



Results of investigation on impact of heat stress to garment labor productivity, Case Study: Phnom Penh

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PROJECT PRINCIPLE INVESTIGATOR

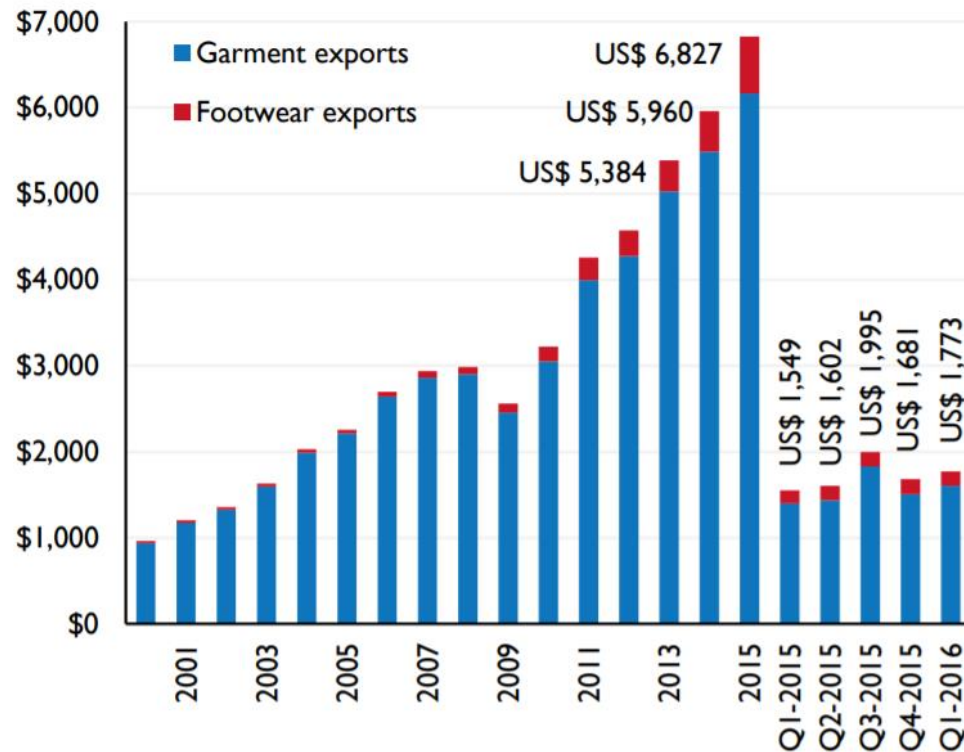
Department of Industrial and Mechanical Engineering
Institute of Technology of Cambodia

Garment sector in Cambodia

Major task are done by human

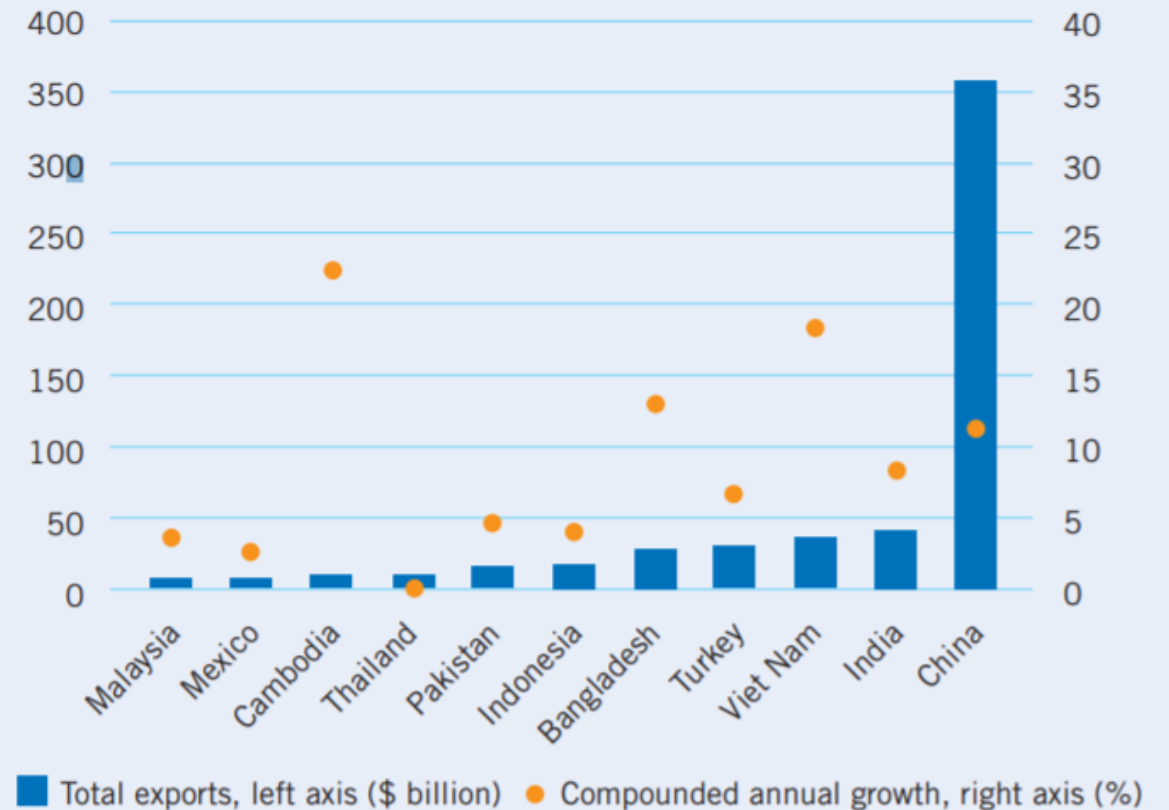
Huge number of human work in garment sector

Figure 11: Cambodia's garment and footwear exports, 1995-2015 (US\$ million)



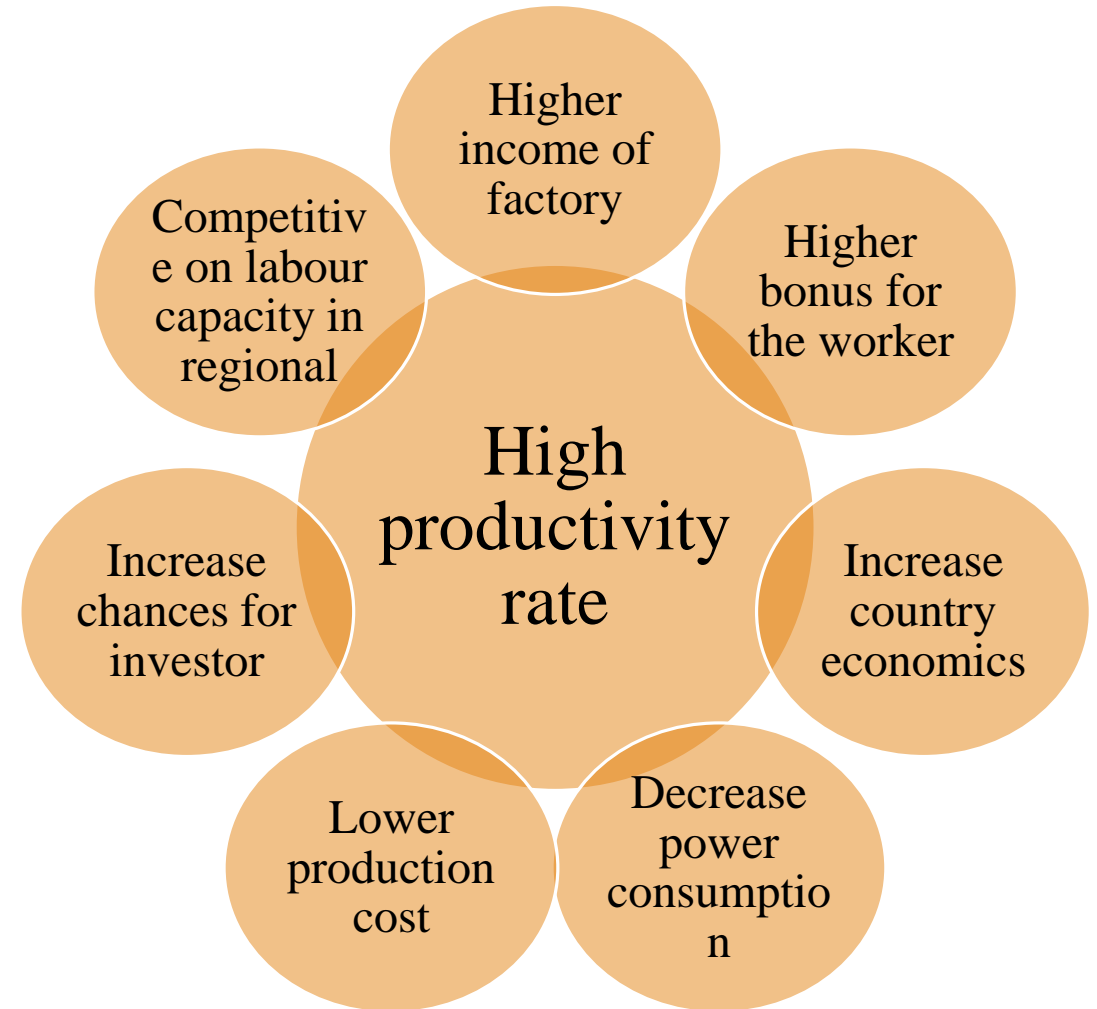
Source: Cambodia's General Department of Customs and Excise

Panel B. Exports from selected economies (\$ billion), 2014, and compounded annual growth (%), 1995–2014



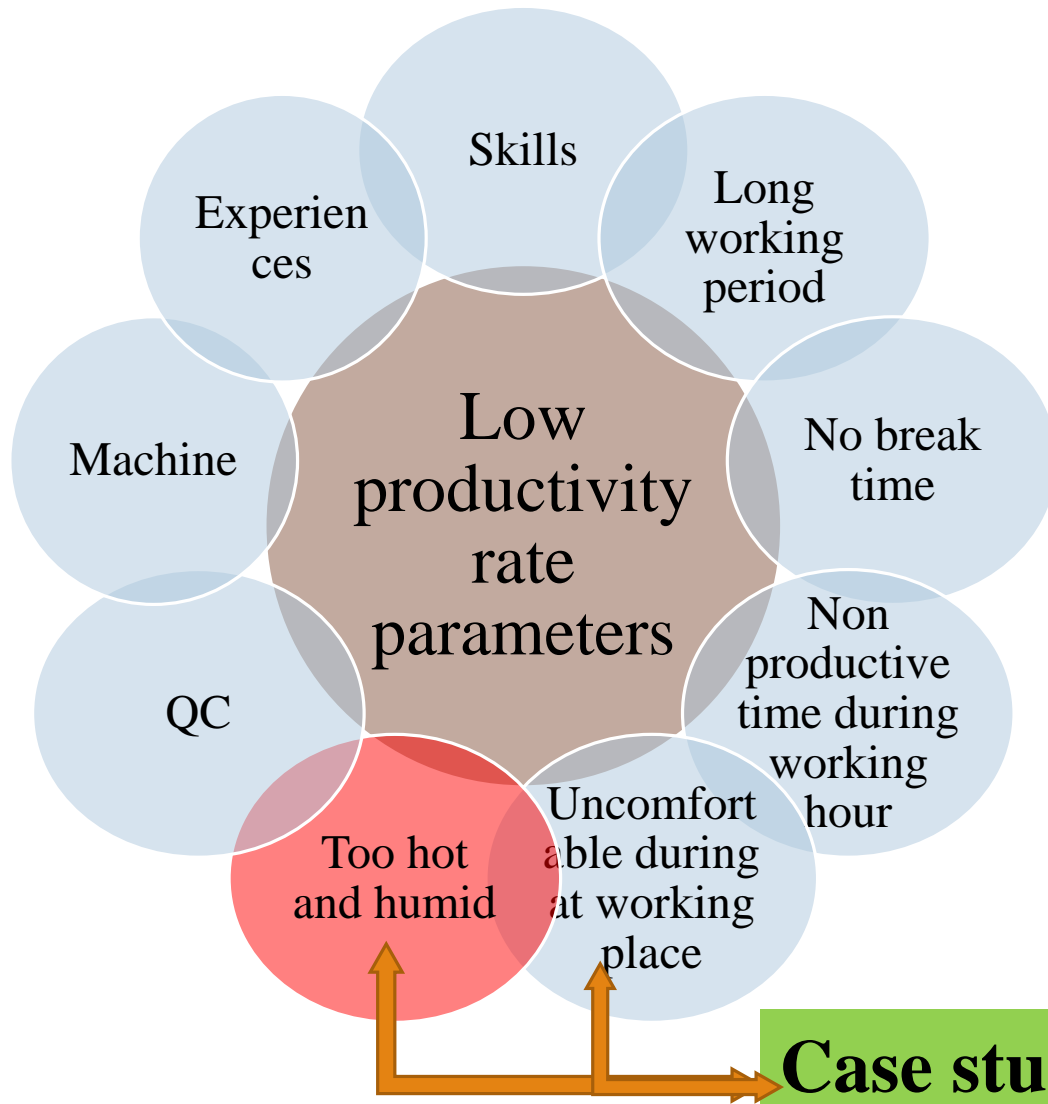
Source: Estimates from UNCTAD: UNCTADstat Database.

