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Research article

Tourism-related short-term migration for heat adaptation: Impacts of socio-economic-institutional, climatic, socio-interactive, emotional, and perceptive-behavioral-psychological factors and implications for responsible tourism development

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ABSTRACT

Many cities have launched heat mitigation and adaptation action plans, but the progress and efficiency are far from expected outcomes. Many cities and citizens have been locked into heat-related consequences. To avoid heat-related illnesses, diseases, and deaths, many citizens prefer short-term migration to cool areas for heat relief. Prior studies have explored long-term migration and associated mechanisms in socio-economic dimensions, while short-term migration has not been explored, and the mechanism remains unclear. Furthermore, in alignment with short-term migration for heat relief, some local governments and communities (i.e., in Chongqing, China) promote the cool tourism industry to ensure sound infrastructure and guarantee migrants' health, safety, and wellness, while relevant knowledge is scarce. Therefore, this study empirically investigated heat-related migration and associated mechanisms among 768 respondents in Chongqing, where whose citizens could potentially travel towards cool, mountainous areas for adaptation during extreme heat periods. In particular, the mechanisms were explored in socio-economic-institutional, social-interactive, emotional, climatic, perceptive-behavioral-psychological aspects. The results indicated that urban heat in Chongqing reached a severe level, and more than 50 % of the respondents' daily functioning was severely affected. More than 40 % of the respondents preferred migration; among them, more than 75 % migrated within the province and 55 % preferred migrating to other provinces. Regarding the mechanism, settlement, health, heat-related impacts, perceived severity, emotion, and risk knowledge were not significant drivers of migration decisions, whereas gender, age, education, income, job, information availability, adaptation awareness, and adaptation knowledge were significant drivers. Income and job flexibility were the key drivers of financial and time support. Typically, the more flexible the jobs, the more likely to migrate, and the farther the respondents could migrate. Accordingly, implications for responsible tourism were delineated. Overall, this study advances the knowledge on short-term migration for heat adaptation and responsible tourism development.

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1. Introduction

Many cities worldwide are threatened by increasingly frequent, severe, and intense urban heat events, along with climate change and urbanization [1]. During summer and autumn, long-lasting high temperatures, sometimes accompanied by high humidity, strong solar radiation, and weak winds, significantly elevate the heat stress and deteriorate human thermal comfort [2]. This not only increases the likelihood of illness, disease, and death [3,4] but also reduces outdoor work productivity [5] and affects economic growth [6]. The most prominent heat events occurred in Europe in 2003, causing approximately 72,000 deaths, occurred in Russia in 2010 causing 55,000 deaths, and occurred in Europe in 2022 causing more than 60,000 deaths [7,8]. A series of physiological diseases in respiratory, digestive, skin, cardiovascular, ophthalmological, metabolic, and urinary systems have been documented and verified in numerous studies worldwide [9, 10]. Psychological symptoms such as emotional irritability, difficulty in controlling tempers, low mood, decline in memory, and insomnia have also been reported [9,11]. Furthermore, an urban heat island is a phenomenon that cities are hotter than their surrounding rural and suburban counterparts, suggesting that citizens are generally under more severe heat exposure and stronger impacts [12].

Climate-adaptive urban design, central to citizens' well-being, thermal comfort, health, and safety, has been proposed to improve the resilience to extreme heat. Prior studies have reported green-blue infrastructure, urban morphology modification, and innovative surface materials to intercept solar radiation, improve ventilation, enhance evaporation, and reduce thermal and moisture properties for cooling purposes. Further studies have explored how to optimize the cooling performance of these strategies by tailoring geographic locations, climate backgrounds, development patterns, materials and structural properties, and biological features. Decision support tools have been developed to close the gaps among heat-related sciences, mitigation technologies, and planning and design practices by not only identifying suitable solutions but also evaluating economic, social, and environmental benefits. Many pioneering governments have piloted cooling actions by compiling mitigation guidelines, launching tree-planting activities, and promoting white roof campaigns. However, cities generally have not prepared for heat mitigation owing to socioeconomic and institutional barriers. The conflict between land and spaces, especially in high-density areas, is another constraint for installing, planting, or setting additional cooling interventions. Citizens must withstand strong heat stress, and vulnerable groups such as the elderly, children, and pregnant women may suffer heat-related illnesses and diseases [13].

To protect citizens from heat-related impacts, adaptation solutions have been prioritized by many local governments and communities [14]. Local authorities have enhanced educational and propaganda campaigns to increase awareness and knowledge of urban heat and adaptation [15]. Both public and individual adaptation solutions were standardized [16]. At the individual level, citizens are encouraged to change daily functions, reschedule activities, stay indoors, and adopt air-conditioning (AC) systems [9]. People can enjoy AC cooling indoors during work hours and adopt household AC systems at home [17]. However, this increases electricity consumption and expenditure, and people with a low income may defer AC systems to lower household expenditures, charting a new vulnerable group. At the public level, local governments and community managers assist in citizens' daily normal activities by identifying walkable routes [18], prioritizing useable areas, installing shelters, water refilling stations, cooling facilities [19], and enhancing health alerts and warning systems [20]. However, prolonged stay indoors causes building syndrome, and outdoor environments challenge their health [21]. Some people and communities have already been locked into urban heat challenges. In other words, due to significant social, economic, institutional, and policy barriers, mitigation and adaptation solutions cannot protect people.

Migration is generally the movement of groups of animals from one place to another for living environments and supplies (e.g., temperature, food, and water) in response to dynamic seasons or circumstances [22]. For citizens, migration also has important implications for finding suitable environments for comfort, health, and safety in surrounding and distant areas [23]. Migration is regarded as the last defensive response [24] to avoid heat exposure, illness, and death, where temperature is a critical driver. For instance, previous studies reported migration among cold-related vulnerable groups in Europe [25], Australia [26], North America [27], and East Asia [28,29]. Moreover, temperature-related migration is seasonal, where people migrate to warmer destinations in winter and return to their original locations in late spring or early summer. This feature differs from floods, drought, and sea level rise [30], as temperature can recover to a thermally tolerant and comfortable level after a lasting period, along with seasonal alteration and atmospheric circulation [31]. However, in contrast to persistent extreme cold events in high-latitude regions, recent years of extreme heat events, despite increasingly lasting, frequent, and intense events, have shown a fluctuating trend in numerous cities. Days with a maximum temperature of 35 °C (i.e., a temperature threshold of heatwave events defined by the China Meteorological Administration) last several days, generally followed by several relatively comfortable days. Daily temperature variations below 26 °C enabled relief. This potentially triggers migration uncertainty.

Beyond climatic factors, heat-related migration among citizens is a complex process, possibly regulated by social, economic, institutional, social-interactive, behavioral, and physiological factors [32–34]. That is to say, human migration is very different from animal migration. For instance, a significant association between migration and socioeconomic attributes suggests a biased capability for migration and social inequality, especially among individuals who must stay [35,36]. Unlike animals, citizens are generally less flexible because they are frequently trapped by jobs and societal responsibilities and thereby they are limited by the time available for migration. Furthermore, migration, for both sending and receiving areas, is a dynamic process of labor and has important implications for economic growth [37]. Permanent labor turnover is often associated with potential economic recession. Furthermore, migration poses a set of challenges to the consumer market associated with moving, transporting, and settling down (i.e., selling or purchasing assets, lowering nonessential expenditures, and reducing investments) [38]. Migration also influences social networks and stability [39]. The migration of urban dwellers towards cool areas is associated with their social status. For example, rural migrant workers who pursue work opportunities in cities endure heat-exposed, heavy, long-hour jobs, poor-quality housing, low job security, and few welfare benefits [14]. However, their urban life is inherently short-term and unstable; therefore, they are in a dynamic urban-rural flow process. Temporarily returning to native rural hometowns, with good heat adaptation environments, resources, and local properties, is a smart and implementable response to thermally inhabitable cities. Another group is decent citizens who have a stable urban life, qualified housing, sound welfare, and decent work, so their migration can be affected by time availability, traffic expenditure, and accommodation costs.

In China, several furnace cities, such as Chongqing, suffer several weeks of extreme heat days every year, triggering people to migrate to cool places. Typically, many citizens of Chongqing choose to migrate to surrounding mountainous areas for heat relief. Local governments and meteorological departments collectively embark on building a cool tourism industry. On the one hand, this provides migrants with sound traffic and living conditions for better health and wellness benefits. On the other hand, responsible planning, design, and construction of cool, mountainous areas can protect ecological systems while promoting local economic growth. Overall, migration and institutional actions promoted the formation of a new phenomenon of tourism-related short-term migration for heat adaptation. Understanding the mechanisms behind migration due to heat shock is important to better prepare for heat-related migration and to cope with socioeconomic effects for

sustainable development.

Prior studies on heat-driven movement have mainly focused on international, permanent migration among households and individuals from less-developed areas for better labor opportunities [36,40]. Limited studies have revealed citizens' tourism-related short-term migration for heat relief, and the impacts of socio-economic-institutional factors, as well as climatic, social-interactive, behavioral, and physiological factors, on short-term migration for heat adaptation are poorly understood. Therefore, this study aims to investigate citizens' experiences of tourism-related short-term migration to avoid heat-related impacts. The objectives were to (i) understand heat-related impacts on daily functioning and emotional and social-interactive behaviors on heat information availability; (ii) explore citizens' perceptive, behavioral, and psychological responses in terms of heat severity perception, heat risk knowledge, adaptation awareness, and adaptation knowledge; (iii) empirically analyze migration and non-migration activities among citizens; (iv) understand citizens' choices of intra-province and inter-province migration; and (v) reveal the impacts of several dimensional factors on migration. Overall, this study is expected to provide theoretical explanations of heat-related migration and better support city managers' decisions on heat governance and sustainable development. This is the first study to empirically and systematically reveal heat-related short-term migration in the context of tourism worldwide. This study takes Chongqing, an extreme heat metropolitan area in China, as the research context and presents a forward-looking vision for tourism-related migration in other increasingly hot cities.

