

Heat stress risk among New York City public school kitchen workers: a quantitative exposure assessment

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Abstract

Despite the known human health risks associated with excessive heat exposure, particularly in occupational settings, data describing potential heat exposures in school kitchens is scarce. The purpose of this study was therefore to quantify the extent of heat stress in New York City public school kitchens and to assess potential risk of heat-related illness and/or acute injury. Full-shift indoor Wet Bulb Globe Temperature (WBGT) indices were measured at 10 school kitchens. A quantitative exposure assessment for three metabolic work-rate scenarios (light, moderate, heavy) was performed in accordance with OSHA's Heat Hazard Assessment methodology. The overall mean indoor WBGT index for all 10 sites was approximately 25.0°C (77.0°F; Standard Deviation [SD] = 2.0°C). The heat stress TLV was exceeded in three school kitchens for the heavy work-rate scenario, but the Action Limit was exceeded in the majority of schools for both the moderate and heavy work-rate scenarios; one school exceeded this recommended Action Limit for the light work-rate scenario. The data collected in the current study suggest that kitchen staff employed in New York City public schools may be exposed to excessive indoor heat levels. Adequate work-rest schedules should be implemented for kitchen workers, in addition to other feasible engineering and administrative controls, to mitigate potential risk of heat-related illness and/or acute injury.

Introduction

- Excessive heat exposure is a significant occupational health and safety concern in both outdoor and indoor environments.
 - Between 2000 and 2010, there were 359 occupational heat-related deaths in the U.S., resulting in a yearly average rate of 2.2 deaths per 100,000 workers.¹
- In addition to heat-related illnesses, excessive heat exposure has also been associated with declines in cognitive function/decision-making abilities² and increased risk-taking behavior.³
- The primary purpose of the current study was to quantify the extent of heat stress in New York City school kitchens and the subsequent risk of heat-related illness and/or acute injury.

Table 1. Overview of New York City public schools included in heat stress evaluation

School	Borough	Sampling Date (Day)	Average Temperature (°C)		Average Humidity (%)	
			Indoor	Outdoor	Indoor	Outdoor
School 1	Brooklyn	May 31 (F)	30.3	23.5	46	55
School 2	Manhattan	June 7 (F)	29.1	23.1	44	58
School 3	Queens	June 14 (F)	25.4	19.4	38	50
School 4	Manhattan	June 21 (F)	28.8	20.3	47	76
School 5	Manhattan	July 12 (F)*	33.0	28.3	43	57
School 6	Brooklyn	August 2 (F)*	32.4	25.6	42	58
School 7	Brooklyn	August 16 (F)*	29.8	24.4	52	68
School 8	Brooklyn	August 23 (F)*	32.7	21.5	40	66
School 9	Bronx	August 29 (Th)*	25.8	25.5	51	46
School 10	Queens	September 26 (Th)	29.0	24.7	47	58

* School was not in session during the sampling event.; F: Friday; Th: Thursday

Methods

- Selection of Schools:** Ten (10) public schools were selected for evaluation in conjunction with the Health and Safety Department of District Council-37, New York City's largest labor union (Table 1).
- Environmental Sampling:** Between 2019 May 31 and September 26, full-shift (~6 to 7 hours) indoor WBGT index (WBGT_{in}) measurements in °C were collected in the 10 school kitchens with a heat stress monitor (QUESTemp Heat Stress Monitor Kit QT36, 3M, Saint Paul, MN, USA) placed as close to the ovens as possible; a data-logging indoor air quality meter (7545 IAQ-Calc, TSI, Shoreview, MN, USA) was co-located with the heat stress monitor to simultaneously measure carbon dioxide (CO₂) and carbon monoxide (CO) levels (Figure).
 - Average outdoor temperature and humidity between 7:00 AM and 3:00 PM were also recorded for each sampling day based on hourly sensor data (The Weather Company, an IBM Business, Brookhaven, GA, USA).
- Exposure Assessment:** A quantitative exposure assessment was performed in accordance with OSHA's Heat Hazard Assessment described in its Technical Manual in which the effective WBGT index (WBGT_{eff}) and metabolic work-rates are compared to the ACGIH Action Limits and TLVs for heat stress.
 - Metabolic work-rate scenarios (in Watts [W]) of 180 (light work; sitting, standing, light arm/hand work, occasional walking), 300 (moderate work; normal walking, moderate lifting), and 415 (heavy work; heavy material handling, walking at a fast pace) were evaluated for kitchen workers.
 - WBGT_{eff} was equal to WBGT_{in} because standard cotton/light polyester short-sleeve shirts and pants were worn by staff (i.e., no clothing adjustment factor was necessary).
 - A publicly-available computer-based tool created by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) was utilized to calculate the Action Limits and TLVs for each work-rate scenario, as well as recommended work/rest schedules.