Garment productivity Rate



<http://garmentstech.com/garments-labor-productivity-rate-of-china-bangladesh-india-pakistan-cambodia/>

Common issue of the factory managers



Heat Index and IAQ



		temperature (°C)																	
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
Relative Humidity (%)	40	27	28	29	30	31	32	34	35	37	39	41	43	46	48	51	54	57	
	45	27	28	29	30	32	33	35	37	39	41	43	46	49	51	54	57		
	50	27	28	30	31	33	34	36	38	41	43	46	49	52	55	58			
	55	28	29	30	32	34	36	38	40	43	46	48	52	55	58				
	60	28	29	31	33	35	37	40	42	45	48	51	55	58					
	65	28	30	32	34	36	39	41	44	48	51	55	58						
	70	29	31	33	35	38	40	43	47	50	54	58							
	75	29	31	34	36	39	42	46	49	53	58								
	80	30	32	35	38	41	44	48	52	57									
	85	30	33	36	39	43	47	51	55										
	90	31	34	37	41	45	49	54											
	95	31	35	38	42	47	51	57											
	100	32	36	40	44	49	54												

LEVEL display (POOR, MODERATE, GOOD)

Level	Category	TVOC [ppb]	eCO2[ppm]
1	GOOD	<250	400-1499
2	MODERATE	250-449	1500-2499
3	POOR	>450	>2500

Heat stress Index (°C)	Category	Dangers
27–32	Caution	Fatigue possible with prolonged exposure and/or physical activity
32–41	Extreme caution	Sunstroke, heat cramps and heat exhaustion possible with prolonged exposure and/or physical activity
41–54	Danger	Sun stroke, heat cramps or heat exhaustions likely, and heatstroke possible with prolonged exposure and/or physical activity
Above 54	Extreme danger	Heat/sunstroke highly likely with continued exposure

CO ₂ [ppm]	Air Quality
2100	BAD Heavily contaminated indoor air Ventilation required
2000	
1900	
1800	
1700	
1600	MEDIOCRE Contaminated indoor air Ventilation recommended
1500	
1400	
1300	
1200	
1100	FAIR
1000	
900	
800	GOOD
700	
600	
500	EXCELLENT
400	

WBGT: wet bulb globe temperature

The American Conference of Governmental Industrial Hygienists (ACGIH)

<u>Work/rest periods</u>	<u>Light work</u>	<u>Moderate work</u>	<u>Heavy work</u>
Continuous work	30.0	26.7	25.0
75% work: 25% rest	30.6	28.0	25.9
50% work: 50% rest	31.4	29.4	27.9
25% work: 75% rest	32.2	31.1	30.0

(These ACGIH temperatures, given in degrees centigrade, are measured using the Wet Bulb-Globe Temperature Index [WBGT] which gives a more accurate measure of heat conditions than ordinary mercury or alcohol thermometers which only measure temperature and not humidity or radiant heat⁵).

REMEMBER:

It is important to know the humidity inside the factory. If the factory is very hot and humid, the process of sweating is not effective and the workers are in danger of over heating.

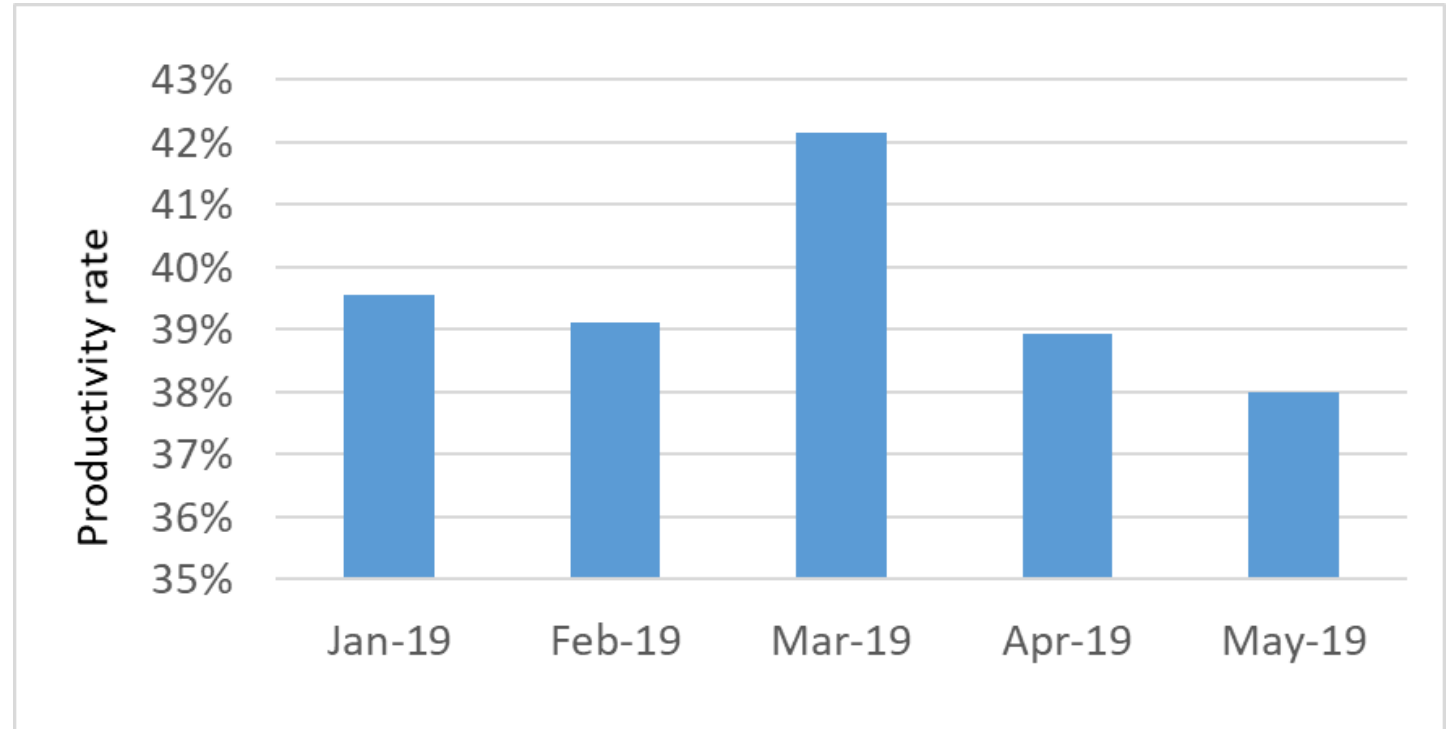
Health Hazards In Garment Industry

Process	Chemicals used	Health hazards
Cutting fabrics	No chemicals Particulates	Little effect on respiratory system
Fusing the interlining to fabric pieces	Fumes of interlining adhesive resin, and fabric finish	Slight effect of adhesive fumes on respiratory system (VOCs)
Sewing	Particulates	Negligible effect on respiratory system
Ironing	Fumes from fabric	Negligible effect on respiratory system

Case study: one factory in Phnom Penh



Factory started in 2009, Total areas: 30,000m²
3500 workers, 90% is female workers
Productivity: 45% annually



Case study: one factory in Phnom Penh



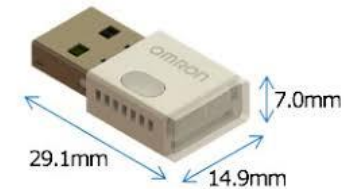
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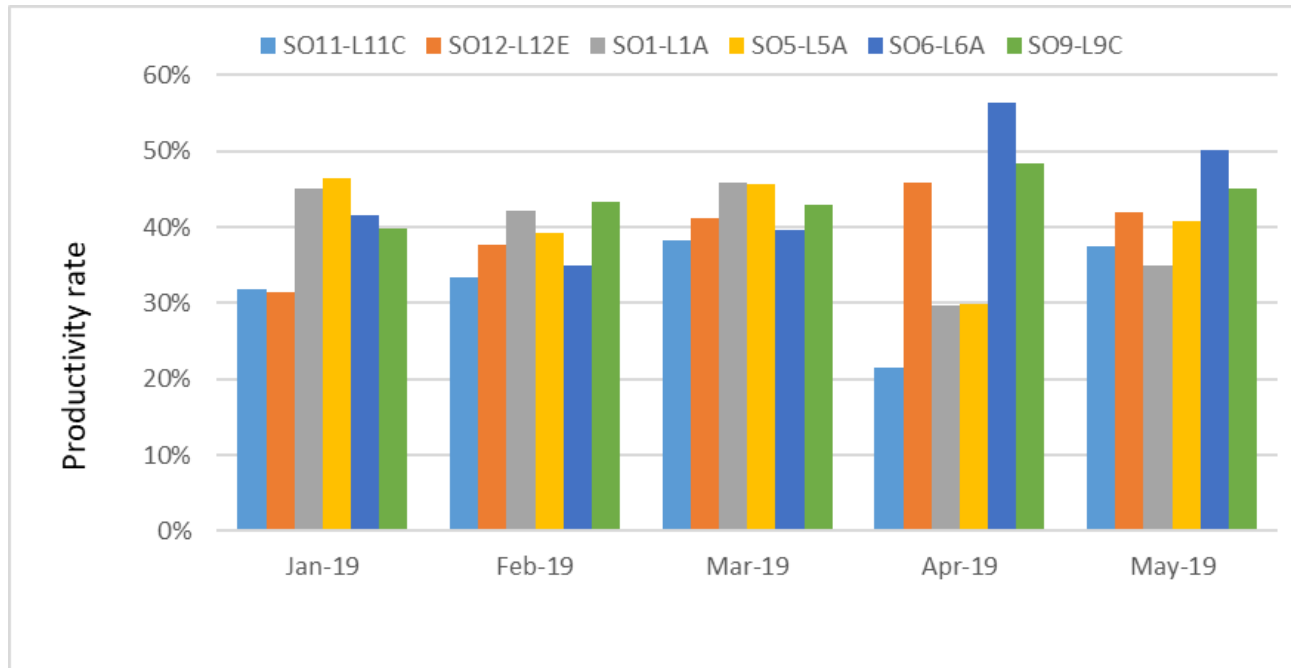
Productivity: 45% annually

This study divided into 2 cases;

1. Questionnaire survey: 130
2. Measurement survey: T, RH, heat index of ambient, velocity



Monthly productivity



Regarding to the monthly productivity was not depending on the month. Therefore, specific locations were required for study to check;

1. Air condition distribution effecting the productivity
2. Once indoor was high temperature and humid then it was direct effected from the ambient air condition

