that they cannot avoid the exposure. The unsheltered homeless often use tents, whose efficacy in reducing heat vulnerability has not been examined.

We considered a typical summertime period in Phoenix with data collection lasting three days and three nights (6.00 p.m. on 7/8/2022 to 6.00 p.m. on 7/11/2022), where the weather conditions fairly represented average summer conditions for the City of Phoenix. The experimental setup used six identical small tents side-by-side on an open concrete surface (basketball court) at a local school, each receiving a different cover material. The choice of identical tents allows for uniform comparison across shade types, and the tents' design, size, and material reflect the standard tent used by people experiencing homelessness in Phoenix. The basketball court was selected as the surface of choice as it reflects nearly exact surface conditions in the streets of Phoenix (concrete or asphalt surfaces) where the people experiencing homelessness install their tents in the open air. The first tent (control) did not have any cover material. The cover materials' albedos for tents 2 through 6 are as follows (see also Fig. 1).

Tent 2: mylar rescue blanket, 92 % albedo
Tent 3: white cotton bedsheet, 57 % albedo
Tent 4: blue tarp, 43 % albedo
Tent 5: sunbrella fabric 67 % albedo
Tent 6: aluminum foil on corrugated cardboard (79 % albedo)

Albedos were determined by using the ratio of outgoing to incoming solar radiation with an NR01 Net Radiometer (Huskeflux, Inc.). The choices of these cover materials and the surface were informed by observations made during rescue missions at the Human Services Campus in Downtown Phoenix, whose primary objective is to provide severely needed resources for populations experiencing homelessness.

Environmental measurements were taken with Kestrel sensors[e]. First, a 5400 Kestrel Heat Meter monitored ambient conditions in the areas and was situated on a tripod (1 m height) approximately 10 m from the tents (see Fig. 1). Variables used in analyses include ambient T_{air}, globe temperature, relative humidity (RH), and wind speed. Second, D2 Kestrel Drops monitored the in-tent T_{air} and RH; two devices were hung 1 foot from the top-center inside each tent using cable ties. Both sensor types collected 5-minute data (see [35] for sensor

[c] Treatment first model focuses on problems associated with homelessness such as substance abuse, deteriorating health, and food [17].

[d] Housing first model prioritizes secure tenancy for the affected populations, recognizing that other associated problems will not be adequately dealt with when people are on the street [17].

[e] A kestrel sensor is a handheld weather station that can measure temperature, relative humidity, wind speed, and dew point among other weather parameters [42].

Fig. 1. Experimental setup of 6 identical tents, shown from left to right with different cover materials, as follows: control (no cover), mylar rescue blanket, white bedsheet, tarp, sunbrella fabric, and aluminum foil on cardboard. a: The Kestrel Heat Stress Meter (far left) on the tripod can be seen alongside the six tents. b: Side view of the six tents. c: Set up of Kestrel Drop sensors within the tents.

information).

Prior to field data collection, all Kestrels devices were calibrated in a controlled heat chamber (T_{air} of 35 °C and RH of 30 %) for 2 hours at 5-min sampling intervals. Sensor-specific offsets were calculated; the average value of the offsets was used to determine deviations of each sensor and applied to the experimental data collected at the field site.

2.2. Data preparation and analysis

The average 5-min values of T_{air} and RH of the two Kestrel Drops in each tent per time stamp for the three days were used in the analysis. The unique calibration offsets were applied to each sensor before analysis.

Data analysis first entailed the computation of descriptive statistics using rain cloud diagrams and boxplots at three levels: combined day and night, daytime only, and nighttime only informed by sunrise and sunset times. Daytime occurred from 5.30 a.m. to 7.45 p.m., whereas nighttime ranged between 7.50 p.m. and 5.25 a.m. The classification translated to 517 daytime observations and 348 nighttime observations across the three days. The means and medians of each experimental tent were compared to each other using the Kolmogorov-Smirnov test and the Mann U Whitney test, respectively, to determine whether there were significant differences between the compared groups. These tests are non-parametric and sensitive to differences in shape and spread of the distribution of samples, thus critical to ascertaining whether any two samples are from the same distribution, or are significantly different [36,37]. Bonferroni adjustments were applied to the resultant p-values, reducing the risk of obtaining a false positive result.