2. Research method and structure

This section describes the research methods to perform the study in Chongqing, China. First, urban heat challenges of Chongqing and the locations of surrounding cities with mountainous landscapes which can be tourism destinations for heat relief, are presented. Second, the design of questionnaire and its delivery procedure are elucidated. Third, the data analysis methods are described.

2.1. Study area

This study was conducted in Chongqing, one of the hottest and most humid cities in China (Fig. 1). Chongqing, one of the largest municipalities globally, has an estimated population of 32.02 million, according to the latest national statistical data. It is in the southwestern region of China, neighboring four provinces: Guizhou, Hubei, Hunan, and Sichuan. Chongqing has a humid, subtropical climate (Cfa). On average, the city (airport station) underwent approximately 30 overheating days (>35.0 °C) from 2008 to 2020. In July-August 2022, extreme heat hit Chongqing, with 29 days of temperatures ranging between 35 and 40 °C and 19 days of temperatures exceeding 40 °C. Its location on the Yangtze River makes it extremely humid throughout the year, threatening the health of citizens. What is worse, the well-urbanized main city areas (urbanization level above 90 %) are 5–10 °C hotter than open and less-developed airport areas. Therefore, tourism-related short-term migration is an important adaptation strategy. The compact main city has limited natural reserves for adaptation compared with suburban/rural areas; therefore, the empirical study focuses on citizens who have been living, studying, or working in Chongqing's main city.

Chongqing is famous for its water and mountainous landscapes. There are many mountainous tourist destinations surrounding the main city of Chongqing (Fig. 1). For instance, in suburban and rural Chongqing, local governments have developed mature tourism industries. There are 12 AAAAA scenic spots, including the Wulong National Forest Park, Dazu Rock Carvings, and Wuling Mountain Great Rift Valley. There are 158 AAAA scenic spots. In 2024, for instance, Wulong District received 47.24 million tourists throughout the year, and the number reached 6.01 million in August. This increases the destination

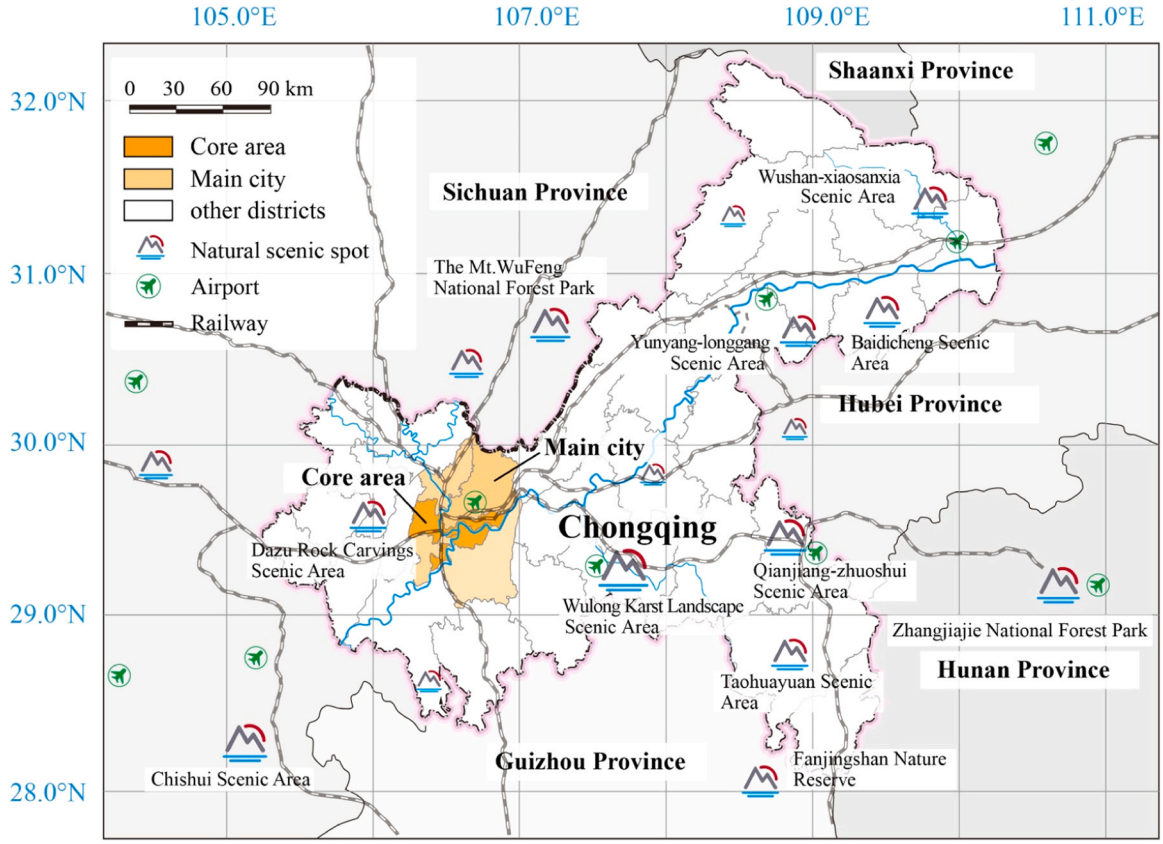

Fig. 1. The location of core area, main city and surrounding tourism destinations.

requirements for traffic and accommodation.

Beyond Chongqing, surrounding provinces such as Guizhou, Sichuan, Hubei, and Hunan are also abundant in mountainous landscapes, making them favorable tourism destinations. For instance, the Zhangjiajie National Forest Park was the first national forest park in China. In July and August, the hottest months of the year, temperatures range between 22 and 31 °C in July and between 21 and 30 °C in August, respectively respectively, making it an attractive attraction as well. Large population migration towards other provinces exerts heavy pressure on local resources as well. For instance, large population migration should be supported by robust transportation infrastructure. However, Chongqing is a mountainous city, where traffic efficiency is significantly reduced. For example, high-speed trains (CR400AF/BF) have a speed of 350 km/h, whereas in Chongqing, the speed reduces to 150–200 km/h.

2.2. Questionnaire design and survey delivery

A questionnaire was designed to investigate i) citizens' socio-economic-institutional characteristics (e.g., gender, age, education, settlement, health, income, and job); ii) heat-related impacts on daily functioning and emotions, and social-interactive behaviors on heat information availability; iii) public perceptive, behavioral, and psychological responses (e.g., heat severity perception, heat risk knowledge, adaptation awareness, and adaptation knowledge), and iv) public migration (e.g., choice and destinations).

The questionnaire comprises four parts. The first part was designed to collect respondents' socio-economic-institutional characteristics of the respondents, such as gender, age, job, settlement, education, income (monthly), and health (self-rated). Gender (Q1), age (Q2), education (Q3), settlement (Q4), and health (Q5) were key social factors, while income (Q6) was a key economic factor affecting respondents' payment capacity for traffic and accommodation costs. Job (Q7) reflected the institutional attributes. For instance, government officers and factory workers are only available to travel on weekends (one or two days), limiting their flexibility of migration (Type 1); staff and students in universities and research institutions generally have summer vacations for eight weeks, so they are temporally flexible to migrate (Type 2); citizens who are self-employed, unemployed, and stay-at-home mothers are available to migrate (Type 2). Q1–Q6 are single-choice questions, whereas Q7 is a fill-in-the-blank question owing to the diversity of job types.

The second part investigated heat-related impacts on respondents' daily functioning (Q8), emotional responses to heat stroke (Q9), and channels for obtaining extreme heat information (Q10). Q8 included five questions on heat-related impacts on outdoor activities (OUAT), work efficiency (WORK), transportation (TSPT), sleep and rest (SLEP), and diet (DIET), based on a five-point assessment method (e.g., 1 = none, 2 = a little, 3 = moderate, 4 = severe, and 5 = extra severe). Q9 lists five kinds of emotional responses, including neutral, angry, sad, fearful, and surprised, to chart citizens' responses. Q10 is on respondents' social-interactive attributes, presenting seven channels, including oral communication, websites, Weibo, WeChat and moments, forums, government text messages, and television.

The third part is to reveal citizens' public perceptive, behavioral, and psychological responses, consisting of perceived urban heat severity (PUHS, Q11), knowledge of heat-related risks (KHRR, Q12), urban heat adaptation awareness (UHAA, Q13), and urban heat adaptation knowledge (UHAK, Q14), based on five-scale options. The fourth part explores whether respondents are likely to migrate out for extreme heat avoidance, and whether the destination was intra-province, inter-province, or both (Q15).

To accurately capture respondents, we set an initial question to enable respondents to identify their settlement of the core area, main city, or outer suburbs/counties (Fig. 1). The survey took place from July to August 2022 and was conducted online via QR codes. A total of 839 questionnaires were received, while there were 71 respondents from the outer suburbs and surrounding counties. After cleaning the feedback, 768 valid responses were obtained for subsequent analysis.

2.3. Statistical analysis and modelling

Overall, we conducted descriptive statistics to understand respondents' heat-related impacts, heat-related information availability, heat-related perception, and their migration toward cool areas. Afterwards, we examined the differences in respondents' answers, before which Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to examine if the dataset followed the distribution of normality. The examination indicated that the dataset did not follow the normal distribution (see Appendix Table 1); therefore, Kruskal-Wallis H and post-hoc tests were carried out to test the significance of differences among heat-related perception, knowledge, and adaptation awareness and knowledge (e.g., PUHS, KHRR, UHAA, and UHAK) to chart citizens' understanding and adaptation capacity. Ordinal logistic regression was conducted to reveal the contribution of socioeconomic and institutional factors, heat-related impacts, and heat information availability to perceived heat severity, heat risk knowledge, adaptation awareness, and adaptation knowledge.