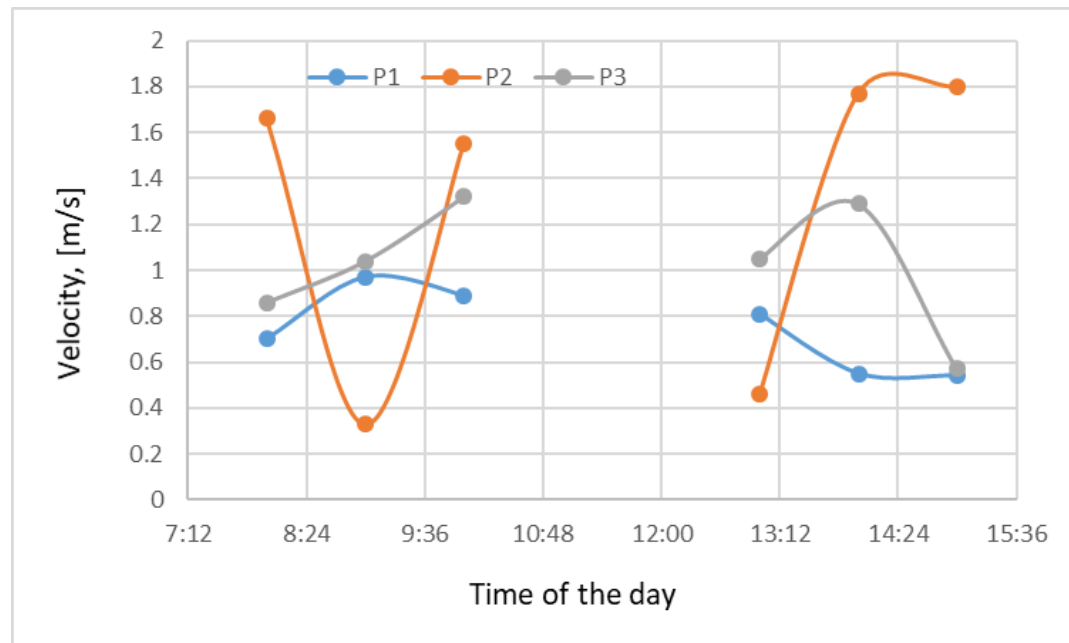
Measurement survey results

Investigation of indoor and outdoor air conditions

Average values of the indoor air conditions

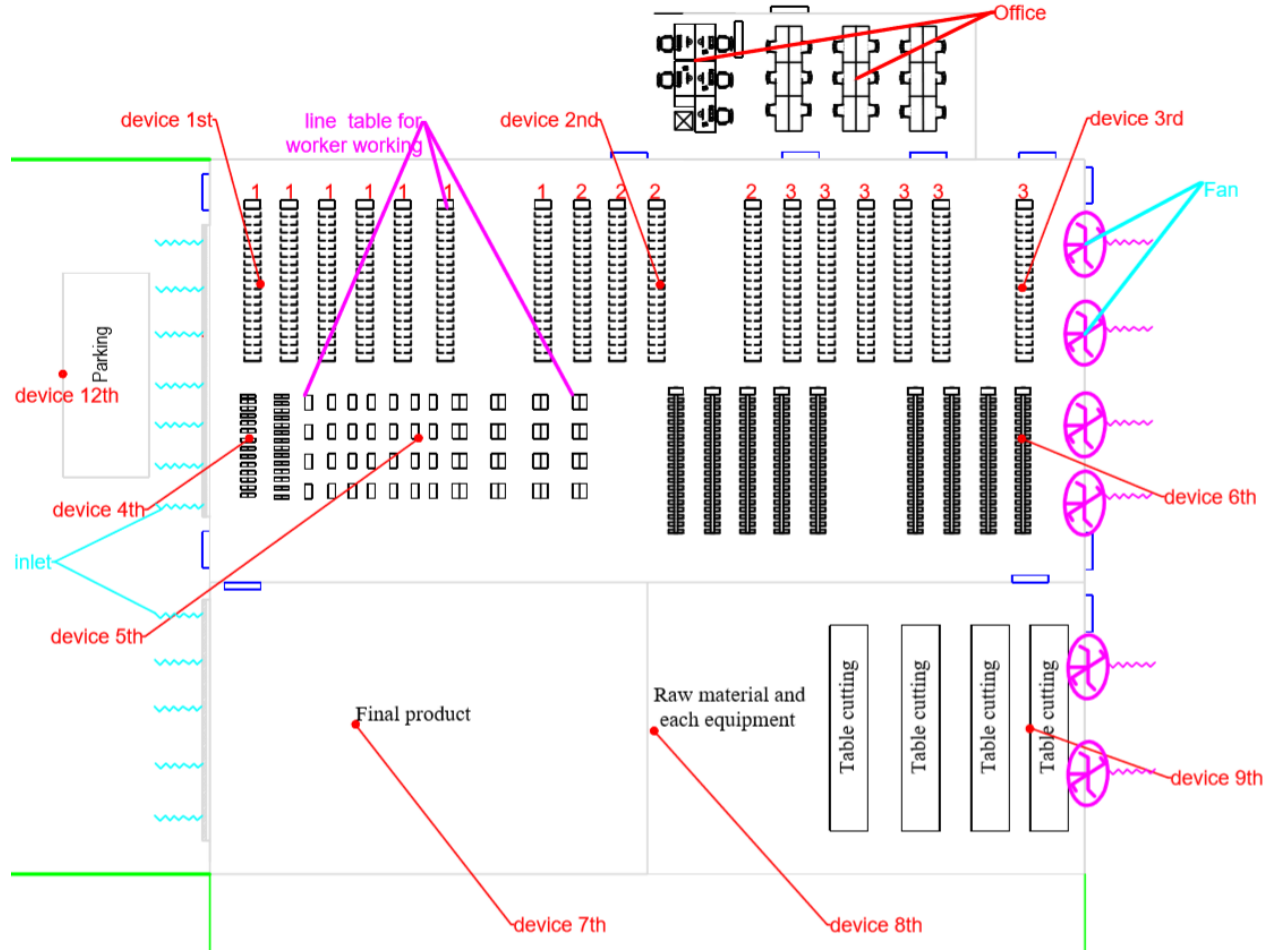
	P1	P2	P3
Velocity, [m/s]	0.74	1.26	0.96
T, [deg. C]	29.47	30.56	31.18
RH, [%]	69.83	68.50	67.50
CO2, [ppm]	361.48	397.50	422.00

P1: entrance to work place
P2: Middle of the work place
P3: outlet of the work place



- Entrance of the work place has smooth air flow and similar to the outlet
- While the middle has no stable velocity

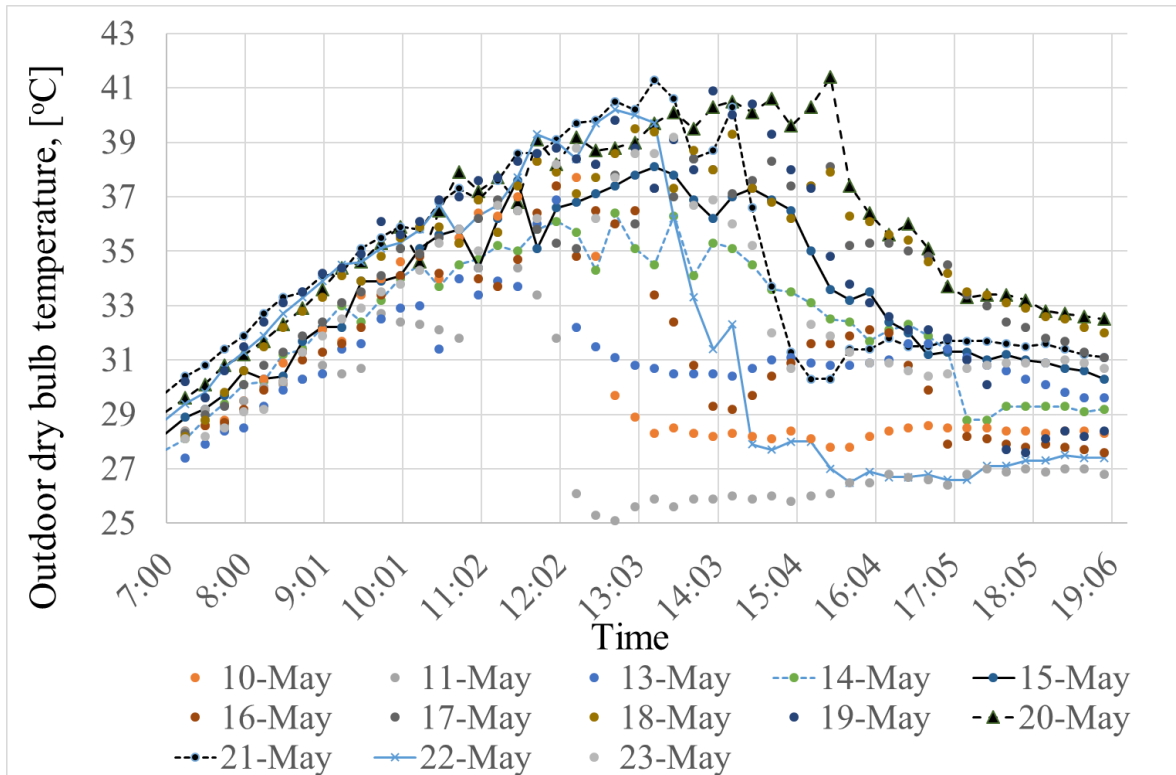
Observation location



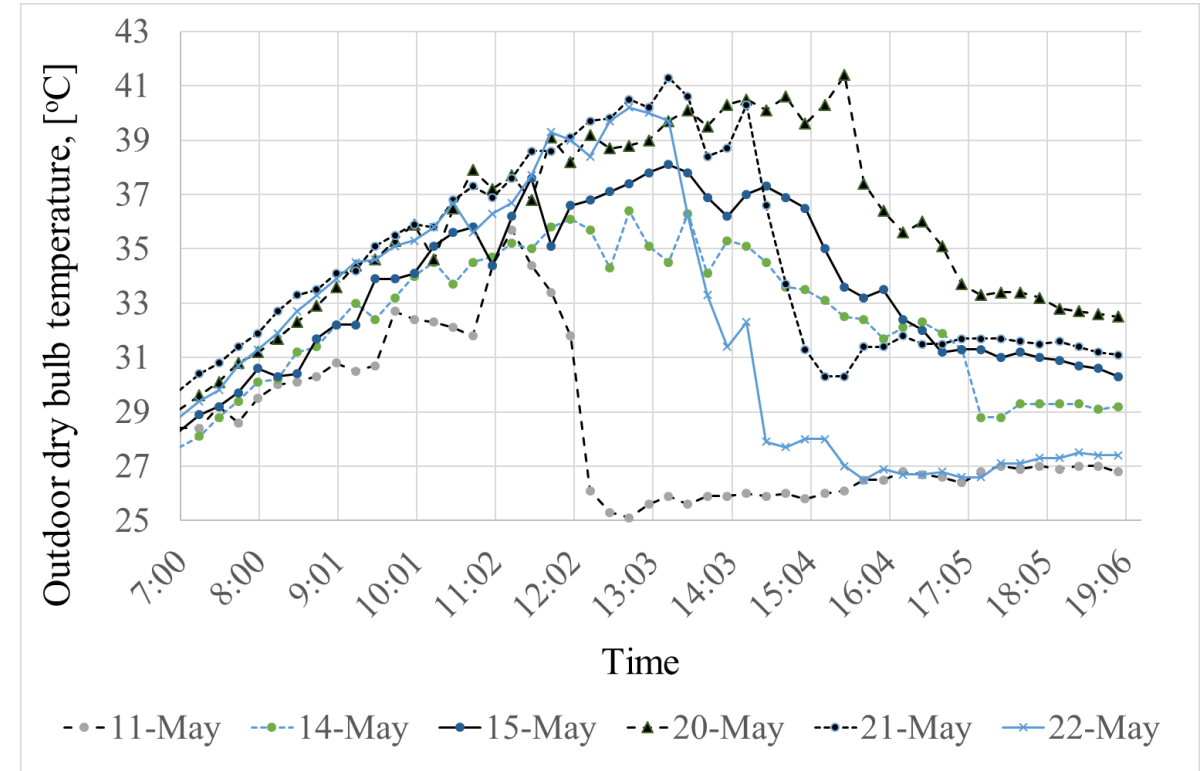
- L1: Inlet air T&RH at sewing department
- L2: Air T&RH at the middle of sewing department
- L3: Outlet air T&RH at sewing department
- L4: Inlet air T&RH at sewing department
- L5: Air T&RH at the middle of sewing department
- L6: Outlet air T&RH at sewing department
- L7: Air T&RH at the middle of ironing department
- L8: Air T&RH at the middle of packing dept.
- L9: Inlet air T&RH at packing department
- L10: Air T&RH at the middle of cutting department
- L11: Air T&RH at the middle of ironing department
- L12: Outdoor air condition

Daily record data: 10-22 May 2019

Ambient temperature



Recorded dry bulb temperature of ambient air (10-22 May 2019)