We conducted a series of regression analyses to account for other variables that could be influencing the in-tent temperature differences while determining specific times of the day when exposure is most severe. Specific combinations and interactions of weather variables could provide a hint as to the most crucial variables that policymakers could target to reduce in-tent temperature. The following regression models with increasing model complexity were conducted while using the control tent as the base reference: (1) Regressing tent categories against tent sensor readings to ascertain differences between the tents without accounting for any control variable; (2) Adding ambient T_{air} as a control variable to model 1 to examine the effects of T_{air} on in-tent temperature differences; (3) Adding day/night binary classification to model 2 which could inform in-tent temperature variability during the daytime and nighttime, while illuminating when the greatest opportunity to mitigate occurs; (4) Breaking day and night classifications into finer periods of 4–5 hours, which could inform the specific time of the day when optimal exposure occurs when using the tents and tent covers. For model 4, the finer time chunks were as follows: Daytime 1 (D1), 5.45 a.m.–10.30 a.m.; D2, 10.35 a.m. to 3.00 p.m.; D3, 3.05 p.m.–7.45 p.m.; Nighttime 1 (N1), 7.50 p.m. to 12.30 a.m.; N2, 12.35 a.m. to 5.25 a.m. Nighttime 2 was used as the reference time classification for model 4.

3. Results

3.1. Overview

Ambient weather conditions on test days reached an average T_{air} of 38 °C (28.1–47.4 °C min–max average) (Table 1), with low daytime RH (23 %) and variable winds, which were calmer in the nighttime (0.68 ms^{-1}) versus daytime (0.94 ms^{-1}). Skies were clear with incoming maximum solar radiation reaching 974Wm^{-2} on the test days.

Results of average T_{air} values between tents and ambient conditions are presented in Table 1, with significance test results provided in Fig. 2, while Fig. 3 shows significance test results using the median value. The time of day is found to be an important factor in assessing the differences between the covered tents with either ambient T_{air} or the control tent. In general, the use of any tent resulted in higher daytime in-tent T_{air} than the ambient T_{air}, yet lower in-tent T_{air} at night. Further, shaded tents had equal or higher T_{air} at all times of day compared to the control tent with no additional shade.

3.2. In-tent air temperatures versus ambient air temperature

For D&N combined and daytime only, the mean in-tent T_{air} values across all tents were significantly higher than the ambient T_{air} (Table 1, Fig. 2), yet at nighttime, these differences were reversed and conditions were cooler in the tents versus ambient T_{air}. For example, overnight, the mean ambient T_{air} (34.6 °C) was significantly higher than the control tent (33.4 °C), white bedsheet (33.9 °C), sunbrella (34.1 °C) and tarp (33.6 °C) tent covers. At night, the tent shaded by aluminum foil had a significantly higher in-tent T_{air} (34.9 °C) than all other tents and the ambient T_{air} (see Fig. 2).

3.3. Shaded in-tent air temperatures versus control tent

Compared to the control tent, shaded tents were significantly warmer for combined D&N and nighttime, except for the tarp-covered tent overnight. Tents covered by Sunbrella fabric and tarp were respectively the warmest for combined D&N (T_{air} = 41.8 °C and 41.9 °C) and daytime (T_{air} = 47.1 °C and 47.5 °C).

The Kolmogorov-Smirnov tests (mean values) and the Mann U Whitney tests (median values) Comparisons of in-tent T_{air} against ambient T_{air} and the control tent were fairly consistent, yet had minor variations, displayed in Fig. 3.

3.4. Regression model results

The four regression models (Table 2) consistently returned the same results concerning the T_{air} differences between the tents, as detailed above. The only variation was found in the R-squared and Aiken Information Criterion values. The estimates of the tent coefficients were similar across the models, indicating uniform influences of explanatory variables across the tent covers. The in-tent T_{air} values with aluminum foil and mylar covers were not significantly different from the control tent in any of the models, whereas the remaining tents had significantly

Table 1
Descriptive statistics of the ambient temperature (°C) conditions for each tent, averaged across three days. Time classifications are presented in three chunks, including combined day (D) and night (N), daytime-only (D), and nighttime-only (N).