The Mann-Whitney U test (a non-parametric method) was used to examine whether the respondents decided to migrate and to reveal their destination preferences. Pearson's chi-square test was conducted to examine the variation in respondents' decisions with their heat-related awareness and knowledge. The binary logit model was used to reveal the contributions of socioeconomic and institutional variables, heat-related impacts, information availability, perceived heat severity, heat risk knowledge, adaptation awareness, and adaptation knowledge to migration choice and migration preference. In examinations, a p-value below 0.05 suggested a significant difference, and the adjusted residual (AR) indicated a strong preference when $AR > 1.96$ (95 % credibility) in the Chi-square test. Odds ratio (OR) quantified the impact of a variable on respondents' feedback in binary logit regression and ordinal logistic regression, where the feedback was generally amplified if the OR value was above 1.0, but weakened if the OR value was below 1.0 [41].

Table 1
Socio-economic-institutional characteristics of the sample.

Variables	Group		Number (%)
	Type	Label	
Gender	Male	1	340 (44.3)
	Female	2	428 (55.7)
Age	< 18	1	36 (4.7)
	18 – 29	2	246 (32.0)
	30 – 39	3	199 (25.9)
	40 – 49	4	130 (16.9)
	50 – 59	5	110 (14.3)
	> 60	6	47 (6.1)
Education	Primary school	1	70 (9.1)
	Junior high school	2	78 (10.2)
	Senior high school	3	77 (10.0)
	Undergraduate or college	4	362 (47.1)
	Postgraduate or above	5	181 (23.6)
Settlement	Core area	1	614 (79.9)
	Main city	2	154 (20.1)
Health (Self-rated)	Very good	1	272 (35.4)
	Good	2	322 (41.9)
	Moderate	3	135 (17.6)
	Bad	4	37 (4.8)
	Poor	5	2 (0.3)
Income (Yuan)	< 1500	1	140 (18.2)
	1500 – 5000	2	250 (32.6)
	5000 – 10,000	3	230 (29.9)
	10,000 – 15,000	4	104 (13.5)
	> 15,000	5	44 (5.7)
Job type	Non-flexible	1	369 (48.0)
	Flexible	2	399 (52.0)

3. Results and analysis

This section presents the statistics of the questionnaire survey in terms of socio-economic-institutional factors, heat-related impacts, heat-related information availability, heat-related perception, and migration toward cool areas. Moreover, this section reports how socio-economic and institutional factors drive migration (e.g., intra-province, inter-province) and the impact of heat-related impacts on daily functioning and heat-related perceptions on migration.

3.1. Socio-economic-institutional factors

Table 1 shows the socio-economic-institutional information of 768 respondents. The sample included 340 male and 428 female respondents, accounting for 44.3 % and 55.7 %, respectively. Respondents aged 18 – 29 years accounted for the largest proportion (32.5 %), followed by those aged 30 – 39 years (25.9 %), 40 – 49 years (16.9 %), and 50 – 59 years (14.3 %). Citizens aged 60 + years accounted for 6.7 %, and those aged < 18 years accounted for 4.3 %. Moreover, 614 responses were from the core area and 154 were from the main city.

The majority of respondents (70.7 %) had received at least undergraduate education, whereas 23.6 % had received postgraduate education. Approximately 32.6 % and 29.9 % of the respondents earned 1500 – 5000 and 5000 – 10,000 Yuan monthly, respectively. The high-salary earners under investigation accounted for 13.5 % (10,000 – 15,000 Yuan) and 5.7 % (above 15,000 Yuan), respectively. Most respondents were in good (41.9 %) and very good (35.4 %) health status, whereas only 4.8 % and 0.3 % of the respondents were in bad and poor health conditions, respectively.

There were 399 respondents (52.0 %) who indicated that they had flexible jobs, slightly higher than those who were conducting non-flexible jobs (48.0 %). According to Fig. 2, the questionnaire survey collected 29 job types, indicating that it did not gather a certain group of citizens. Type 1 (non-flexible) included 15 types and Type 2 (flexible) included 14 types.

Type 1 consists of financial and accounting staff (5.08 %), catering staff (1.04 %), designers (3.13 %), engineers (7.03 %), factory workers (6.12 %), government staff (4.82 %), IT programmers (1.17 %), lawyers (0.26 %), medical staff (2.73 %), new media and advertising (0.65 %), police and security (0.91 %), products and services (5.47 %), service staff (1.43 %), transport industry personnel (0.39 %), and white-collar employees (7.81 %). Type 2 consists of businessmen (0.91 %), construction workers (0.78 %), delivery industry personnel (0.39 %), drivers (1.69 %), education staff (5.47 %), farmers (1.30 %), freelancers (5.21 %), part-time service staff (0.52 %), retirees (3.26 %), self-employed (2.73 %), stay-at-home mothers (1.43 %), students

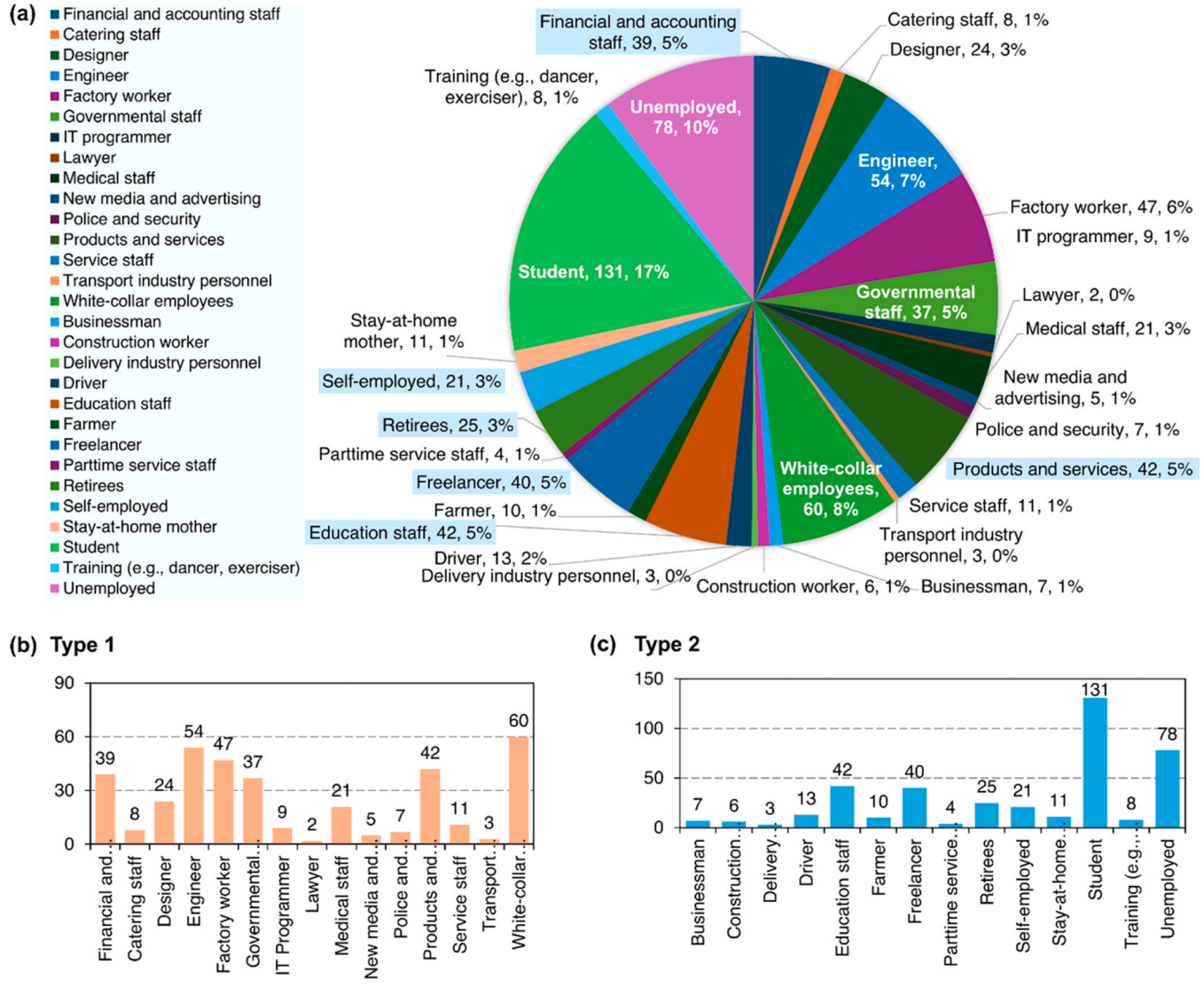

Fig. 2. Job types and proportion of 768 respondents. (a) job types and proportion, (b) statistics of Type 1, and (c) statistics of Type 2.

(17.06 %), training (e.g., dancer, exerciser) (1.04 %), and the unemployed (10.16 %).

The number of students at the undergraduate and postgraduate levels was 131, about 53 % of the total respondents were aged between 18 and 29 (246) and those younger than 18 (36). This is consistent with the recent college entrance examination admission ratio of 55 %. Following them, the unemployed ranked second, white-collar employees ranked third, and engineers ranked fourth.