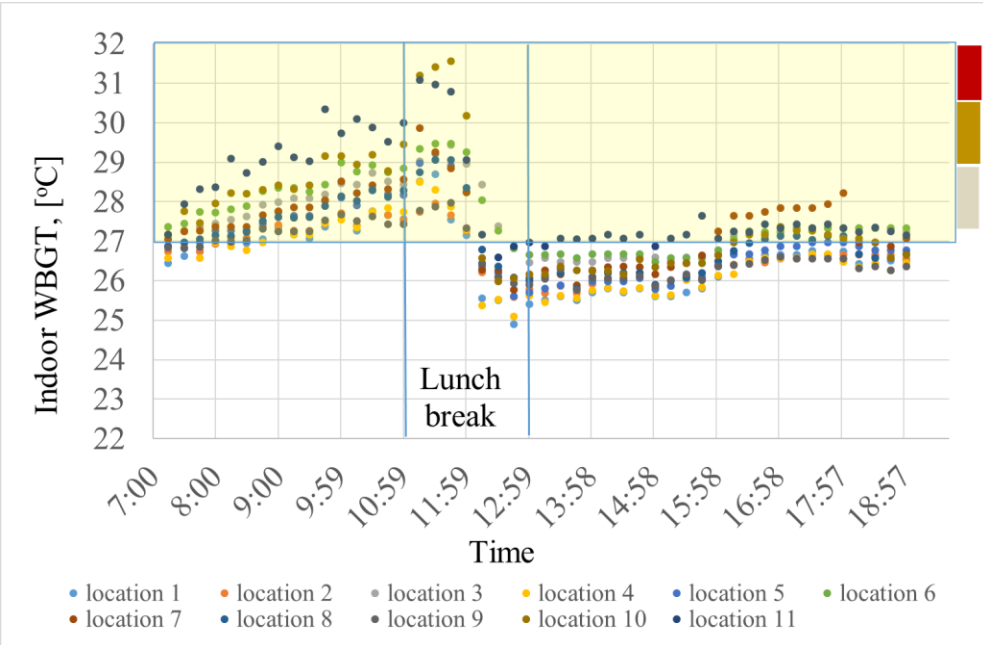
Recorded dry bulb temperature of ambient air (for specific day)

14th and 15th MAY 2019 were hot day without raining

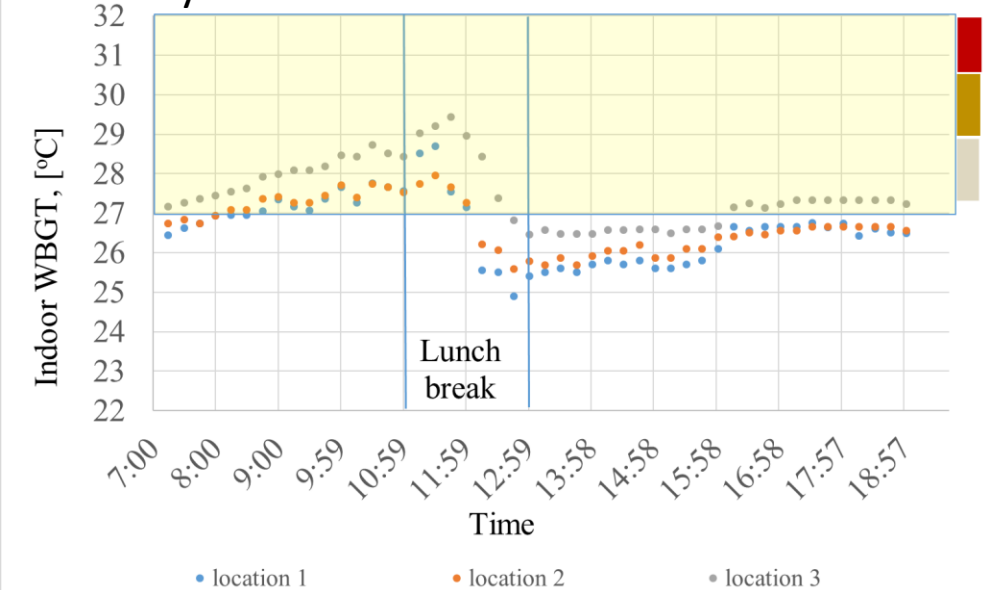
11th , 21st , 22nd May 2019 were hot in the morning and raining in the afternoon

=> These few days were presented here to see the different of the outdoor air condition

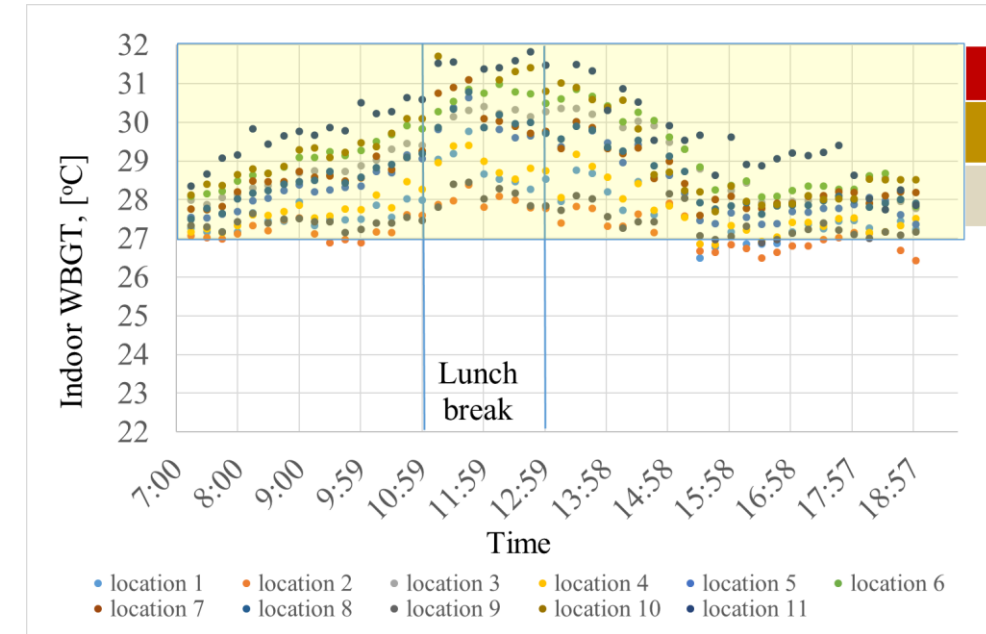
Indoor WBGT



11th May 2019

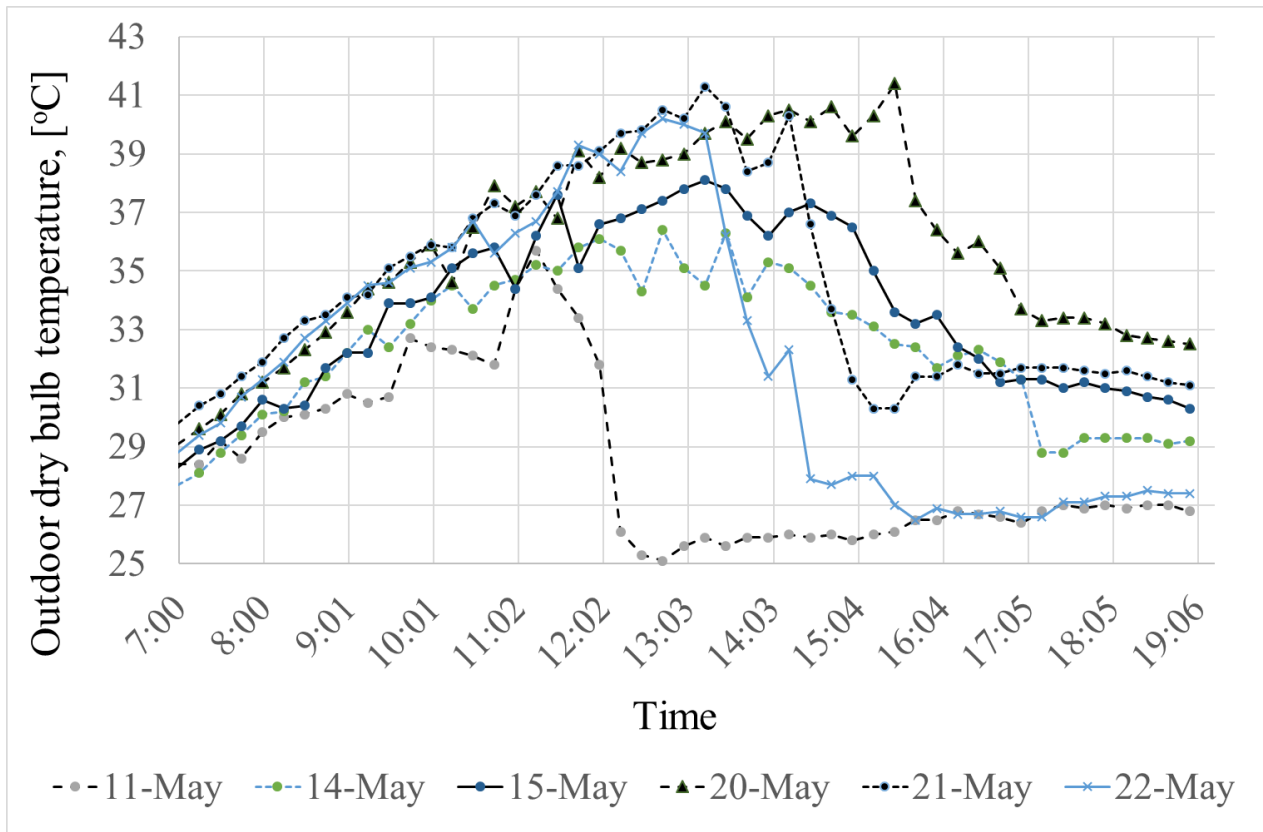


- Evaporated cooler was applied. It is off during the lunch break.
- The ironing department is hottest location compare to others
- The air contribution are not homogenous
- Caution period is mostly occupied.