Recordings	Time classification	n	Range	Min	Mean	CI	Max	SD
Control	D&N	865	24.9	27.6	39.5	(±0.43)	52.5	6.46
	D	517	24.8	27.7	43.6	(±0.43)	52.5	4.97
	N	348	10.8	27.6	33.4	(±0.23)	38.4	2.22
Mylar	D&N	865	20.5	30.0	39.7	(±0.38)	50.5	5.76
	D	517	20.5	30.0	43.2	(±0.41)	50.5	4.71
	N	348	8.7	30.4	34.5	(±0.22)	39.1	2.06
White Bedsheet	D&N	865	25.7	29.2	40.6	(±0.47)	54.9	7.04
	D	517	25.7	29.2	45.1	(±0.47)	54.9	5.42
	N	348	9.05	29.4	33.9	(±0.22)	38.4	2.10
Tarp	D&N	865	30.5	29.2	41.9	(±0.59)	59.7	8.85
	D	517	30.5	29.2	47.5	(±0.61)	59.7	7.08
	N	348	8.9	29.3	33.6	(±0.22)	38.2	2.07
Sunbrella	D&N	865	27.4	29.5	41.8	(±0.55)	56.9	8.28
	D	517	27.4	29.5	47.1	(±0.57)	56.9	6.59
	N	348	9.1	29.6	34.1	(±0.22)	38.7	2.13
Aluminum Foil	D&N	865	18.3	30.0	39.5	(±0.35)	48.3	5.22
	D	517	18.3	30.0	42.7	(±0.37)	48.3	4.23
	N	348	8.9	30.7	34.9	(±0.23)	39.6	2.15
Heat Meter (Ambient air)	D&N	865	19.3	28.1	38.0	(±0.30)	47.4	4.57
	D	517	19.1	28.3	40.3	(±0.37)	47.4	4.30
	N	348	11.5	28.1	34.6	(±0.24)	39.6	2.31

n = number of observations, Min = Minimum air temperature, max = Maximum air temperature, SD= Standard Deviation, CI = Confidence Interval.

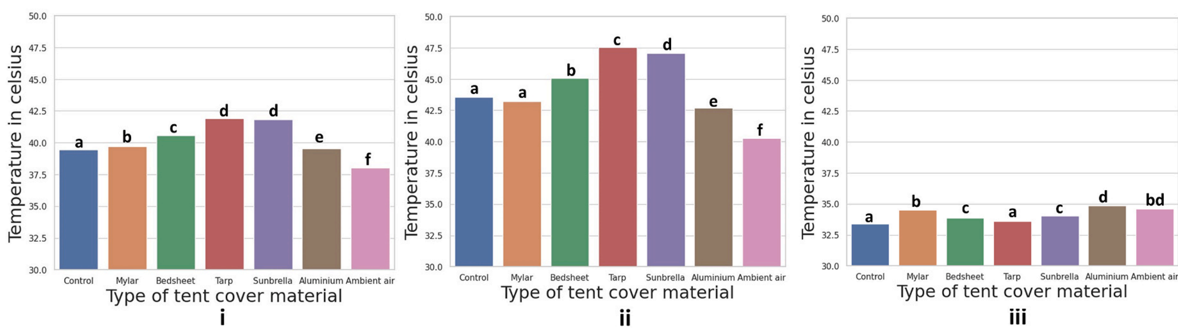

Fig. 2. Mean air temperature (°C) inside each tent and from the ambient sensor. i) Day & night combined, ii) daytime only, iii) nighttime only. Bars with the same letters (e.g., Tarp and Sunbrella in graph i) denote the means are statistically the same (or not statistically significantly different) for the given period using the Kolmogorov-Smirnov test using the mean values.

higher T_{air} than the control tent for all times of the day. Compared to the control tent, aluminum foil, mylar, sunbrella, tarp, and white bedsheet covers were associated with 0.08 °C, 0.23 °C, 2.36 °C, 2.46 °C, and 1.11 °C higher T_{air}, respectively, controlling for T_{air} and time classification as shown in model 3. Specifically, model 1 indicates that average in-tent temperatures are expected to be 39.5 °C, without adding any tent cover, corresponding to the control tent's mean value in Table 1 above. Model 2 indicates that in-tent thermal comfort is largely explained by air temperature because when we control for air temperature the expected average in-tent temperature for the control tent should be −11.9 °C.

