



## A Systematic Review: Investigation of Occupational Studies Performed by Environmental Heat Stress Indices in Iran

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### ABSTRACT

**Introduction:** Many studies, especially in recent years, have evaluated and controlled the occupational heat stress in Iran using environmental indices. However, so far, no comprehensive study has been conducted to review and classify these studies. Therefore, this study aimed to review and investigate the occupational studies performed by environmental heat stress indices in Iran.

**Material and method:** In the present study, the published articles from 2000 to 2016 were searched using Persian and English keywords including heat stress, heat strain, hot condition, warm condition, occupational health, thermal environment and Iran in databases such as Web of Science, Google Scholar, PubMed, Scopus, Science Direct, SID, Magiran, Civilica, Iran Medex, Barakatks and Irandoc. Finally, 134 articles were included in this study.

**Results:** Based on the results, most studies have been carried out in the indoor industrial environments of Isfahan, Tehran, and Assaluyeh between years of 2010 to 2016. As well as, WBGT index with 76 percent and the UTCI and PHS indices with 0.6 percent had the highest and lowest usage in all environments and industries, respectively. In addition, the industries of the refinery, steel, glasswork, melting and casting, mines, and ship repairs have the highest mean values of WBGT index, respectively.

**Conclusion:** The results showed the need to more attention of researchers for conducting studies in outdoor environments, in different cities of Iran, on development and validation of novel heat stress indices, and on implementation and evaluation of control measures in the environments with high heat stress.

**Keywords:** Occupational Studies, Heat stress, Environmental index

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### 1. Introduction

Higher than 82 percent of Iran area has located at arid and semi-arid regions. In addition, some industries in Iran because of outdated equipment or inherent characteristics produce and diffuse the heat and moisture. These conditions can cause excessive exposure and subsequently heat-related diseases in Iranian employees. Many studies were performed with the aim of assessing and controlling the heat stress in Iran. However, any study has comprehensively reviewed these studies. Therefore, the present study was aimed to review and analyze the occupational studies performed using environmental heat stress indices in Iran [1-8].

### 2. Material and Methods

In the present study, all article published by Iranian authors from 2000 to 2016 were searched using Persian and English keywords including heat stress, heat strain, hot condition, warm condition, occupational health, thermal environment and Iran in databases of Web of Science, Google Scholar, PubMed, Scopus, Science Direct, SID, Magiran, Civilica, Iran Medex, Barakatks and Irandoc. In total, 323 articles were found. In next step, their

titles and abstract were studied and non-related articles to aim of the present study were excluded. Subsequently, non-research articles such as book review, letter to editor, and public texts and repetitive articles were removed. In final, 134 articles were entered to the review study based on the exclusion criteria. The extracted information of the articles comprised title, year of publication, place of study, city of study, type of work environment, type of industry, used heat stress indices, and values of WBGT index. Finally, data were analyzed using SPSS software.

### 3. Results and Discussion

Based on the results, most numbers of the studies, with 93.3 percent of the total researches related to publish article, have been carried out between years of 2010 to 2016. As well as, most of studies with 61.9 percent were related to the indoor industrial environments. Most of studies were also performed in cities of Isfahan with 31.08 percent, Tehran with 16.89 percent, and Assaluyeh with 11.48 percent, respectively. WBGT index with 76 percent and the UTCI and PHS indices with 0.6 percent had the highest and lowest usage

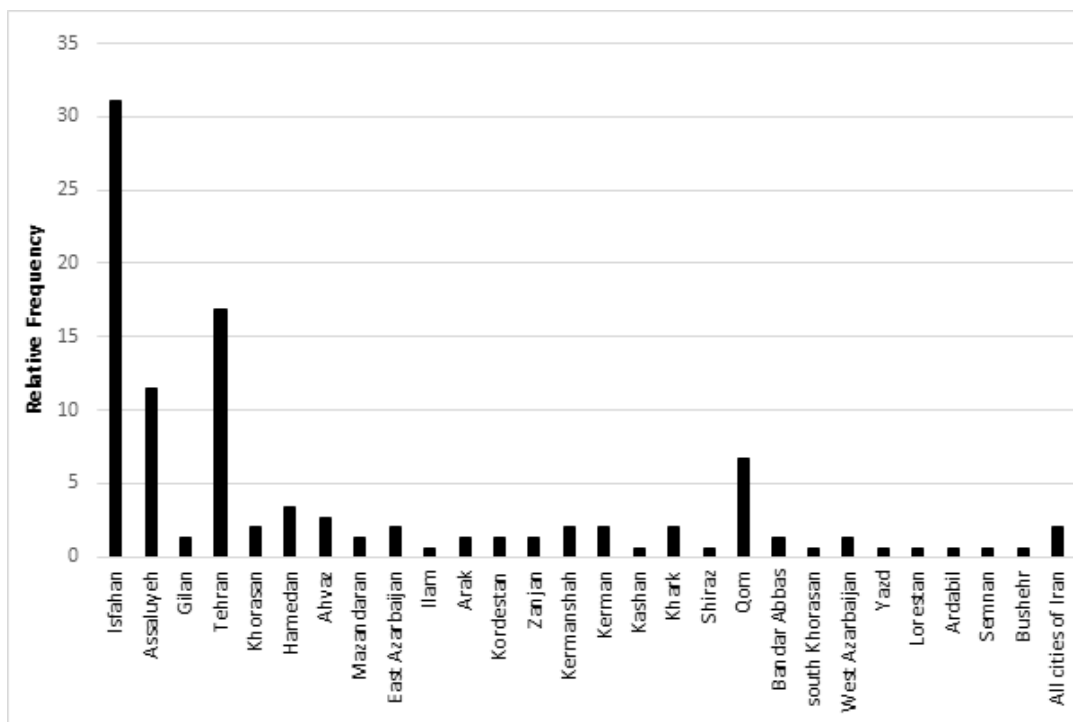


Fig. 1. Frequency distribution of studies based on the city of research

**Table 1.** Frequency distribution of studies based on place of research and type of environment

Category		Frequency	Relative frequency
place of research	Climatic chamber	32	23.9
	Field	102	76.1
	Total	134	100
type of environment	Indoor	83	61.9
	Outdoor	27	20.2
	Both environment	24	17.9
	Total	134	100