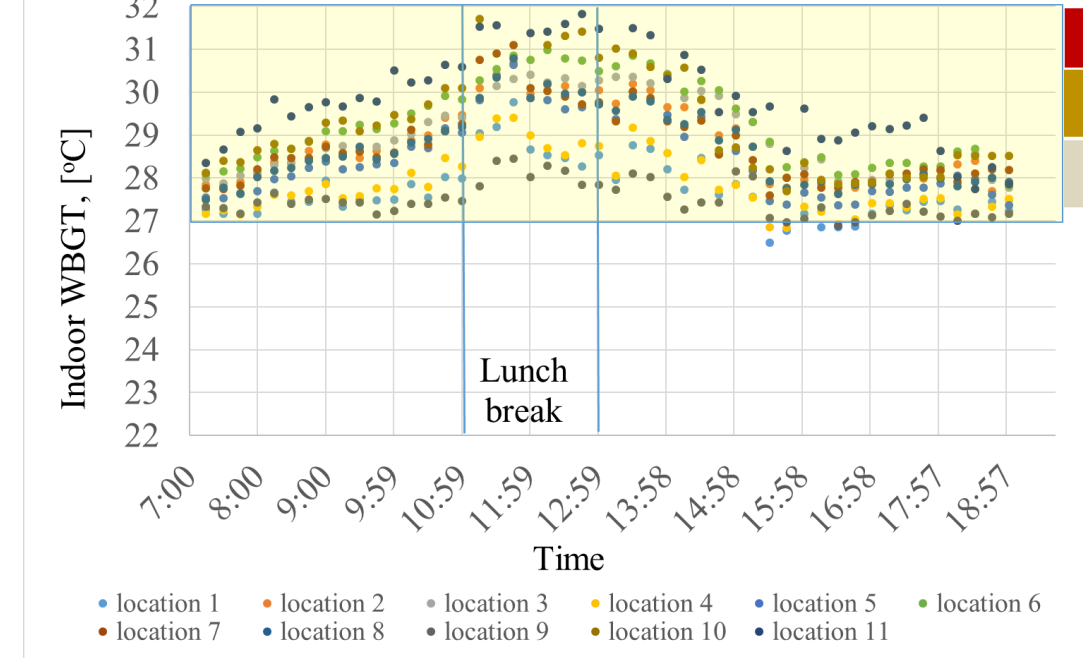


22nd May 2019

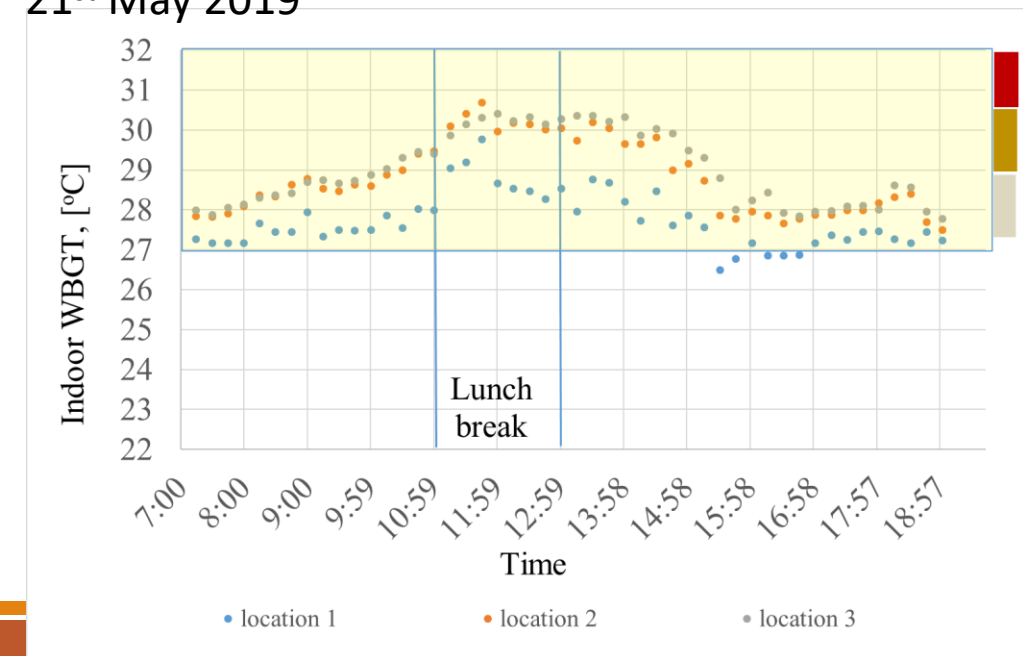




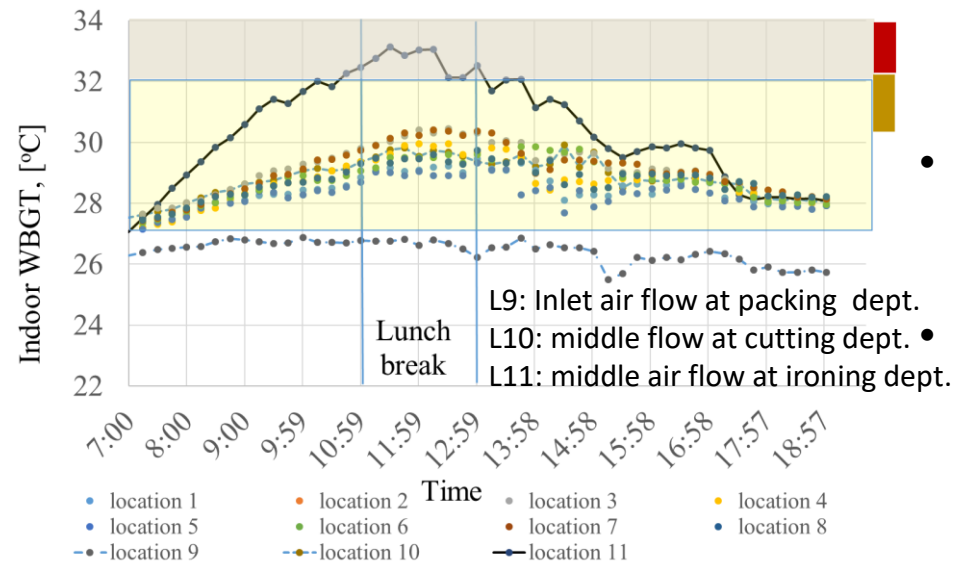
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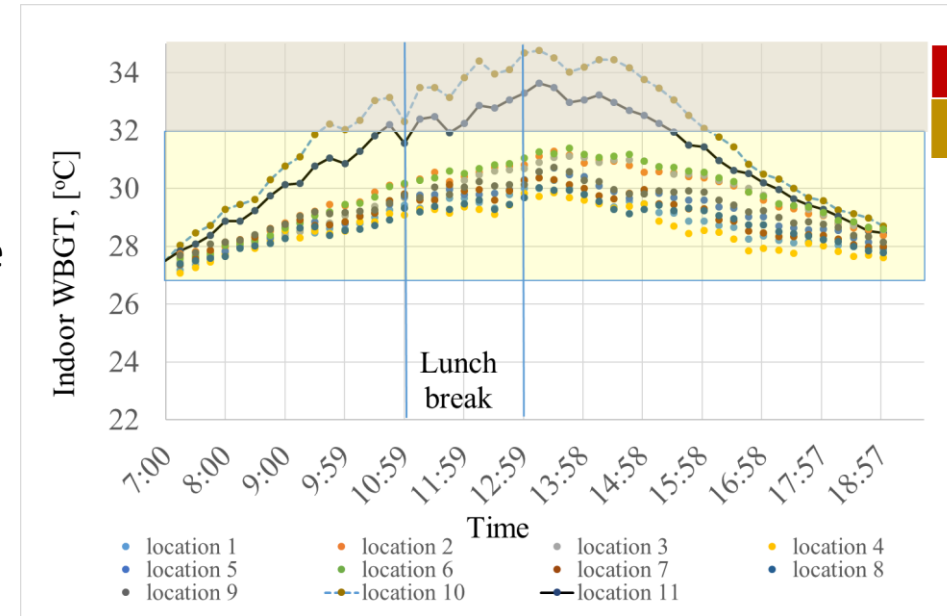
21st May 2019



Indoor WBGT

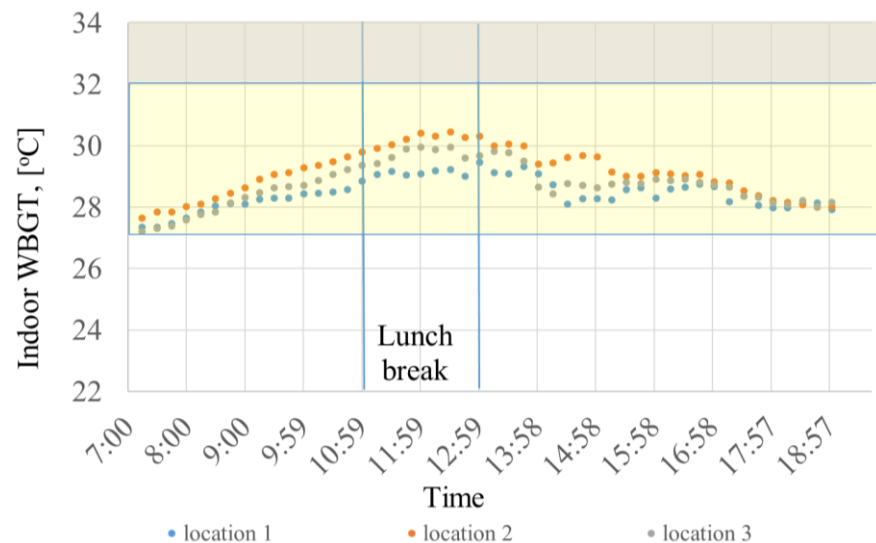


- Evaporated cooler was applied. It is off during the lunch break.
- Extremely caution during the hot day at the ironing dept.



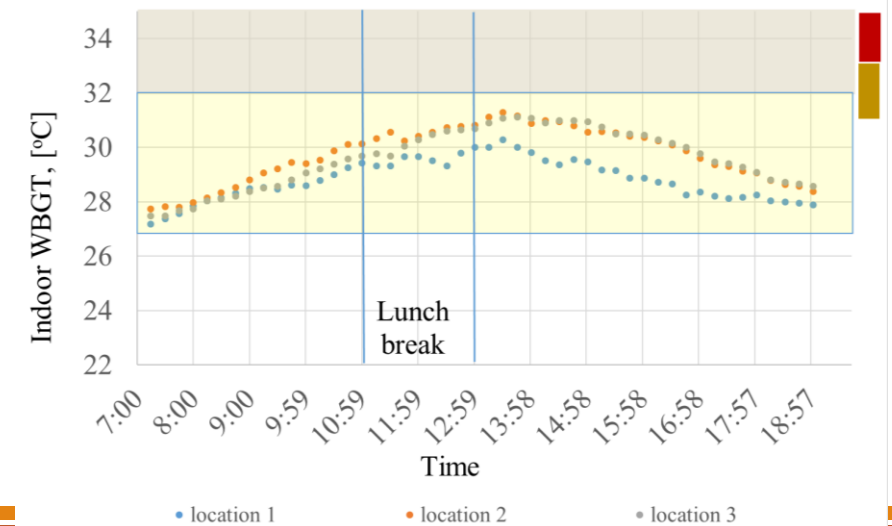
Note: No working day

14th May 2019

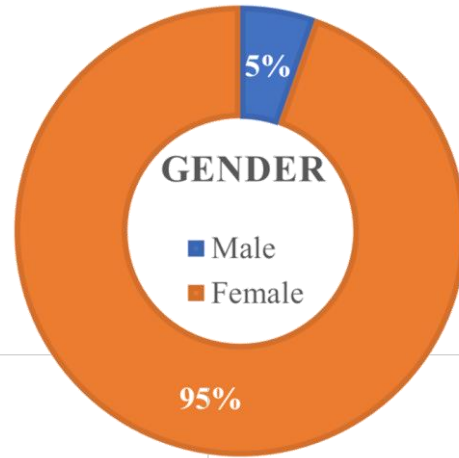


Air distribution are not homogenous, the middle location is mostly higher than inlet