3.2. Heat-related impacts, emotional, and social-interactive attributes

Fig. 3 shows the heat-related impacts on daily functioning. Regarding OUAT, 34 % of the respondents suggested that they suffered extra-severe impacts, while 37 % expressed severe impacts. This suggests that more than 70 % of respondents were severely affected. Regarding WORK, 52 % of the respondents answered at least severe impacts and approximately 28 % of the respondents suggested moderate impacts. In terms of TSPT, 68 % of respondents suggested that they were at least severely affected. For SLEP, approximately 47 % (less than 50 %) of the respondents were at least severely affected, and 8 % of the respondents suggested that they were not affected at all. Furthermore, approximately 40 % of the respondents were at least severely affected in terms of DIET.

Kruskal-Wallis H and post-hoc tests were performed to examine whether there were significant differences among these five types of daily functioning. The analysis indicated significant differences among them ($p < 0.001$), suggesting that heat-related impacts were heterogeneous. Post-hoc tests further indicated that heat-related impacts on OUAT (3.80 ± 1.20) were much stronger than those on WORK (3.41 ± 1.12) ($p < 0.001$). However, there was no significant difference between heat-related impacts on OUAT and those on TSPT (3.79 ± 1.10) ($p = 0.088$). The impacts on OUAT were also much stronger than those on SLEP (3.34 ± 1.13) ($p < 0.001$) and DIET (3.24 ± 1.07) ($p < 0.001$). Heat-related impacts on WORK were weaker than those on TSPT ($p < 0.001$) but stronger than those on diet ($p < 0.001$), while they had no significant difference from the heat-related impacts on SLEP ($p < 0.092$). Furthermore, the impacts on TSPT were stronger than those on SLEP ($p < 0.001$) and diet ($p < 0.001$). In addition, heat-related impacts on SLEP were stronger than those on DIET ($p < 0.001$). Overall, the impacts followed an order of OUAT, TSPT, WORK, SLEP, and DIET.

The number of respondents who thought that they were at least severely affected was counted (Fig. 3f). Overall, 26 % of the respondents said that they were at least severely affected in all five aspects, and 14 % of the respondents expressed that they were at least severely affected in four aspects. 15 % of the respondents were severely affected in three aspects. Nevertheless, 17 % of the respondents expressed that they were not severely affected in all five aspects.

Fig. 4a shows the respondents' emotional responses when they hear of a heat stroke. 33 % of the respondents found that they were neutral without positive or negative emotions. This group ranked first. Following this, 25 % of the respondents were surprised, indicating that they did not fully understand the heat-related deaths. Moreover, 22 % of the respondents feared heat. Due to their fear, they might migrate. In addition, 16 % of the respondents felt sad and 4 % felt angry.

Fig. 4b shows the heat information availability where 499 respondents adopted WeChat and moments, shaping it as the most prevalent channel for heat-related information. This suggests that WeChat, which is a cross-platform communication tool, contributes to heat warnings and alerts. Following this, website and oral communication ranked second and third with 390 and 391 respondents, respectively. In addition, TV, governmental text messages, and Weibo ranked fourth,

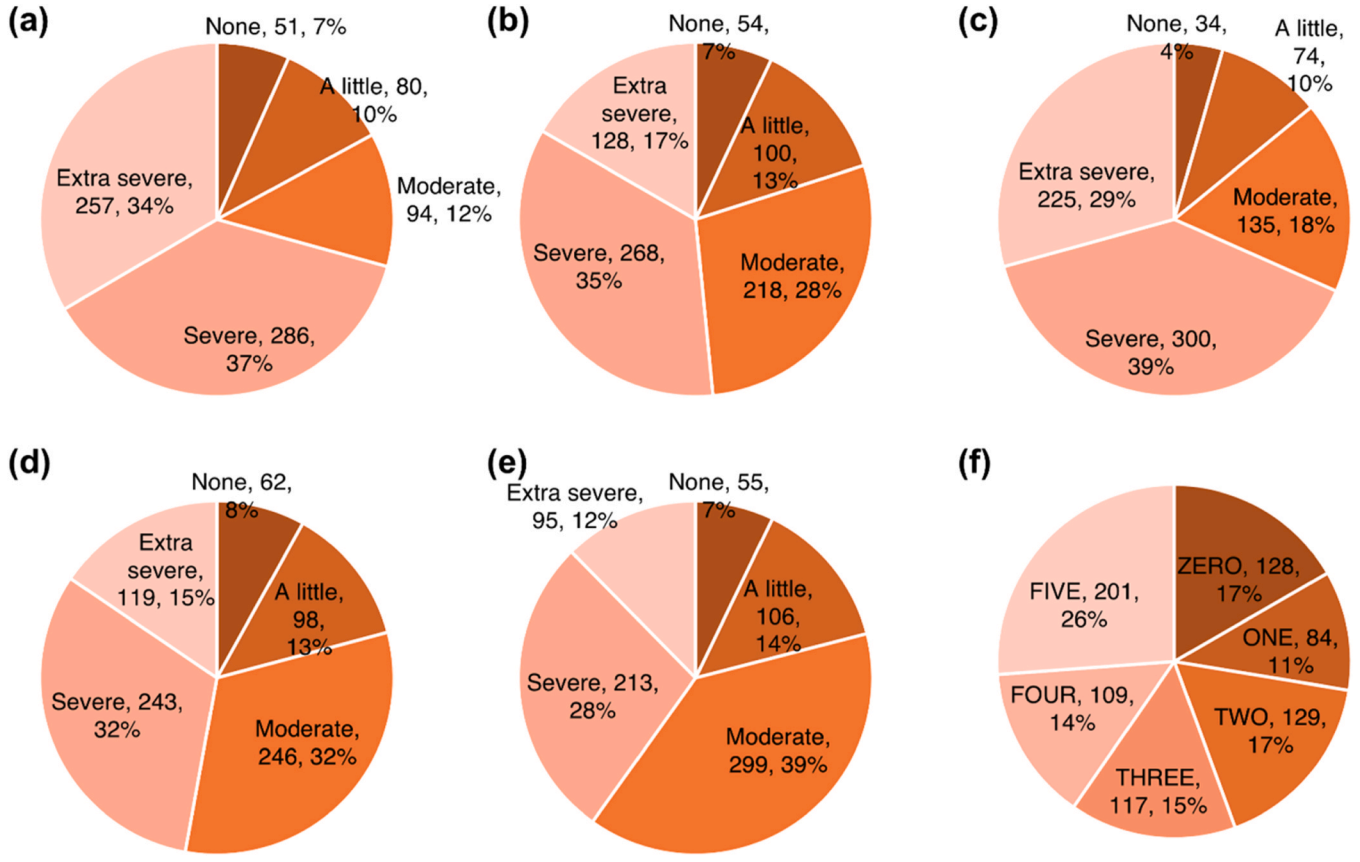

Fig. 3. Heat-related impacts on daily functioning. (a) outdoor activities (OUAT), (b) work efficiency (WORK), (c) transportation (TSPT), (d) sleep and rest (SLEP), (e) diet (DIET), and (f) multiple impacts.

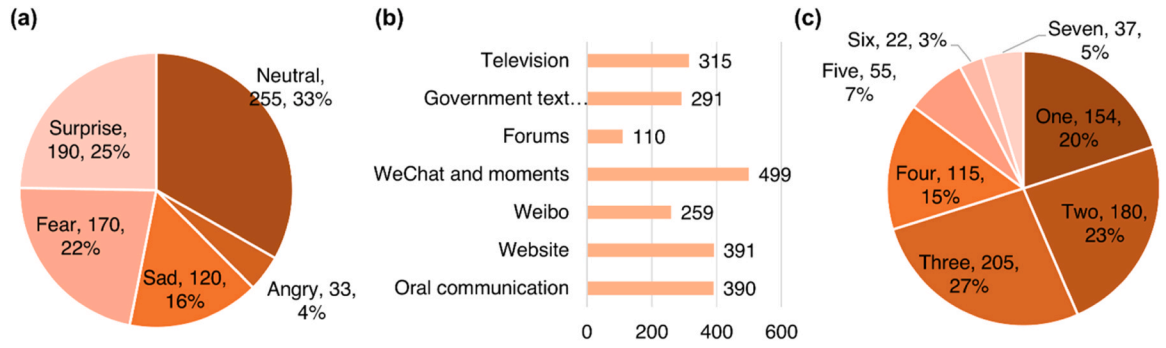

Fig. 4. Respondents feedback of emotional response and heat-related information availability. (a) emotional response, (b) information channel, and (c) multiple channels.

fifth, and sixth, with 315, 291, and 259 respondents, respectively. In comparison, 110 respondents relied on the forums.

Further investigation of information availability (Fig. 4c) indicated that about 15 % of the respondents could obtain information through at least five channels. This was followed by four channels among 115 respondents (10 %), three channels among 205 respondents (27 %), two channels among 180 respondents (23 %), and one channel among 154 respondents (20 %). Overall, none suggested that they could not receive heat information.

3.3. *Perceptive, behavioral, and psychological responses*

The original results for heat-related awareness and knowledge are presented in Table 2. Respondents under investigation thought that urban heat in Chongqing was severe (PUHS: 4.12 ± 0.82). However, these respondents did not fully recognize heat-related risks (KHRR: 2.54 ± 0.98). A significant gap was found between heat-related severity and risk-related knowledge (H=27.876, $p < 0.001$). Respondents' awareness (UHAA: 2.85 ± 0.97) and knowledge of heat adaptation (UHAK: 2.77 ± 0.92) were far from adequate, below the moderate level. Awareness and knowledge of heat adaptation were significantly weaker than heat severity (H=22.183, $p < 0.001$; H=23.357, $p < 0.001$), but significantly stronger than risk-related knowledge (H=-5.694, $p < 0.001$; H=-4.519, $p < 0.001$). There were no significant differences between heat adaptation awareness and knowledge. Overall, urban heat was severe, but the respondents lacked risk-related knowledge. In such situations, respondents may start to adapt to some extent, but their awareness is weak, and their knowledge is deficient.