Additionally, compared to nighttime in-tent T_{air}, daytime in-tent T_{air} was 5.01 °C higher controlling for tent cover material and ambient temperature as shown in model 3. Model 4 indicates that D2 and D3 time classifications are associated with 15.87 °C and 13.44 °C more in-tent warming compared to N2. The consistency of the results here and in the above tests—even with increasing model complexity and breaking down the time classification into finer periods—indicates that the significant differences between the tents outlined in sections 3.2 and 3.3 are strong. Given the consistency of the results across the models, model 3 parsimoniously explains the differences between the tents and the influences of ambient temperature conditions.

4. Discussion

Rising global temperatures, alongside an increasing number of people experiencing homelessness, present significant public health concerns, necessitating a thorough analysis and the development of targeted heat response strategies to safeguard human lives [38,39]. Tents are often used to help offer a place of refuge and privacy by providing a durable, lightweight, and weather-resistant personal space in place of emergency shelters. Although the provisioning of tents and tent shading is assumed to offer some form of protection against all weather extremes, results show that in the daytime, the T_{air} within a tent, whether covered or uncovered, is higher than the ambient T_{air}, yet lower at night. Thus, based on T_{air} only, tents may not protect the unsheltered homeless from extreme summer air temperatures, as all conditions would cause issues with heat stress; hence alternative sheltered accommodation, such as heat-ready housing, could be implemented as a public health measure. Further, multiple tests show that adding cover materials to shade tents during the summer may cause higher T_{air} exposures during the sweltering Phoenix summer, thus causing higher heat risk. Cooler nighttime in-tent T_{air} may be attributed to cooler in-tent surface temperatures due to shading and well as faster cooling rates after sunset of the tent/shading materials compared to concrete. Overall, shaded tents had equal or significantly higher T_{air} for combined day and night compared to the non-shaded control tent. Based on these results, there is