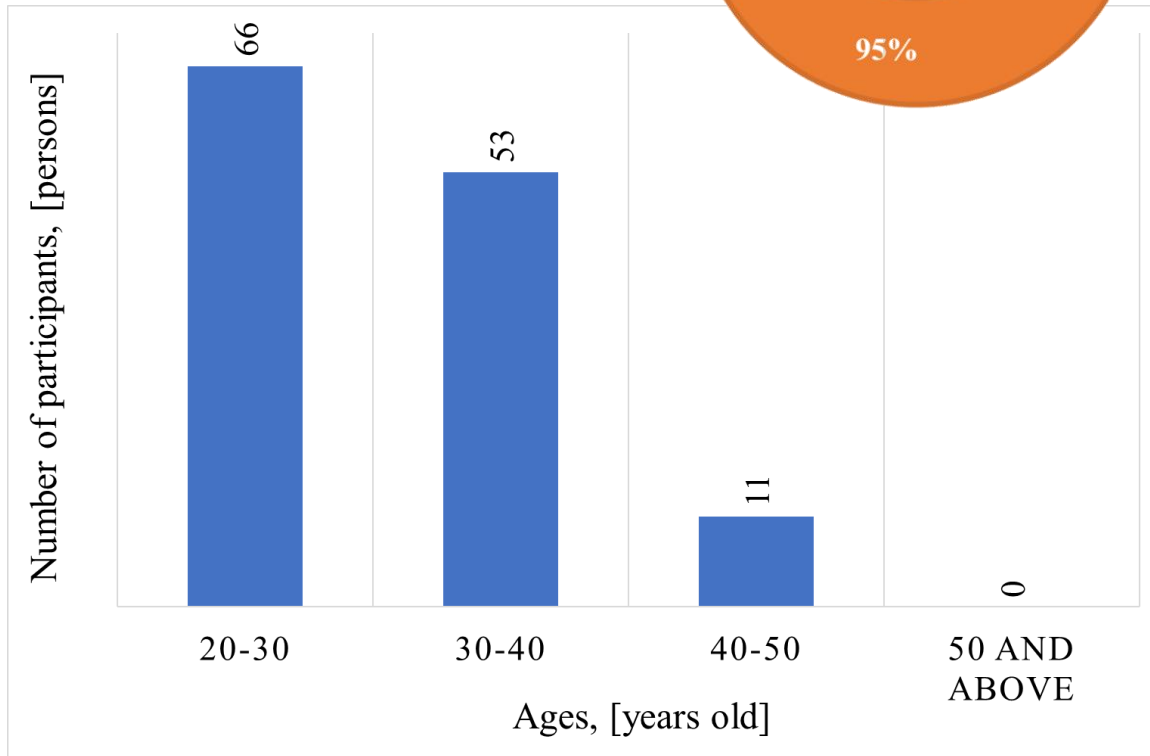
15th May 2019



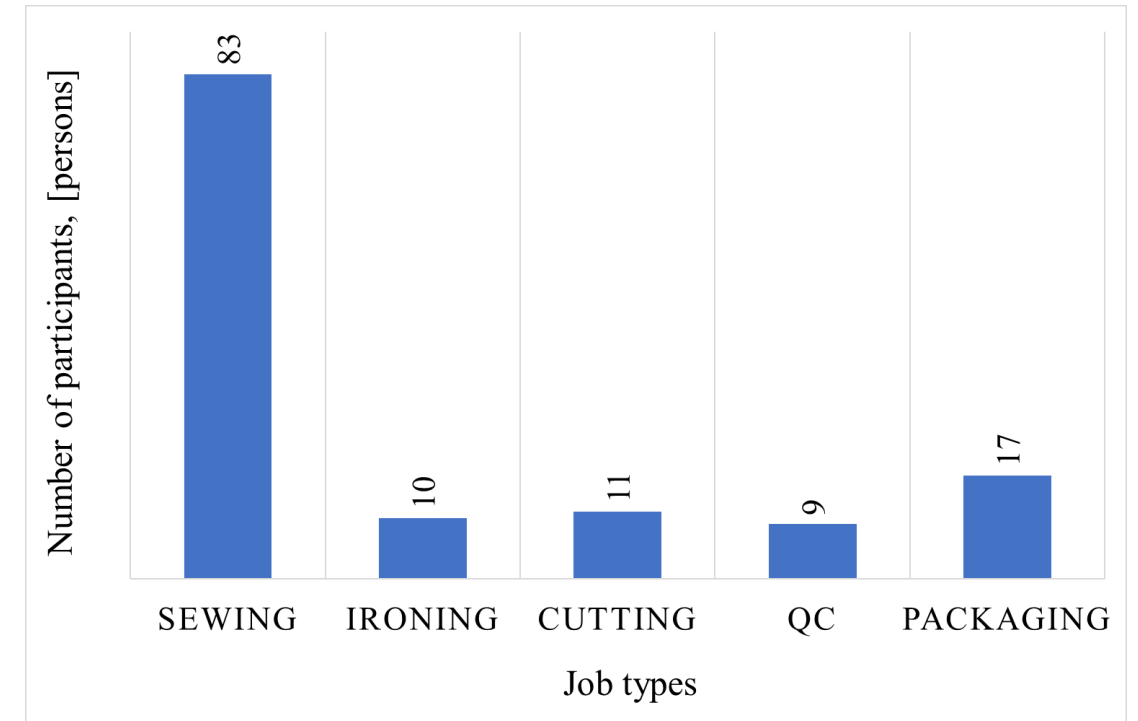
Questionnaire survey results



- 95% of female participated the survey and Female is major work force in garment factory
- Major of age is around 20-30 years old
- Most of them are working at sewing department



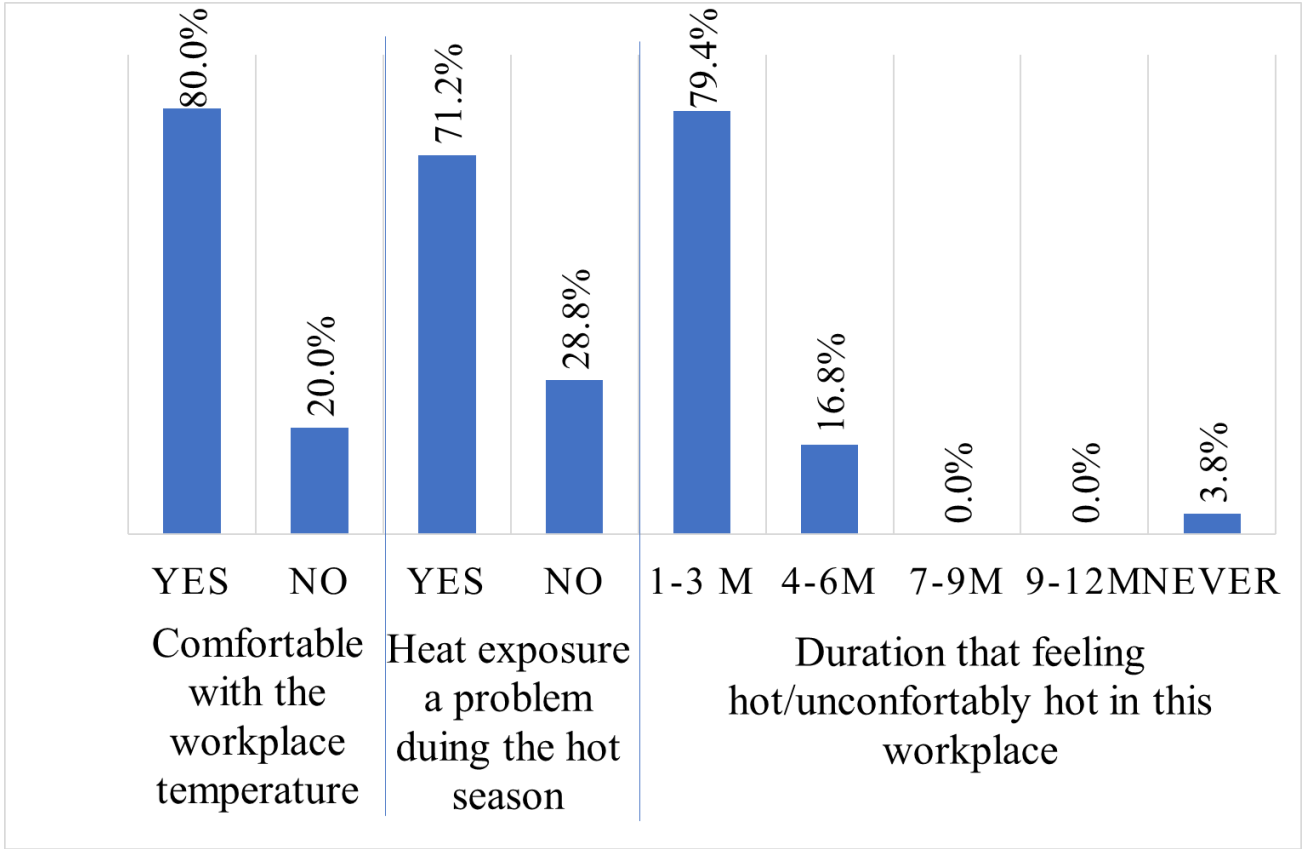
Number of participants involves in this survey short by ages



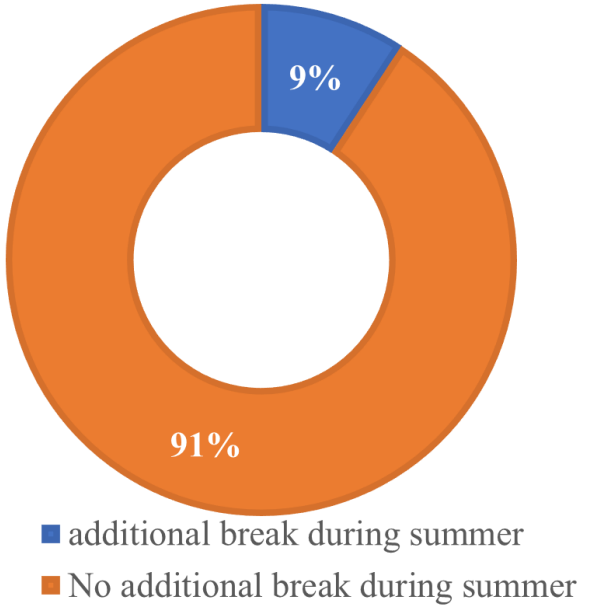
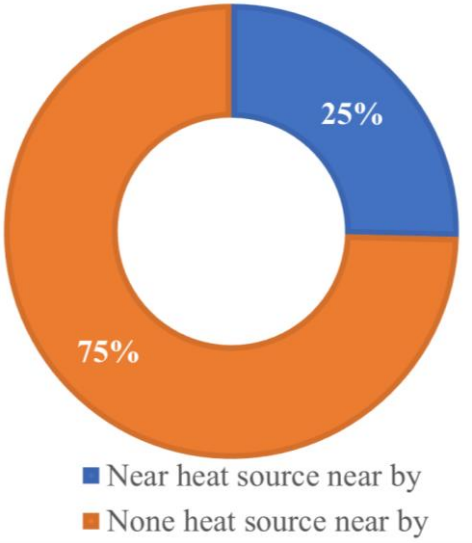
Number of participants involves in this survey short by work task

Investigate the relation between heat stress and productivity

- Most of them feel comfortable
- Major of them think they got problem with the heat exposure during hot season
- They feel hot the most is around 1-3 months

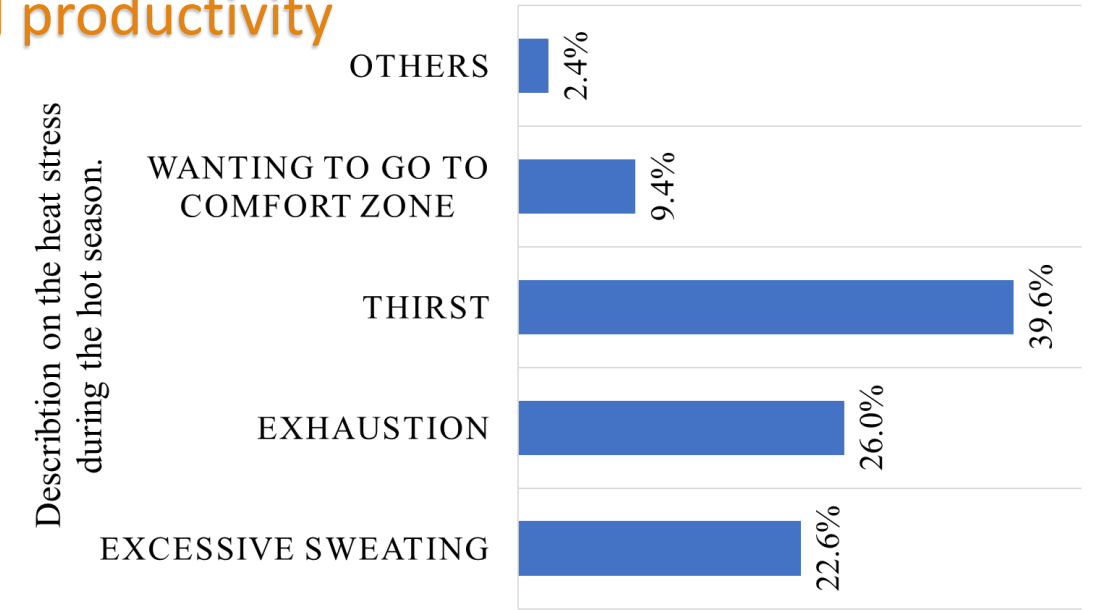


Feeling of the participants at working place

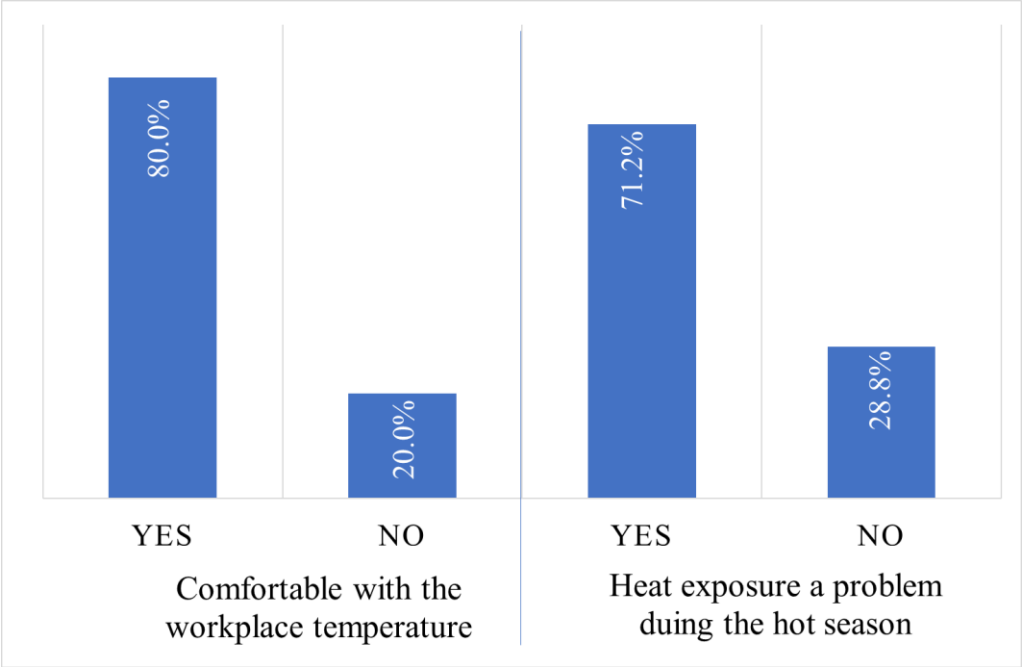
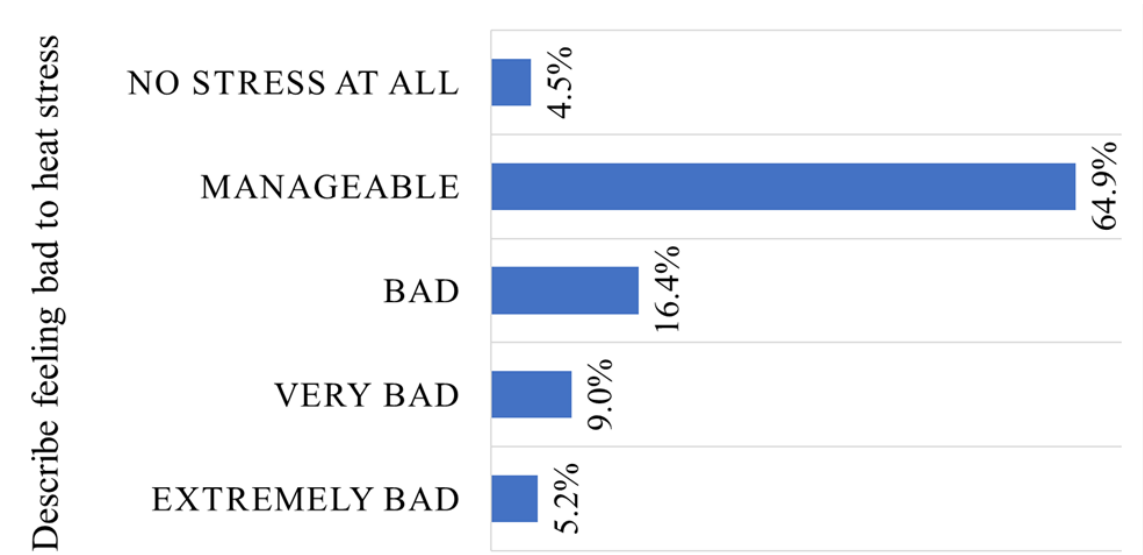