Table 3 examines how urban heat, socio-economic-institutional factors, and information availability affect public perception and adaptation knowledge. Overall, the sum of the impacts (Fig. 3f) in OUAT, WORK, TSPT, SLEP, and DIET played significant, positive roles in PUHS, KHRR, UHAA, and UHAK. This result verifies that increasing the impacts on daily functioning could significantly drive citizens to elevate their awareness, knowledge, and adaptation intention. In particular, every unit increase in the impacts on daily functioning resulted in a PUHS increase of 1.492 times (95 % CI: 1.378 – 1.616 times), a KHRR increase of 1.164 times (95 % CI: 1.078 – 1.256 times), a UHAA increase of 1.114 times (95 % CI: 1.034 – 1.199 times), and a UHAK increase of 1.103 times (95 % CI: 1.023 – 1.188 times). Heat information availability positively promoted adaptation awareness and knowledge, while it made no significant contribution to heat-related knowledge. This result verifies that educational and propaganda interventions can improve citizens' adaptation capacity. Moreover, every unit increase in information availability could lead to a 1.208-time (95 % CI: 1.108 – 1.317 times) and 1.237-time (95 % CI: 1.134 – 1.350 times) increase in UHAA and UHAK, respectively.

The impacts of socio-economic-institutional factors on public perception and knowledge were highly heterogeneous, where gender and health conditions made no significant contribution to PUHS, KHRR, UHAA, and UHAK. In comparison, settlement was a significant contributor to all four aspects. Citizens in main city, compared with those living in core area, exhibited stronger heat-related severity (95 % CI: 1.152 – 2.339 times), risk knowledge (95 % CI: 1.318 – 2.608 times), adaptation awareness (95 % CI: 1.345 – 2.632 times), and adaptation knowledge (95 % CI: 1.339 – 2.628 times). Age was a significant contributor to PUHS, UHAA, and UHAK, but it did not differ significantly in KHRR. In particular, every unit increase in age caused a 1.129-time (95 % CI: 0.987 – 1.293 times), 1.153-time (95 % CI: 1.010 – 1.317 times), and 1.140-time (95 % CI: 1.001 – 1.299 times) increase in heat-related severity, risk knowledge, adaptation knowledge, respectively. Overall, this result verifies that heat severity, risk knowledge, and adaptation knowledge could be temporally and socially driven. An increase in age corresponds to experience and knowledge accumulation.

Education made no significant contribution to PUHS and KHRR, but it positively drove UHAA and UHAK. Fundamentally, an increase in education level was conducive to enhancing adaptation capacity, while education did not shift the pattern of heat exposure and heat risks. In particular, every unit increase in education level resulted in a 1.179-time (95 % CI: 1.017 – 1.367 times) and 1.152-time (95 % CI: 0.993 –

Table 2
Differences among perceived urban heat severity (PUHS), knowledge of heat-related risk (KHRR), urban heat adaptation awareness (UHAA), and urban heat adaptation knowledge (UHAK).

Factors	Independent-samples K-W test	Post-hoc test[a]			
		PUHS	KHRR	UHAA	UHAK
PUHS (4.12 ± 0.82)	89.792[b] ***	1	27.876***	22.183***	23.357***
KHRR (2.54 ± 0.98)			1	−5.694***	−4.519***
UHAA (2.85 ± 0.97)				1	1.174
UHAK (2.77 ± 0.92)					1

[c]Standard test statistic value.
***$p < 0.001$ at 2-sided tests.
[a] Pairwise comparison with adjusted significance values by Bonferroni correction
[b] H value;

Table 3
Significant contributors to respondents' heat-related awareness and knowledge.

Constant and factors	PUHS ($n = 768$)			KHRR ($n = 768$)		
	Estimate	*OR*	95 % CI	Estimate	*OR*	95 % CI
Constant 1	−4.158			−0.707		
Constant 2	−1.708			2.273		
Constant 3	0.698			3.563		
Constant 4	2.720			4.719		
Gender	0.035	1.036	0.784 – 1.368	−0.043	0.958	0.725 – 1.265
Age	0.122*	1.129	0.987 – 1.293	0.142**	1.153	1.010 – 1.317
Education	−0.005	0.995	0.855 – 1.158	0.042	1.043	0.897 – 1.213
Settlement	0.496***	1.642	1.152 – 2.339	0.618***	1.854	1.318 – 2.608
Health	−0.039	0.962	0.803 – 1.152	0.069	1.071	0.896 – 1.281
Income	0.132*	1.142	0.988 – 1.319	0.047	1.048	0.907 – 1.210
Job	−0.280*	0.756	0.563 – 1.016	−0.202	0.817	0.608 – 1.097
Impact	0.400***	1.492	1.378 – 1.616	0.152***	1.164	1.078 – 1.256
Information	0.041	1.042	0.954 – 1.138	0.070	1.073	0.982 – 1.172
AIC	1687.325			1950.630		
BIC	1747.694			2010.999		
Constant and factors	**UHAA ($n = 768$)**			**UHAK ($n = 768$)**		
	Estimate	***OR***	**95 % CI**	**Estimate**	***OR***	**95 % CI**
Constant 1	−0.845			−0.590		
Constant 2	2.667			2.725		
Constant 3	4.134			4.311		
Constant 4	5.614			6.002		
Gender	0.105	1.111	0.847 – 1.458	0.094	1.098	0.836 – 1.443
Age	0.025	1.026	0.901 – 1.168	0.131**	1.140	1.001 – 1.299
Education	0.165**	1.179	1.017 – 1.367	0.141*	1.152	0.993 – 1.335
Settlement	0.632***	1.882	1.345 – 2.632	0.629***	1.876	1.339 – 2.628
Health	0.015	1.015	0.852 – 1.210	0.026	1.026	0.861 – 1.224
Income	0.102	1.107	0.963 – 1.273	0.022	1.023	0.888 – 1.177
Job	0.124	1.132	0.849 – 1.508	0.056	1.058	0.793 – 1.412
Impact	0.108***	1.114	1.034 – 1.199	0.098*	1.103	1.023 – 1.188
Information	0.189***	1.208	1.108 – 1.317	0.213***	1.237	1.134 – 1.350
AIC	1983.676			1943.863		
BIC	2044.045			2004.232		

***, $p < 0.01$; ** $p < 0.05$; *, $p < 0.1$; OR = Odds ratio; CI = confidence interval.
AIC = Akaike's Information Criteria.
BIC = Bayesian Information Criterion.

1.335 times) increase in adaptation awareness and adaptation knowledge, respectively. Income made no significant contribution to KHRR, UHAA, and UHAK, but it significantly affected PUHS. Every unit increase in income corresponded to a PUHS increase of 1.142 times (95 % CI: 0.988 – 1.319 times). This reveals the income-shaped heat exposure patterns. In addition, job type also significantly affected PUHS, but it did not significantly contribute to KHRR, UHAA, and UHAK. Citizens with flexible jobs expressed less heat severity than those who had non-flexible jobs, by 0.756 times (95 % CI: 0.563 – 1.016 times), suggesting that job type shaped heat exposure as well.

3.4. Heat-driven migration and significant contributors

The results of respondents' decisions on migration and their destinations are shown in Fig. 5. Approximately 41.4 % of the 768 respondents suggested that they migrated for heat relief, but the size was smaller than those who did not migrate (U=242,688, z = -6.938, $p < 0.001$). However, this proportion was already large when scaling up to the large population of the main city. Among the 318 respondents who preferred to migrate out, 241 had the experience of traveling to cooler areas within Chongqing Municipality, and 176 had been to other provinces for cooling. Intra-province migration was more popular than inter-province travel (U=39,658, z = -5.441, $p < 0.001$). Furthermore, 99 respondents (about 12.9 % of the 768 respondents) answered that crossing the province boundary was not a barrier to their migration destination choice.

Table 4 examines the variation in migration choice with respondents' heat perception, risk knowledge, adaptation awareness, adaptation knowledge, and emotions (Fig. 4a). Overall, the results indicate that migration choice did not vary with PUHS (χ^2=7.201, $p = 0.126$), suggesting that perceived heat severity was not a significant driver. In comparison, risk knowledge was a significant driver

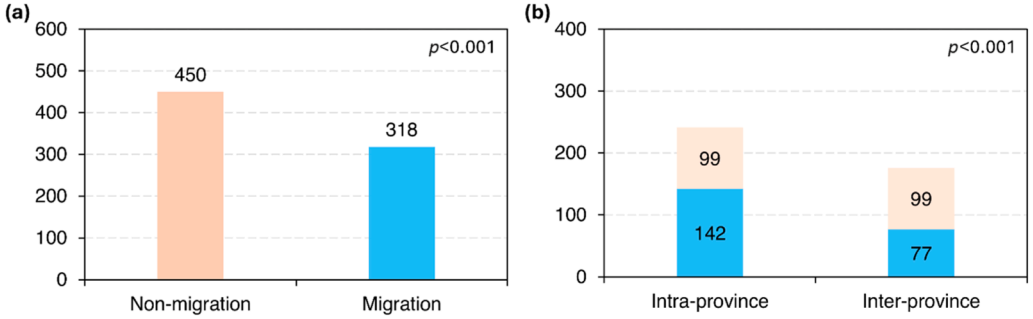

Fig. 5. Responses on migration for heat adaptation. (a) Non-migration and migration, (b) Intra-province and inter-province.