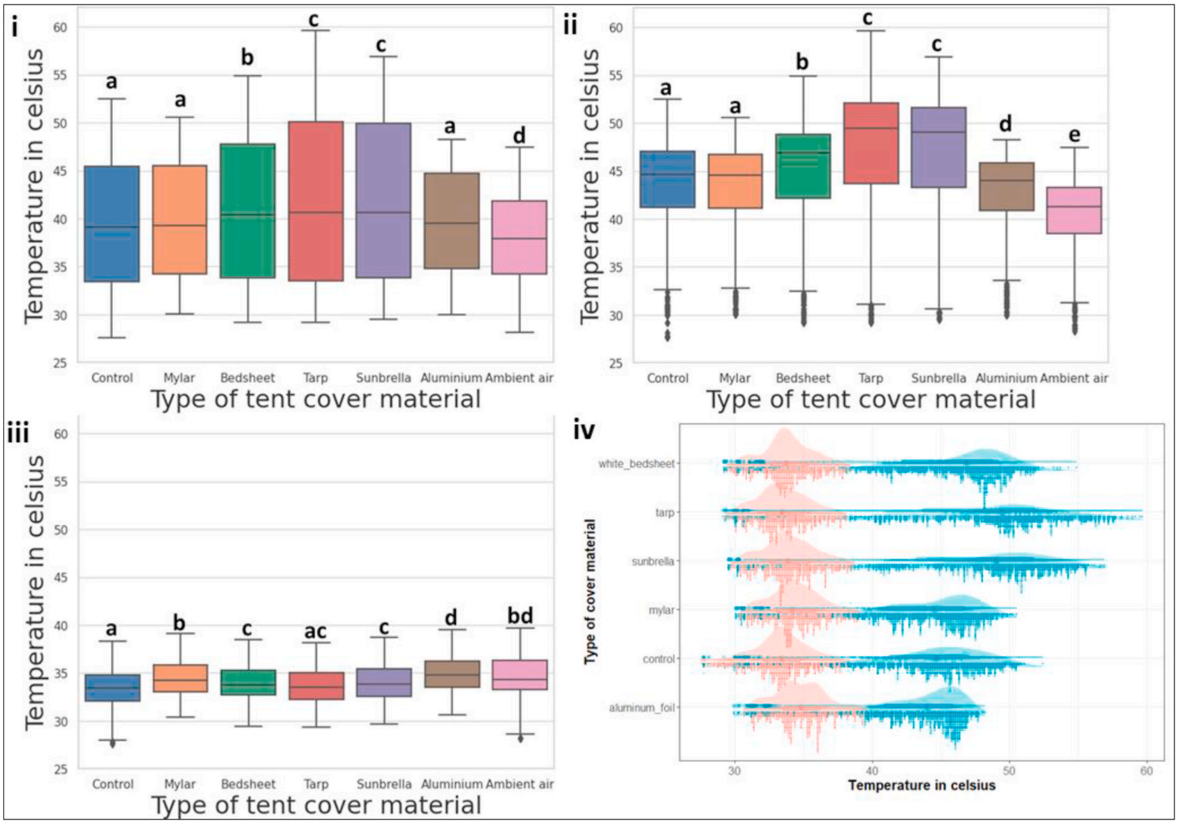

Fig. 3. (i–iii) Box and whisker plots for the combined day and night (i), daytime (ii), and nighttime (iii). Boxplots with the same letters within the graph do not have significant differences in T_{air} based on the median value using the Mann U Whitney test. (iv) Raincloud plot displaying the distribution and frequency of T_{air} values for all tents with cover and the control tent. The blue symbology represents daytime readings and the red symbology represents nighttime readings. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
Summary of regression models, indicating consistency across all four models. Model 1 is a regression of tent categories against temperature values. Model 2 added ambient temperature as a covariate to model 1. Model 3 added binary time classification (day/night) to model 2. Model 4 modified the binary time classification in model 3 into finer chunks of 4–5 h.

	Model 1		Model 2		Model 3		Model 4	
	estimate	p-value	estimate	p-value	estimate	p-value	estimate	p-value
Intercept	39.462	0.000	−11.858	0.000	−2.410	0.000	32.45	0.000
Aluminum foil	0.083	0.807	0.083	0.615	0.083	0.540	–	–
Mylar	0.234	0.490	0.234	0.154	0.234	0.083	–	–
Sunbrella	2.358	0.000	2.358	0.000	2.358	0.000	–	–
Tarp	2.464	0.000	2.464	0.000	2.464	0.000	–	–
Bedsheet	1.105	0.001	1.105	0.000	1.105	0.000	–	–
Ambient T_{air}	–	–	1.350	0.000	1.023	0.000	–	–
Classification	–	–	–	–	5.010	0.000	–	–
Ambient T_{air}:classification	–	–	–	–	–	–	–	–
Classification D1	–	–	–	–	–	–	8.37	0.000
Classification D2	–	–	–	–	–	–	15.87	0.000
Classification D3	–	–	–	–	–	–	13.44	0.000
Classification N1	–	–	–	–	–	–	3.25	0.000
AIC	35,015		0.770		25,463		29,041	
R [2]	0.021		0.770		0.845		0.69	
AdjR [2]	0.020		27,503		0.845		0.69	

AIC = Aiken Information criterion; R^2; AdjR [2] = Adjusted R-squared.

a need for local authorities and welfare associations to reconsider how and when tents are used, as well as perform further testing to assess the entire heat exposure situation more holistically (i.e., integrating solar radiation, wind speed, and humidity into the heat exposure assessment) [40].