Investigate the relation between heat stress and productivity

- In hot season, major of the participants feel thirsty, exhaustion, excessive sweating and want to go to comfort zone
- But the answer above is focus on the hot season because generally the worker feeling fine.
- Most of those problem is manageable but around 10% feeling very bad and 5%feeling extremely bad



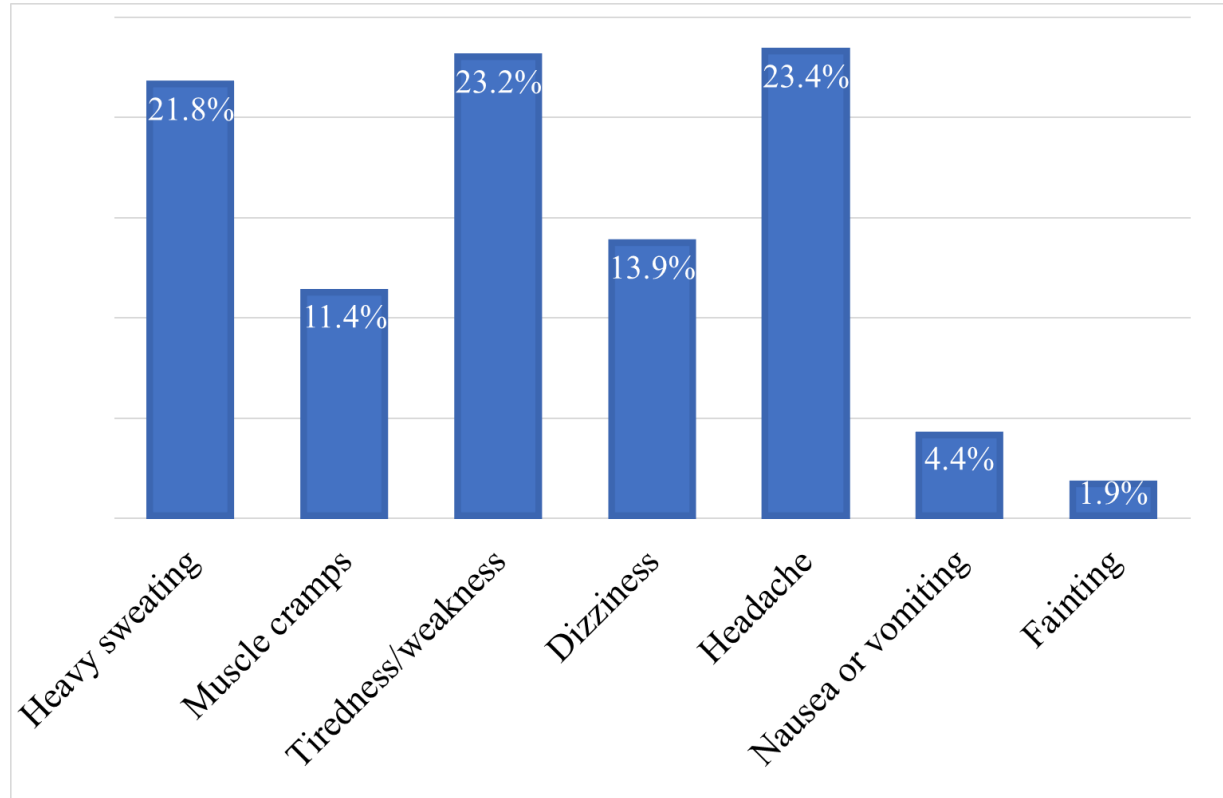
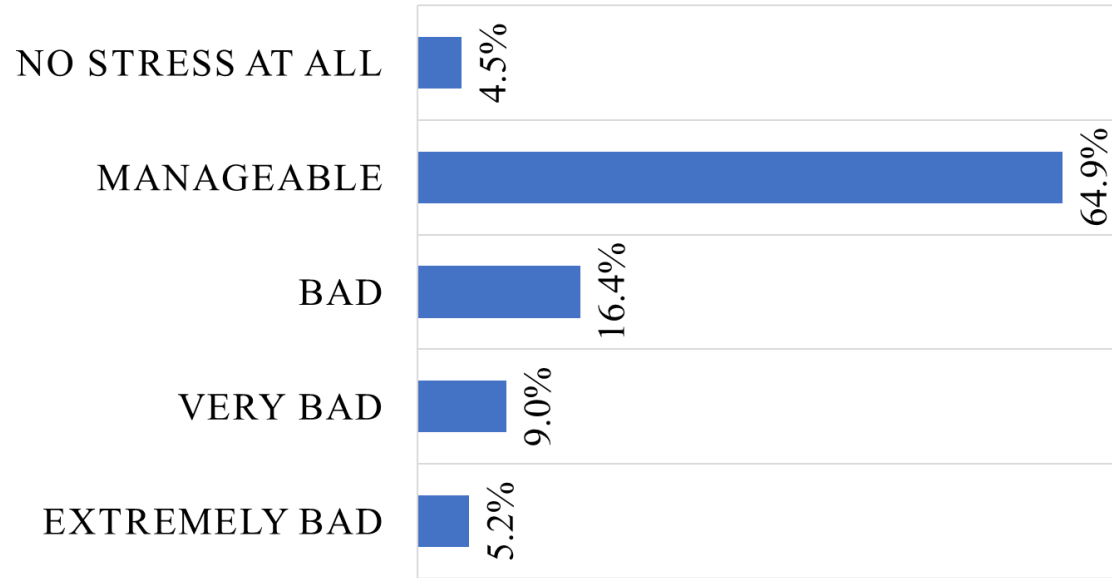
Symptoms facing during the hot month



Investigate the relation between heat stress and productivity

- In hot season, major of the participants feel thirsty, exhaustion, excessive sweating and want to go to comfort zone
- But the answer above is focus on the hot season because generally the worker feeling fine.

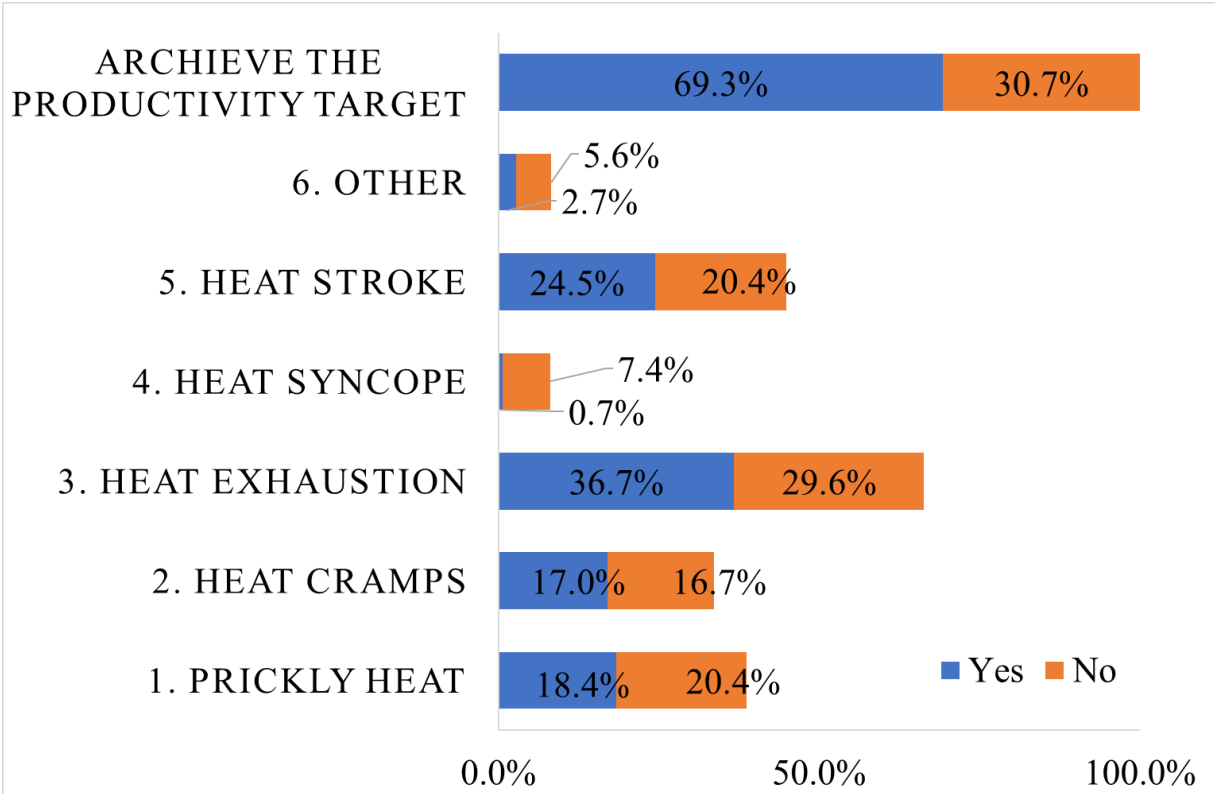
Describe feeling bad to heat stress



Investigate the relation between heat stress and productivity

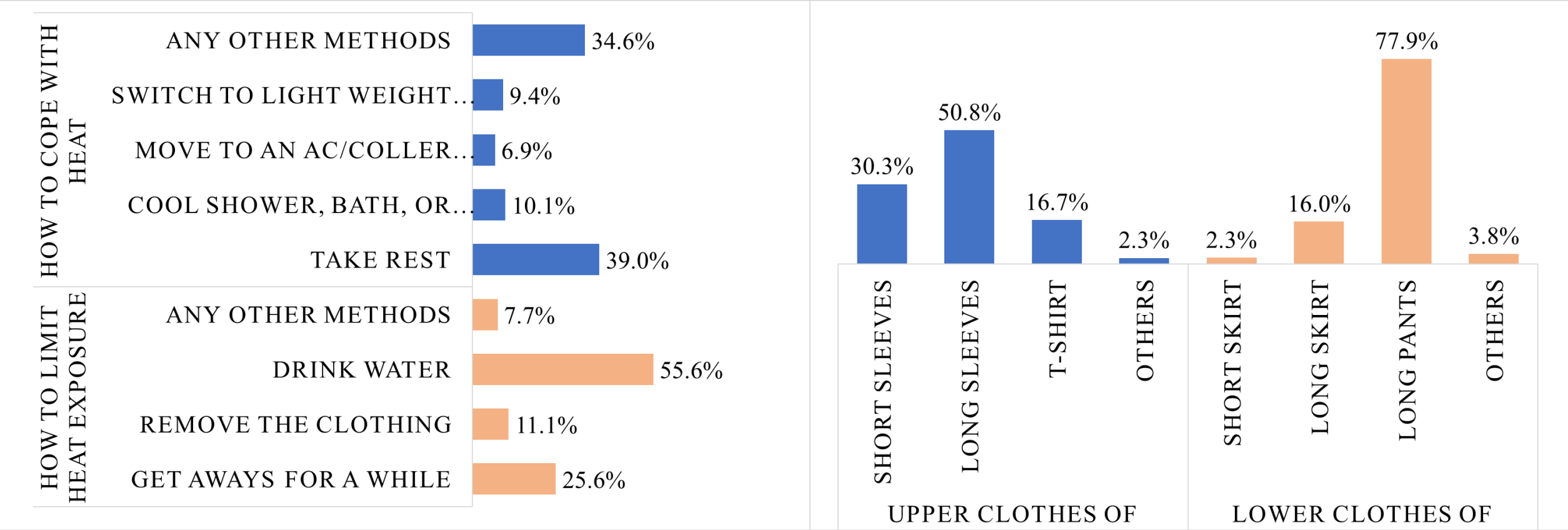
- 69% of the participants take the extra working hours

- This graph detected the people who take extra hours due to they got heat strain. However, based on the current results of the survey, it showed that participants with heat strain and non-heat strain are taking extra working hours.