(χ^2=21.856, $p < 0.001$), where higher levels of risk knowledge corresponded to stronger migration decisions. This result reveals that an increased understanding of risk knowledge enhances citizens' migration for adaptation. Adaptation awareness differentiated migration choice (χ^2=49.824, $p < 0.001$), where higher levels of adaptation awareness resulted in a stronger choice of migration. Adaptation knowledge was also a significant driver, with higher levels of adaptation knowledge resulting in a stronger choice to migrate (χ^2=48.892, $p < 0.001$). In comparison, respondents' emotions were not significant drivers (χ^2=1.873, $p < 0.759$). Overall, perceived heat severity and respondents' emotions were not significant drivers, while risk knowledge, adaptation awareness, and adaptation knowledge were significant drivers.

Table 5 shows the significant drivers of respondents' migration decisions based on the binary logit model. The results indicated that settlement, health conditions, heat-related impacts, and heat risk knowledge were not significant contributors ($p > 0.10$). Gender, age, education, income, job type, heat information availability, adaptation awareness, and adaptation knowledge were significant contributors ($p < 0.10$). These results revealed that migration for heat adaptation was not directly related to heat-related impacts and citizens' health conditions, which might be because citizens might take many other solutions for adaptation. Migration decisions were dependent on socio-economic-institutional, social-interactive factors, and behavioral-physiological factors.

Female respondents were more likely to migrate, about 1.462 times (95 % CI: 1.050 – 2.035 times) higher than male respondents. The older the respondents, the higher the likelihood of migration; every unit increase in age resulted in a 1.366-time increase in migration decisions (95 % CI: 1.158 – 1.611 times). The increase in education level enhanced migration likelihoods; every unit increase in education corresponded to a 1.381-time increase in migration decisions (95 % CI: 1.150 – 1.658 times). Income was a significant contributor: the richer the respondents, the higher the likelihood of migration. Every unit increase in income corresponded to a 1.603-time increase in migration decisions (95 % CI: 1.348 – 1.906 times). Job was also a significant contributor, where the migration likelihood increased by 1.923 times among respondents with flexible jobs (95 % CI: 1.349 – 2.741 times) compared to those with non-flexible jobs.

Table 4
Variations of migration decisions with respondents' perception, awareness and knowledge towards urban heat.

Variables	Label	Migration (0 = No, 1 = Yes)				χ^2	*p*
		0	*AR*	1	*AR*		
PUHS	1	2	1.2	0	−1.2	7.201	0.126
	2	13	0.6	7	−0.6		
	3	92	1.0	55	−1.0		
	4	192	1.3	120	−1.3		
	5	151	−2.4	134	2.4		
KHRR	1	39	1.2	20	−1.2	21.856	0.000***
	2	255	2.9	147	−2.9		
	3	105	−0.4	78	0.4		
	4	35	−2.7	44	2.7		
	5	16	−3.2	29	3.2		
UHAA	1	16	2.3	3	−2.3	49.824	0.000***
	2	219	4.8	100	−4.8		
	3	143	−0.3	104	0.3		
	4	57	−3.6	72	3.6		
	5	15	−4.8	39	4.8		
UHAK	1	21	2.9	3	−2.9	48.892	0.000***
	2	214	3.6	110	−3.6		
	3	157	0.6	104	−0.6		
	4	48	−4.7	74	4.7		
	5	10	−4.0	27	4.0		
EMOT	1	155	0.9	100	−0.9	1.873	0.759
	2	18	−0.5	15	0.5		
	3	65	−1.1	55	1.1		
	4	102	0.4	68	−0.4		
	5	110	−0.2	80	0.2		

* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

Table 5
Significant contributors to respondents' decisions on migration ($n = 318$, $N = 768$).

Constant and factors	Estimate	*OR*	95 % CI
Constant	1041.874		
Gender	0.380**	1.462	1.050 – 2.035
Age	0.312***	1.366	1.158 – 1.611
Education	0.323***	1.381	1.150 – 1.658
Settlement	−0.062	0.940	0.616 – 1.435
Health	−0.006	0.994	0.802 – 1.232
Income	0.472***	1.603	1.348 – 1.906
Job	0.654***	1.923	1.349 – 2.741
Impact	0.051	1.052	0.961 – 1.152
Information	0.090*	1.094	0.985 – 1.216
KHRR	0.121	1.128	0.934 – 1.363
UHAA	0.320**	1.377	1.069 – 1.775
UHAK	0.234*	1.264	0.968 – 1.651
AIC		925.804	
BIC		986.174	

***, $p < 0.01$; ** $p < 0.05$; *, $p < 0.1$; OR = Odds ratio; CI = confidence interval.
AIC = Akaike's Information Criteria.
BIC = Bayesian Information Criterion.

Heat information availability was also a significant positive driver of migration decisions, where every unit increase in information availability resulted in an increase in migration decisions by 1.094 times (95 % CI: 0.985 – 1.216 times). Adaptation awareness could significantly promote migration likelihood, and every unit increase in awareness led to a migration likelihood increase by 1.377 times (95 % CI: 1.069 – 1.775 times). Adaptation knowledge was also a significant positive driver, where every unit increase in adaptation knowledge promoted migration decisions by 1.264 times (95 % CI: 0.968 – 1.651 times). Overall, when comparing these significant socio-economic-institutional, social-interactive, and behavioral-physiological factors, job flexibility was found to have the strongest impact.

Further investigation of significant contributors to migration destinations is presented in Table 6. The significant contributors were similar to those of the migration decisions, where settlement, health, and impacts were not significant drivers ($p > 0.10$). These results verified that living area, health conditions, and heat-related impacts did not affect migration destinations. For significant contributors, however, their impacts were somewhat different in intra-province, inter-province, and intra- & inter-province. For instance, gender was the only significant contributor to inter-province, where females' responses were 1.556 times that of males (95 % CI: 1.066 – 2.271 times). In comparison, it made no significant difference to intra-province and intra- & inter-province ($p > 0.10$). Education could significantly and positively enhance intra-province (*OR*: 1.274, 95 % CI: 0.830 – 1.956) and inter-province (*OR*: 1.251, 95 % CI: 1.018 – 1.537), while education made no difference to intra- & inter-province ($p > 0.10$).

Income was a significant, positive driver of intra-province, inter-province, and intra- & inter-province. Every unit increase in income resulted in an increase of 1.261 times (95 % CI: 0.882 – 1.802 times) in intra-province migration, 1.538 times (95 % CI: 1.281 – 1.846 times) in inter-province migration, and 1.502 times (95 % CI: 1.205 – 1.873 times) in intra- & inter-province migration. Job did not differentiate intra-province and intra- & inter-province migration ($p > 0.10$), while its flexibility affected inter-province migration, with each unit increase in job flexibility causing an inter-province migration increase by 1.969 times (95 % CI: 1.330 – 2.914 times). This result reveals that increasing job flexibility enables respondents to spend more time traveling farther for heat relief.

Heat information availability was important for intra-province, inter-province, and intra- & inter-province. Every unit increase in information availability resulted in an increase of 1.152 times (95 % CI:

Table 6
Significant contributors to respondents' decisions on intra-province migration, inter-province migration, and intra- & inter- province migration.

Constant and factors	Intra-province ($n = 241$, $N = 768$)			Inter-province ($n = 176$, $N = 768$)			Intra- & inter-province ($n = 99$, $N = 768$)		
	Estimate	*OR*	95 % CI	Estimate	*OR*	95 % CI	Estimate	*OR*	95 % CI
Constant	955.560	1.183	0.840 – 1.667	826.779			590.288		
Gender	0.168	1.438	1.218 – 1.698	0.442**	1.556	1.066 – 2.271	0.229	1.257	0.786 – 2.011
Age	0.363***	1.283	1.063 – 1.548	−0.033	0.968	0.811 – 1.154	0.021	1.021	0.825 – 1.263
Education	0.249***	1.274	0.830 – 1.956	0.224**	1.251	1.018 – 1.537	0.163	1.177	0.910 – 1.522
Settlement	0.242	0.996	0.797 – 1.245	0.034	1.035	0.649 – 1.650	0.585**	1.794	1.050 – 3.067
Health	−0.004	1.429	1.201 – 1.700	0.113	1.119	0.880 – 1.423	0.175	1.192	0.885 – 1.605
Income	0.357***	1.261	0.882 – 1.802	0.430***	1.538	1.281 – 1.846	0.407***	1.502	1.205 – 1.873
Job	0.232	1.034	0.942 – 1.137	0.677***	1.969	1.330 – 2.914	0.223	1.249	0.776 – 2.011
Impact	0.034	1.125	1.009 – 1.254	0.078	1.081	0.975 – 1.198	0.082	1.086	0.954 – 1.236
Information	0.118**	1.152	0.951 – 1.394	0.104*	1.110	0.990 – 1.244	0.210***	1.234	1.072 – 1.420
KHRR	0.141	1.518	1.170 – 1.971	0.133	1.142	0.931 – 1.401	0.229*	1.257	0.981 – 1.611
UHAA	0.418***	0.974	0.740 – 1.283	0.116	1.123	0.850 – 1.484	0.310*	1.363	0.967 – 1.921
UHAK	−0.026	1.183	0.840 – 1.667	0.251*	1.286	0.957 – 1.728	−0.101	0.904	0.628 – 1.300
AIC	878.573			770.329			554.313		
BIC	938.943			830.699			614.682		

***, $p < 0.01$; ** $p < 0.05$; *, $p < 0.1$; OR = Odds ratio; CI = confidence interval.
AIC = Akaike's Information Criteria.
BIC: Bayesian Information Criterion.