The uncovered tent offered cooler thermal conditions based on air temperature exposures compared to those with shade for combined D&N and nighttime. Conditions particularly worsened when using the tarp (the most commonly used form of shade on the street, yet potentially the most hazardous), bedsheet, or sunbrella. Thus, results do not support using tents and tent covers as a mechanism to reduce daytime air temperature exposure. Although there is no other study, to our knowledge, that has examined tent cover impact on T_{air}, a study of stroller coverings was completed during warm weather in Australia [41]. These researchers found that in-stroller temperatures were substantially higher by draping a dry blanket or flannelette cloth, often used for shade, over the stroller, thus worsening conditions for an infant. Including airflow and evaporative cooling was suggested to protect infants during hot weather. Thus, in a similar sense, although the tent covers provide shade to reduce sun exposure, the covers also result in lowered airflow, a build-up of water vapor, and an inability for long- or short-wave radiation to escape the tent. These findings may be crucial to consider for rescue missions and by local governments, public health officials, and general donors from the public to avoid adding cover materials during the summer that may worsen heat vulnerability for the unsheltered. Future research could evaluate the optimal strategies for heat protection during extreme heat which could involve a combination of well-ventilated daytime shade (tarps, trees) and, if possible, intermittent access to climate-regulated indoor areas or large, cooled, reflective tent shelters with adequate airflow. Allowing heat to escape tents through minimizing covers and opening tent windows and doors to avoid trapping heat and moisture will support cooling. However, future research must incorporate solar radiation and wind flow to assess the entire heat exposure situation (i.e., integrating solar radiation, wind speed, and humidity). Furthermore, experiments that allow the opening of tent doors and in-tent mixing of air are crucial for the overall evaluation of the efficacy of tent shading. Also, the housing-first response model guarantees protection against the extreme summer heat. Policies and guidelines related to heat vulnerability should be reviewed periodically, based on science, to ensure that heat mitigation efforts do not further marginalize the most vulnerable, such as those experiencing unsheltered homelessness.

A limitation of our study is that we used an identical series of tents; an opportunity lies in examining different tent designs across the shading materials to establish the relationships between the various configurations. Further, incorporating qualitative data detailing the attitudes and perceptions of people experiencing homelessness and public health practitioners about the use of tents and tent covers could enrich future studies.

5. Conclusion

Homelessness is both a driver and a consequence of poor health, and such populations have limited capacity to moderate their heat exposure translating to amplified heat mortality compared to the general population. This study evaluated the effectiveness of different tent cover materials used by homeless individuals for shade, personal space, and to safeguard themselves against extreme heat exposure in the summer. We established that any enclosed tent can increase daytime temperature exposures relative to the ambient air temperature and that additional tent covers for shading are associated with a higher daytime in-tent air temperature relative to a non-shaded control tent. These findings are crucial for implementing public health strategies concerning heat vulnerability, especially among people experiencing homelessness. Therefore, using tent covers as a mitigation measure may exacerbate the heat risk of the unsheltered homeless. Removing the shade covers from the tents at night would support heat removal from the tent via long-wave emission and airflow. This study supports the evaluation of heat mitigation and adaptation efforts to avoid unintended consequences of maladaptation and propagating further marginalization of the most at-risk groups. Rising global temperatures in tandem with a growing number of individuals experiencing homelessness are central public health challenges, and policy and research efforts should address these two public health concerns toward attaining health equity. Heat vulnerability policies and guidelines should be reviewed periodically to reflect research findings about the most effective passive personal heat reduction interventions. Future studies could incorporate solar radiation measurements and a mixed-method approach, where qualitative data about attitudes and perceptions about the use of tents and tent covers by people experiencing homelessness or local government officials could be captured. Testing multiple tent designs in the future could inform whether in-tent temperatures are dependent on tent design.

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Author statements

The development of the paper was a collaborative effort among the three authors, with contributions for all aspects of the paper being shared: Conceptualization, Jaime, Jennifer, and Joseph; Fieldwork, Jaime, Jennifer, and Joseph; Analysis, Joseph and Jennifer; Writing, Joseph, and Jennifer; Writing, Review and Editing, Jaime, Jennifer, and Joseph. All the authors have read and agreed to the submitted version of the manuscript.

Statement of ethical approval

Ethical approval was not required for this study, as the experimental set-up did not involve human or animal subjects.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2023.100450.

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