Results

- The school kitchens ranged in volume from approximately 6,800 to 45,600 ft³ and the number of total meals served ranged from 7 to 1,257; for student meal service, frozen foods were re-heated using electric ovens and steamers.
- The overall mean WBGT_{in} among all 10 New York City public school kitchens was approximately 25.0°C (77.0°F; SD = 2.0°C) (Table 2).
- Action Limits of 28.1°C (82.6°F), 25.0°C (77.0°F), and 23.0°C (73.4°F), expressed as WBGT_{eff}, were calculated for the light, moderate, and heavy work-rate scenarios, respectively.
- Similarly, TLVs of 30.8°C (87.4°F), 28.2°C (82.8°F), and 26.6°C (79.9°F) were calculated for the light, moderate, and heavy work-rate scenarios, respectively.
- Regarding the ACGIH Action Limits, 10% of school kitchens sampled exceeded this recommended limit for the light work-rate scenario; 60% of schools exceeded this limit for the moderate work-rate scenario, and 80% of schools exceeded this limit for the heavy work-rate scenario. For the ACGIH TLVs, none of the kitchens exceeded these limits for the light or moderate work-rate scenarios; 30% of kitchens were in excess of this limit for the heavy work-rate scenario (Table 3)
 - Recommended work/rest schedules are also presented in Table 3.
- Full-shift CO₂ and CO air concentrations ranged from 435 to 911 ppm (mean = 648; SD = 158) and 0.0 to 3.2 ppm (mean = 0.9; SD = 0.9), respectively.

Table 2. Mean full-shift WBGT_{in} measurements in New York City public school kitchens

School	Sample Duration (hr:min)	WBGT _{in} (°C)		
		Mean	SD	Range
School 1	7:18	25.5	0.6	23.6 – 26.4
School 2	6:32	24.7	0.5	23.5 – 25.8
School 3	7:09	21.4	0.6	19.9 – 22.6
School 4	6:45	24.3	1.0	20.7 – 26.0
School 5	6:39	28.1	0.9	25.5 – 29.5
School 6	5:52	26.7	0.6	25.2 – 28.0
School 7	6:00	25.8	0.3	24.7 – 26.5
School 8	5:42	26.7	0.9	24.4 – 29.7
School 9	6:00	21.7	0.8	20.4 – 22.7
School 10	6:00	25.4	0.5	23.6 – 26.9

SD: Standard Deviation



Figure. Example of school kitchen and sampling equipment set-up (Photographs by AMI).

Discussion

- The mean WBGT_{in} for all 10 kitchens (25.0°C; SD = 2.0) in this study is comparable to WBGT_{in} indices (range: 24.1 – 24.5°C) reported in the only other studies^{4,5} identified that evaluated heat stress in school kitchens that used ovens for cooking.
- The majority of the work observed during the sampling events was subjectively considered light to moderate work by the investigator (AMI).
 - Further investigation that quantitatively measures metabolic output of kitchen staff, and other workers in general, would be useful in producing more refined heat exposure assessments.
- Full-shift CO₂ and CO air concentrations were well below ACGIH TLVs for these chemicals, and indicated that sufficient outdoor air exchange was achieved at each sampling site.

Table 3. Heat stress Action Limit and TLV exceedances in New York City public school kitchens by metabolic work-rate and recommended work/rest schedules^a

School	Action Limit			TLV		
	Light	Moderate	Heavy	Light	Moderate	Heavy
School 1	+	● (52)	● (32)	+	+	+
School 2	+	▲ (59)	● (40)	+	+	+
School 3	+	+	+	+	+	+
School 4	+	▲ (59)	● (44)	+	+	+
School 5	● (59)	● (21)	● (13)	+	▲ (59)	● (38)
School 6	+	● (36)	● (22)	+	+	● (58)
School 7	+	● (48)	● (31)	+	+	▲ (50)
School 8	+	● (36)	● (22)	+	+	● (58)
School 9	+	+	+	+	+	+
School 10	+	● (54)	● (33)	+	+	+

^aThe number of minutes per hour an individual can work continuously without break is presented in parentheses for exceedances and values within 1°C of WBGT_{eff}.

● = Exceedance; ▲ = Within 1°C; + = Staff may work up to a full hour without break

Conclusions & Recommendations

- Based on the results of current study, kitchen staff employed in New York City public schools may be exposed to excessive indoor heat levels, depending on their individual work-rate output and degree of heat acclimatization.
- Control measures, including adherence to appropriate work-rest schedules, installation of air-conditioning units, and proper training, among others, should be implemented and adhered to by kitchen workers to mitigate potential risk of heat-related illness and/or acute injury.

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References: ¹Gubernot et al. (2015); ²Schmit et al. (2017); ³Chang et al. (2017); ⁴Haruyama et al. (2010); ⁵Matsuzuki et al. (2011)