0.951 – 1.394 times) in intra-province migration, 1.110 times (95 % CI: 0.990 – 1.244 times) in inter-province migration, and 1.234 times (95 % CI: 1.072 – 1.420 times) in intra- & inter-province migration. Heat risk knowledge was a significant driver of intra- & inter-province, but it did not differentiate intra-province or inter-province separately. Each unit increase in heat risk knowledge promoted intra- & inter-province migration by 1.257 times (95 % CI: 0.981 – 1.611 times). Adaptation awareness significantly promoted intra-province migration and intra- & inter-province migration but did not significantly affect inter-province migration ($p > 0.10$). Each unit increase in adaptation awareness led to an increase in migration by 0.974 times (95 % CI: 0.740 – 1.283 times) in the intra-province scenario and 1.363 times (95 % CI: 0.967 – 1.921 times) in the intra- & inter-province scenario. In addition, adaptation knowledge promoted respondents to migrate farther, with significant contributions to inter-province, while it made no significant difference to intra-province and intra- & inter-province ($p > 0.10$). In particular, every unit increase in adaptation knowledge resulted in an inter-province increase of 1.286 times (95 % CI: 0.957 – 1.728 times).

4. Discussion and implications

Many cities and citizens have been locked into urban heat, given the insufficient implementation and weak performance of mitigation and adaptation solutions. Moreover, the number of locked cities and citizens will undoubtedly increase with global and local warming. To protect comfort, health, and safety, short-term migration for heat relief is an emerging phenomenon among many citizens. Local governments and communities of potential migration destinations are preparing for this phenomenon by building sound infrastructure to ensure health and wellness benefits. The fact that short-term migration for heat adaptation meets the responsible tourism industry presents dual challenges for understanding short-term migration. This study presents an empirical investigation of heat-driven migration and its associated drivers in Chongqing, China. This comprehensive study advances the knowledge of i) the formation of perceptive, behavioral, and psychological responses, ii) the decision of migration and potential destinations, and iii) the development of a sustainable, responsible tourism industry.

4.1. Perceptive, behavioral, and psychological responses: complicated results of socio-economic-institutional factors, heat-related impacts, and social-interactive attributes

Previous studies have mostly investigated socioeconomic characteristics and ethnicity to explore heat-related impacts, risk knowledge, adaptation awareness, and adaptation knowledge [42–44]. These studies have revealed that the elderly, pregnant women, patients with physical diseases, and low-income groups are often vulnerable, with higher mortality and morbidity [45–47]. These factors are often associated with physiological resistance, availability of cooling facilities, and outdoor workload. In the United States, African, Hispanic, and Mexican groups are often vulnerable because of their low income and their settlements in slums with poor built environments [48–50].

Beyond the factors in previous studies, we further explored the impacts of settlements, job types, heat-related impacts, and heat information availability. These factors indicate the influence of the public and individual adaptation capacities of citizens. For instance, in contrast to slums in many cities in the United States, settlements in Chinese cities are well-planned and built. Therefore, the heat exposure of citizens in Chongqing is generally associated with outdoor exposure caused by heat island effects, rather than poorly constructed buildings. Understanding job types is associated with citizens' flexibility of migration, potentially showing their individual capacity to migrate to cooler areas. The results showed that approximately 52 % of respondents had relatively flexible jobs.

Heat-related impacts were climatic drivers that promoted the survival and wellness of citizens. The results indicated that outdoor activities among more than 70 % of the respondents were severely affected, and the transportation among 68 % of the respondents was at least severely affected. It is essential to add cooling interventions to reduce outdoor exposure. Heat information availability indicates social-interactive impacts through public media, and this shows the influence of increasing governmental and community education and propaganda on public adaptation. The results indicated that all respondents could receive heat information, and 80 % of the respondents could obtain heat information through at least two channels (Fig. 4c), indicating strong social-interactive interventions.

Perceived heat severity revealed that more than 70 % of the respondents indicated at least severe heat, and an average score of 4.12 verified this. Typically, this round of the questionnaire survey showed more severe heat compared with the round in 2020 [9], with only 50 % of the respondents suggesting at least severe impacts, with an average score of 3.46. This shows increasingly severe heat impacts in Chongqing, which further indicates that Chongqing must urgently take action for mitigation and adaptation. If mitigation solutions have not been achievable in the planning industry in recent years, the Chongqing government and local governments should promote pilot projects and adopt stringent urban planning and building design standards and guidelines to include mitigation and adaptation strategies.

Alternatively, different governmental departments and local communities should enhance adaptation solutions to guide individuals to adopt effective adaptation strategies beyond the projection and forecasting of extreme heat weather. Among these, short-term migration is a recommended solution.

In comparison, heat risk knowledge, adaptation awareness, and adaptation knowledge were far lower than the perceived heat severity (Table 2). Compared with the investigation in 2020 [9], respondents' risk knowledge, adaptation awareness, and adaptation knowledge did not show a prominent elevation. Although citizens can obtain heat information through different media, their risk knowledge, adaptation awareness, and adaptation knowledge have not been enhanced. This is consistent with the situation in which different media generally circulate extreme heat and alerts but do not make extensive contributions to improving risk knowledge, adaptation awareness, and adaptation knowledge. Another reason might be that the heat is too severe to handle, and general knowledge made little difference to heat adaptation. Therefore, action should be taken to enhance the capacity for public adaptation. Lack of risk knowledge and adaptation knowledge will lock citizens into heat-related impacts, or they will have to migrate out for adaptation.

This study revealed that gender, education, health, and information availability made no significant difference to perceived heat severity and risk knowledge. First, the results on gender, education, and health differed from those of existing studies that gender, education, and health could significantly differentiate respondents' feedback. This showed that all people under extreme heat and body properties could not help them escape from extreme heat. Furthermore, the availability of heat information cannot reshape people's perceptive responses and risk knowledge, which also suggests that media systems should enhance risk knowledge education. Age was a significant contributor that the older the perceived heat, the more severe the perceived heat, and the higher the risk knowledge. This might be related to the weakening of body resistance to heat and accumulated knowledge with age.

Respondents in the main city thought that heat was more severe and had more risk knowledge, where this might be relevant to working conditions and living environments. This could be somewhat reflected by the conclusion that the stronger the heat-related impacts on daily functioning, the more severe the perceived heat, and the more the risk knowledge. However, the exact reasons behind settlement-related differentiation of perceived heat severity and risk knowledge should be further explored. Furthermore, people with higher income thought heat was more severe, while they did not have more risk knowledge. This indicates that high-income respondents were more sensitive to extreme heat; low-income respondents (e.g., unemployed, self-employed) might be capable of heat avoidance, and they did not have to work outdoors. This was further confirmed by the conclusion that the more flexible the job, the lower the perceived heat.

Regarding adaptation awareness and knowledge, gender, health, income, and job did not necessarily enhance behavioral, psychological responses. It is understandable that adaptation awareness and knowledge should be enhanced through education campaigns, which can be verified by the finding that the more urban heat information, the more adaptation awareness and knowledge. This reveals that heat information media is conducive to adaptation awareness and knowledge enhancement, so information media should play a role in promoting and enhancing heat-related adaptation knowledge and recommendations to elevate adaptation awareness and knowledge (Table 2). The increase in age did not significantly affect adaptation awareness, but it had a significant impact on adaptation knowledge, which might be because of the knowledge accumulation over time. The increase in education also enabled people to have more adaptation awareness and knowledge, which might be associated with the capability enhancement of knowledge acquisition. Furthermore, settlement has been proven to have a significant impact on adaptation awareness and knowledge, and the reasons for this should be further explored. In addition, adaptation awareness and knowledge were also dependent on heat-related impacts, indicating that heat exposure promoted people to adapt to extreme heat for better environments for relief.

4.2. *Migration: an independent variable of socio-economic-institutional, social-interactive, and behavioral-physiological attributes*

Migration is an adaptation solution that avoids uncomfortable and unsafe environments. Apart from the political and economic challenges associated with war, conflicts, economic recession, and agricultural productivity, climate (e.g., drought, flood, and extreme heat) is now a common life-threatening challenge that promotes the migration of many people. For instance, Southeast Asian cities are regularly affected by extreme heat stress. A questionnaire study reported that 23 % of the respondents would like to migrate for heat relief [51]. Compared to non-migrants, migrants generally experience heat stress, illnesses, and mortality [52]. However, heat is not the sole factor determining migration, although actual migration can be affected by many factors. For instance, migration on the southern United States border caused deaths due to dehydration, indicating that the environment and medical conditions are important for ensuring physiological conditions [53]. Some studies have reported that women and older groups have stronger decisions to migrate [51]. Moreover, migration is always associated with traffic and accommodation costs, and poor groups cannot afford to migrate [35]. Information about migration destinations is also important for ensuring a normal, decent life (e.g., job, income, wellness) after migration [35,52]. Due to the lack of destination information, economic foundation, and life conditions after resettlement, international migration generally cannot happen among residents to escape local rural poverty, while internal migration towards urban areas is large [35].

Overall, actual migration is associated with factors that cause migration intention, economic and physiological conditions during migration, and potential consequences after migration. This study examined the potential impacts of socio-economic-institutional, heat-related impacts, social-interactive and emotional, and perceptive-behavioral-psychological factors on migration and destination decisions. Accordingly, understandings of the factors arising from migration intention and the economic and physiological conditions during migration had been promoted. Prior studies on heat-driven migration had not explored the influence of institutional, social-interactive, emotional, and perceptive-behavioral-psychological factors. The results (Table 4) indicated that perceived heat severity and emotional responses did not significantly affect migration decisions, showing that perceptive heat and emotions did not affect migration. Moreover, the results indicated that heat-related impacts did not actually contribute to migration decisions (Table 5) or destinations (Table 6). This draws a different conclusion from existing studies that heat was not a significant direct driver of short-term migration, but this suggests that short-term migration is a complex decision associated with many other factors. For instance, adaptation awareness and knowledge were significant positive contributors to migration decisions (Table 5), while heat-related impacts significantly drove adaptation awareness and knowledge (Table 3). Accordingly, the analysis revealed that heat-related impacts could indirectly affect short-term migration by influencing adaptation awareness and knowledge.