**Table 2.** Frequency distribution of used environmental indices in studies

Heat stress index	Type of environment							
	Indoor		Outdoor		Both environments		total	
	Frequency	Relative frequency	Frequency	Relative frequency	Frequency	Relative frequency	Frequency	Relative frequency
WBGT <sup>1</sup>	70	83.24	23	62.16	24	66.70	117	75.97
PMV <sup>2</sup>	3	3.70	1	2.70	0	0.00	4	2.60
SW <sup>3</sup>	1	1.20	4	10.80	0	0.00	5	3.25
DI <sup>4</sup>	0	0.00	3	8.10	1	2.80	4	2.60
HIS <sup>5</sup>	3	3.70	0	0.00	1	2.80	4	2.60
P4SR <sup>6</sup>	0	0.00	1	2.70	1	2.80	2	1.30
TWL <sup>7</sup>	0	0.00	0	0.00	3	8.30	3	1.95
ESI <sup>8</sup>	1	1.20	2	5.40	0	0.00	3	1.95
CET <sup>9</sup>	2	2.50	1	2.70	2	5.60	5	3.25
Humidex	0	0.00	1	2.70	0	0.00	1	0.60
ET <sup>10</sup>	0	0.00	0	0.00	2	5.60	2	1.30
AET <sup>11</sup>	1	1.20	0	0.00	0	0.00	1	0.60
PHS <sup>12</sup>	0	0.00	0	0.00	1	2.80	1	0.60
UTCI <sup>13</sup>	0	0.00	0	0.00	1	2.80	1	0.60
THI <sup>14</sup>	0	0.00	0	2.70	0	0.00	1	0.60
Total	81	100.00	37	100.00	36	100.00	154	100.00

<sup>1</sup>Wet Bulb Globe Temperature, <sup>2</sup>Predicted Mean Vote Index, <sup>3</sup> Required Sweat Rate, <sup>4</sup> Discomfort Index, <sup>5</sup> Heat Stress Index, <sup>6</sup> Predicted 4- Hour Sweat Rate, <sup>7</sup> Thermal Work Limit, <sup>8</sup>Environmental Stress Index, <sup>9</sup>Corrected Effective Temperature, <sup>10</sup> effective temperature, <sup>11</sup> Allowable Exposure Times, <sup>12</sup> Predicted Heat Strain, <sup>13</sup>Universal Thermal Climate Index, <sup>14</sup>Temperature Humidity Index

in all environments and industries, respectively. In addition, the results showed that WBGT index had most usage in industries of melting and casting with 15.7 percent, petroleum with 8.3 percent, and outdoor small occupations with 8.3 percent, respectively. Based on the results, the industries of the refinery, steel, glasswork, melting and casting, mines, and ship repairs have the highest mean values of WBGT index, respectively

**4. Conclusions**

The results of the present study showed that most of the studies were carried out in indoor industrial environments and in the cities of Isfahan, Tehran and Assaluyeh. the most used indices in all

environments and industries were WBGT index. These results show the need to more attention of researchers for conducting studies in outdoor environments, in different cities of Iran, on development and validation of novel heat stress indices, and on and evaluation of control measures in the environments with high heat stress.

**5. Acknowledgment**

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**Table 3.** Values of WBGT index in studied units and industry

Type of industry	Range	Mean	Standard deviation
Refinery	32.8 - 33.7	33.20	0.40
Melting and casting	22.1 – 39.5	31.09	4.92
Steel	24.5 – 44.9	32.27	6.53
Car assembly	18.9 – 22.3	20.83	1.18
Hospital	17.4 – 26.8	21.43	3.10
Pastry	23.0 – 23.0	22.97	0.00
Bakery	26.0 – 33.7	29.98	2.14
Glass making	27.6 – 35.6	31.73	3.43
Outdoor mine	29.8 – 32.6	30.99	1.23
Petrochemical	22.3 – 33.3	29.88	4.29
Forging (hot press)	28.6 – 31.2	29.89	1.86
Outdoor Small Businesses	23.2 – 27.0	26.17	1.15
Agriculture	24.0 – 32.0	29.49	2.52
Brick	21.9 – 30.8	26.66	3.24
Ship repairs	30.0 – 32.0	30.96	0.79
Tile making	20.7 – 27.9	24.73	3.67
Dairy	23.4 – 27.5	25.45	2.89
Cement	20.2 – 33.8	27.00	9.61
Oil terminal	25.7 – 30.6	27.27	1.45
Asphalt	24.3 – 30.2	28.53	2.48
Construction	22.6 – 27.5	25.05	3.46
Laundry	29.0 – 29.0	28.98	0.00
Biscuit making	19.0 – 23.2	21.07	2.29

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