When the feeling sick and require more working hours

Investigate the relation between heat stress and productivity

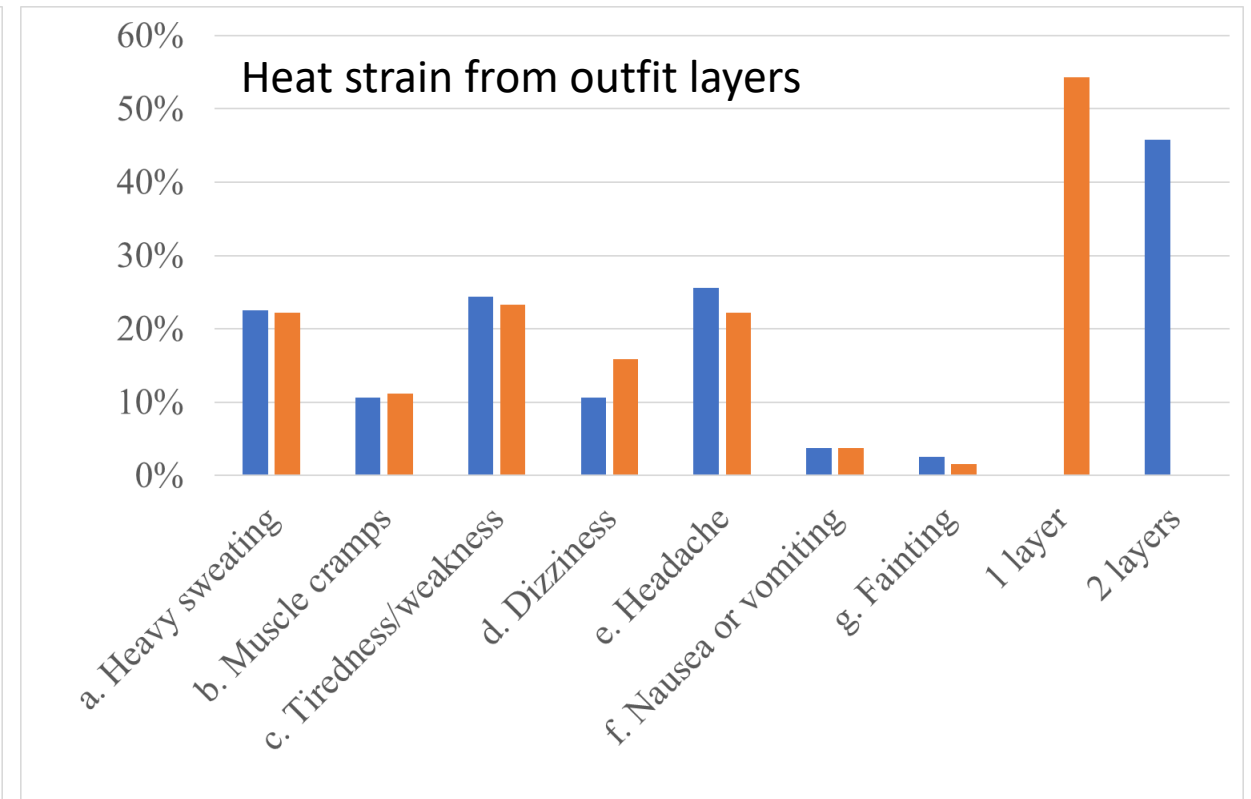
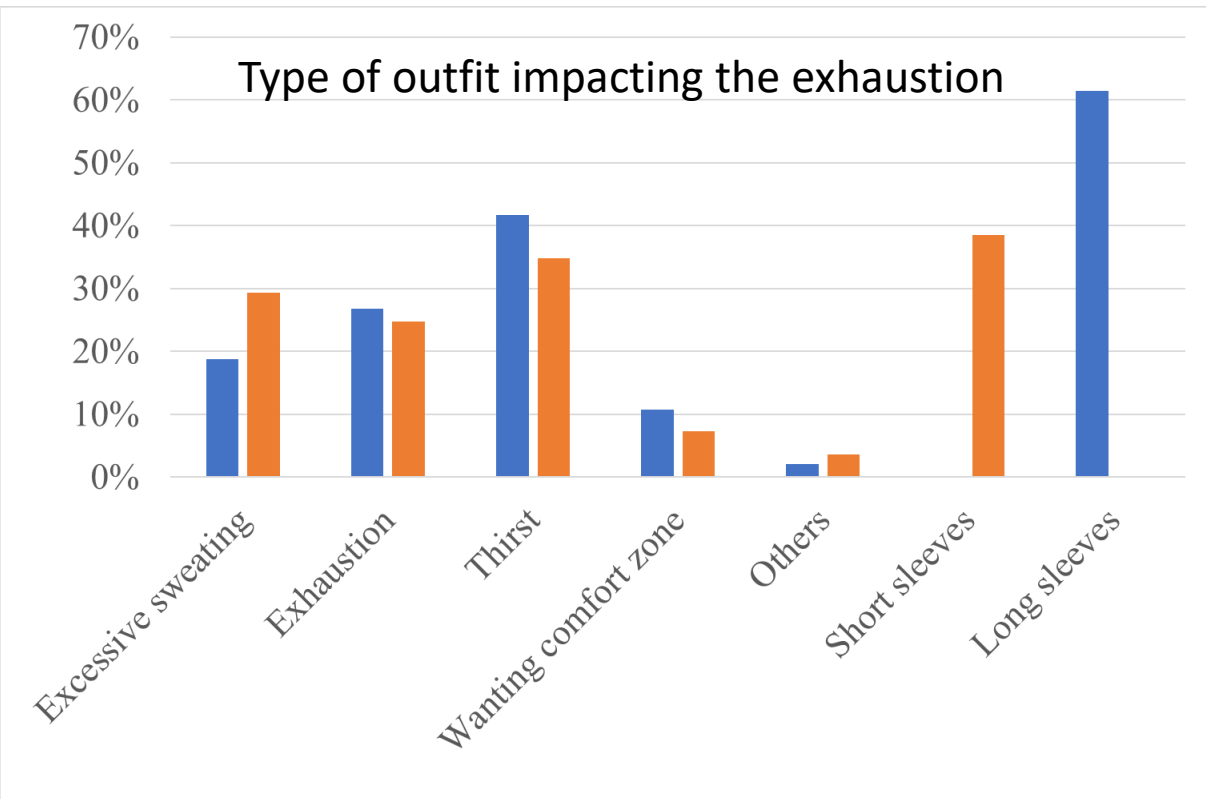


To limit the heat exposure, drinking water and get away from the place for while are the common method

Most of workers wear long sleeves and long pants

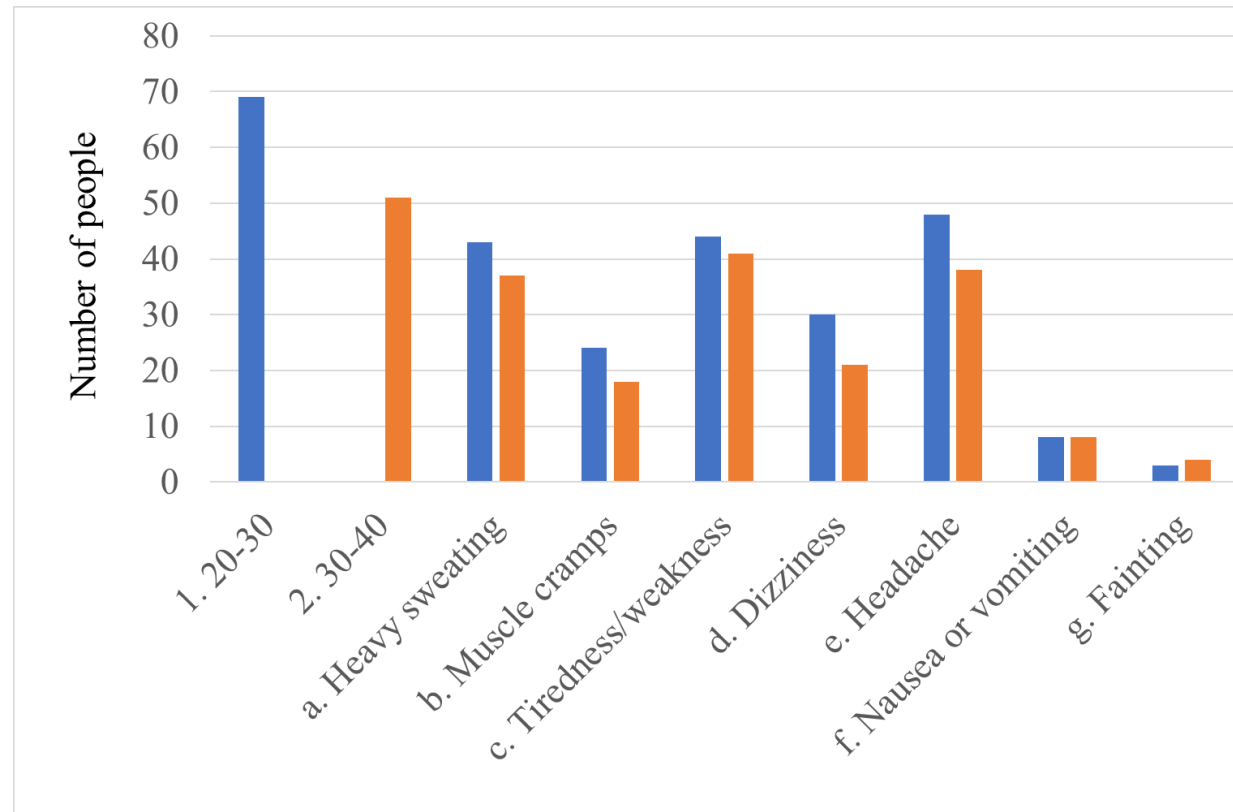
Relation between productivity and outfit

- Outfit long sleeves and short sleeves has very similar exhaustion
 - 2 layers outfit has slightly higher heat strain than single layer
- => Outfit too many layer has slightly significant to the heat stress



Relation between heat strain and ages

- 2 groups of ages, 20-30 and 30-40 years old, they are having very similar trend of heat strain
=> Ages has no significant to the heat strain.



Summarize

1. Major WBGT in the factory is in **Caution (27-32 °C)** which causing tiredness or lack of energy, no motivation and no energy.
2. In the hot day, WBGT at the ironing dept. was up to in **Caution (32-35 °C)** which is extremely caution, Heat stroke, heat cramps, and heat exhaustion.
3. Current setting temperature is still within the caution period at the sewing dept. for the hot day. But it is fit to the cool day.
4. None homogenous of temperature and velocity at each location.
5. Indoor quality are good based on the CO₂ and TVOC values

=> Lower setting temperature and consider official break time for ironing dept.

Summarize

6. It is clear that 69% of participants take extra working hours, showing that the productivity time is not sufficient
7. Low productivity might come from the workers do something activities else (walking to drink, drinking, take a rest, fan, etc.) besides their job
8. Generally the working place is comfortable for them, but it is not during the hot season
9. The more they move away from the working area then more causing in efficient for productivity

-> Allocate official break time might be one of the solution

Further study

1. Analyse productivity in hour for Lowest, middle, high skill during the working time and comparing with different ambient air condition
2. Study on adaptation of Break/tea time after 4 pm impacting productivity
3. Take into the account of the heat reduction in the factory

Acknowledgement



CCCA, NCSD, fund provider



Partner universities

Garment factory for being Case study

Mr. Ou Puthy, Mr. Kum Visal, Mr. Chea Vabotra students, and participants in this project

Thank you for your kind attention