Similar to the results of previous studies, this study verified that gender, age, education, and income were significant drivers. The female and elderly groups were more likely to migrate; the higher the education level, the more likely they were to migrate; and the higher the income, the more likely they were to migrate. The institutional factor of job flexibility significantly affected migration decisions, where flexible jobs were important to allow citizens to migrate. Overall, income ensures financial support, while job flexibility guarantees time availability. The social-interactive factor of heat information availability is a significant driver of migration. This might be because the media information contained migration suggestions, which is potentially consistent with the

findings of existing studies that information availability is a key factor [35].

Regarding migration destination, gender did not affect intra-province migration, while the female group was more likely to migrate to other provinces. Moreover, age made differences in intra-province migration rather than inter-province migration, possibly because inter-province migration increased physiological stress. Overall, in contrast to the conclusions of existing studies, this study revealed that the impacts of gender and age on migration were dependent on migration destinations, adding new knowledge of the drivers of heat-related migration. Moreover, this study originally revealed that education made significant differences in both intra-province and inter-province migration, and respondents who had higher education levels were more capable of migrating. However, education did not significantly differ between intra- & inter-province. Overall, this study adds to the understanding of how education affects migration destinations. Income was a significant factor in providing robust financial support for intra-province, inter-province, and intra- & inter-province migration. The higher the income, the more robust the migration decisions. This advances our knowledge of income-related migration. Moreover, job flexibility allowed citizens to migrate farther to surrounding provinces, but it had no impact on intra-province and intra- & inter-province migration. This finding reveals that intra-province migration is beyond the impact of job flexibility.

Regarding social-interactive, behavioral, and psychological factors, their contributions to migration destinations varied. Heat information availability was a significant factor for intra-province, inter-province, and intra- & inter-province migration, which was consistent with existing findings and advanced our understanding of how social-interactive attributes affected migration. Adaptation awareness promoted intra-province and intra- & inter-province migration, but it made no difference to inter-province migration, whereas adaptation knowledge promoted inter-province migration. Overall, migration destinations were sensitive to social-interactive, behavioral, and psychological factors, but these factors were not always significant.

4.3. Tourism-related short-term migration destination: final step to ensure migrants' comfort, health and wellness

Migrants' decisions on migration and destinations also depend on the achievement of comfort, health, and wellness expectations, raising emerging requirements to build cool, comfortable tourism destinations. This study has implications for building responsible tourism destinations. First, this study verified an emerging phenomenon in which more than 40 % of the respondents migrated towards cool areas for heat relief, which provided local governments and communities of cool, mountainous regions with a solid, scientific basis to promote the cool tourism industry. Second, three quarters of migrants preferred to cool down in surrounding suburbs and counties in Chongqing, while 55 % preferred to migrate to surrounding provinces for relief. According to this, tourism developers can understand the size of tourism market as well as its potential economic benefits on the one hand, and estimate the needs of critical infrastructure (e.g., electricity, water, transportation, accommodation, and food) on the other. Third, local developers are required to improve service and medical capabilities given the migration of large populations and diverse groups. For instance, our study indicated that aged tourists were a key migration group, although they might suffer physiological stress in migration destinations. Fourth, local governments and communities must provide cooling resources. It is essential to preserve local cooling resources and avoid warming effects during construction.

Urban heat is a fatal weather-related disaster that is expected to intensify in the coming years. Owing to insufficient implementation of mitigation and adaptation solutions, many cities and citizens have been locked into urban heat. In particular, extensive heat-related deaths have been reported in many countries. With a principle central to people, exploring feasible and implementable adaptation solutions to protect citizens from heat-related illnesses, diseases, and deaths is an urgent priority for local governments. Unlike long-term migration, which may deteriorate economic growth, short-term migration is a cost-effective and feasible solution to effectively ensure health and safety, and should be promoted by the governments of cities with strong heat impacts (e.g., Chongqing, Shanghai, Tokyo, Hong Kong, Athens, Tirana, Lisbon, Madrid, Milan, and Paris). This study verified that the availability of heat information is a key driver of migration. Therefore, local governments and communities of cool tourism destinations can collaborate with meteorological departments and the media to promote migration destination information. Moreover, increasing adaptation awareness and adaptation knowledge was conducive to enhancing migration for heat adaptation, suggesting that governments of cities with extreme heat challenges should make efforts to improve public adaptation awareness and knowledge. In addition, based on the conclusions relevant to the institutional factors of job flexibility, it is essential to adopt flexible working patterns to allow more people to adapt to protect themselves. Job flexibility is a new factor that causes heat-related inequalities.

5. Conclusions

Migration is a feasible solution for many citizens to escape heat-related impacts on their health and lives. However, short-term migration for heat adaptation, mostly linked to tourism development, has not been sufficiently explored. This empirical study was conducted in Chongqing, one of the hottest and most humid cities in China, to reveal people's short-term migration and associated mechanisms. This study delineated the mechanism in socio-economic-institutional, heat-related impacts, emotional, social-interactive, and perceptive-behavioral-psychological aspects. The analysis revealed that urban heat in Chongqing reached a severe level and citizens' outdoor activities and transportation were severely affected. However, respondents' adaptation capacity was weak, basically at a little level. The lack of mitigation and adaptation solutions in Chongqing had driven citizens to migrate to cool areas for heat relief. More than 40 % of the respondents preferred short-term migration, 75 % preferred intra-province migration, and 55 % preferred inter-province migration. Migration was not dependent on settlement, health, heat-related impacts, perceived heat severity, emotions, and risk knowledge but was dependent on socio-economic-institutional factors (e.g., gender, age, education, income, and job), social-interactive factors (e.g., heat information availability), and behavioral-psychological factors (e.g., adaptation awareness and knowledge). Preference for migration destinations was dependent on these factors, but these factors differentiated intra-province, inter-province, and intra- & inter-province migration. Overall, this study adds new knowledge on short-term migration for heat adaptation and generates implications for responsible tourism development.

CRediT authorship contribution statement

Bao-Jie He: Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jinda Qi:** Resources, Project administration, Investigation, Formal analysis. **Ali Cheshmehzangi:** Validation, Supervision, Investigation, Data curation, Conceptualization. **Shady Attia:** Project administration, Methodology, Data curation. **Deo Prasad:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Formal analysis. **Leila Mohaghegh Zahed:** Writing – review & editing, Supervision, Resources, Funding acquisition, Conceptualization. **Yao Mao:** Software, Resources, Methodology, Investigation, Data curation. **Junqing Tang:** Software, Project administration, Methodology, Conceptualization. **Andreas Matzarakis:** Writing – review & editing, Validation, Investigation, Formal analysis, Conceptualization. **Zhengxuan Liu:** Writing – review

& editing, Investigation, Formal analysis, Data curation, Conceptualization.

Ethics statement

The studies involve human participants, and written informed consent for participation was filled in accordance with the national legislation and the institutional requirements.

Declaration of Competing Interest

The authors including Bao-Jie He, Ali Cheshmehzangi, Andreas Matzarakis, Jinda Qi, and Deo Prasad are Executive Editors/Associate Editors/Senior Advisory Members for this journal and were not involved in the editorial review or the decision to publish this article.

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Appendix

Appendix Table 1
An examination of the normality of different categories of variables

Categories	Variables	Kolmogorov-Smirnov			Shapiro-Wilk			Normality
		Statistic	df	Sig.	Statistic	df	Sig.	
Socio-economic-institutional characteristic	Gender	0.371	768	0.000	0.632	768	0.000	No
	Age	0.194	768	0.000	0.904	768	0.000	No
	Education	0.319	768	0.000	0.820	768	0.000	No
	Settlement	0.491	768	0.000	0.490	768	0.000	No
	Health	0.239	768	0.000	0.833	768	0.000	No
	Income	0.201	768	0.000	0.903	768	0.000	No
	Job	0.351	768	0.000	0.636	768	0.000	No
Heat-related impacts on daily functioning	OUAT	0.272	768	0.000	0.830	768	0.000	No
	WORK	0.216	768	0.000	0.899	768	0.000	No
	TSPT	0.259	768	0.000	0.855	768	0.000	No
	SLEP	0.193	768	0.000	0.904	768	0.000	No
	DIET	0.200	768	0.000	0.907	768	0.000	No
	Impact sum	0.155	768	0.000	0.882	768	0.000	No
Emotional responses	Emotion	0.226	768	0.000	0.821	768	0.000	No
Social-interactive attributes	Oral communication	0.345	768	0.000	0.636	768	0.000	No
	Websites	0.346	768	0.000	0.636	768	0.000	No
	Weibo	0.425	768	0.000	0.597	768	0.000	No
	WeChat and moments	0.418	768	0.000	0.603	768	0.000	No
	Forums	0.515	768	0.000	0.416	768	0.000	No
	Government text messages	0.404	768	0.000	0.615	768	0.000	No
	Television	0.388	768	0.000	0.625	768	0.000	No
	Sum	0.186	768	0.000	0.897	768	0.000	No
Perceptive-behavioral-psychological attributes	PUHS	0.229	768	0.000	0.827	768	0.000	No
	KHRR	0.311	768	0.000	0.828	768	0.000	No
	UHAA	0.249	768	0.000	0.855	768	0.000	No
	UHAK	0.253	768	0.000	0.858	768	0.000	No
Migration action	Migration	0.387	768	0.000	0.625	768	0.000	No
	Intra-province	0.437	768	0.000	0.583	768	0.000	No
	Inter-province	0.479	768	0.000	0.518	768	0.000	No

Data availability

Data will be available on request.

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