Occupational heat stress and health impact assessment at a shoe factory in China

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2012

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Abstract

Background: Putian city Fujian province has long fully humid hot summers where a huge number of people working in manufacturing sector. There is no research done on Occupational heat stress in shoe factories of Putian city despite the workers in those factories have high possibility of exposing to heat stress and this problem would be exacerbated by the happening climate change.

Aim: The main aim of this study is to find out whether people working inside shoe factory in Putian city Fujian province of China are exposed to occupational heat stress that may cause health risks. This study also aimed to find the temperature variation on an hourly basic in the factory and the purposively selected house in the study area and to quantify the working hours that the workers are exposed to different occupational heat stress levels as well as to estimate the corresponding health risk and work capacity lost during the study period.

Methods: A cross-sectional study design was adopted where data loggers were used to record the hourly air temperature and dew point of the factory and the house for July and August of 2010 in Putian city. Temperature between the factory and the house were compared (using temperature in the house as reference point) and the indoor WBGT values were calculated for each working hour of the factory to describe the occupational heat stress situation in the factory during the study period in Putian city. The heat stress levels were compared with heat and health guideline to estimate health risk.

Results: It was found that temperature inside the factory is higher than the temperature in the house during July and August 2010 in Putian city. The workers of the shoe factory had exposed to level I and level II of occupational heat stress from 48% to 51% and 18% to 21% of their working time respectively during the study period. This may cause negative effects on the health of workers, even develop heat related diseases such as cardiovascular disease, kidney diseases and so on. It was also found that the heat exposure may cause the workers having risk of 2.5 fatal heat stroke per million workers per month, 8 non-fatal heat stroke per million workers per month and 4800 of one-day heat exhaustion per million workers per month during the study period. Also significant work capacity loss was found in this study at each WBGT levels.

Conclusions: Workers in the factory were exposed to different levels of occupational heat stress which amounts 69% of the study period and they were likely to be suffered from heat
stress. Climate change in future will exacerbate this burden which could increase the potential impacts on health further in future. While the relevant policies and regulations were not applied well for addressing the problem, this study emphasize the urgent need for interventions against occupational heat stress, powerful policies and regulations for the safety of factory workers in Putian.

Key words: Climate change, air temperature, dew point, occupational heat stress, health impact, Putian Fujian China, WBGT index, productivity.
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Abbreviations

IPCC = Intergovernmental Panel on Climate Change
WHO = World Health Organization
CMA = China Meteorological Administration
CNCC = China National Climate Center
GDP = Gross Domestic Product
HOTHAPS = High Occupational Temperature Health and Productivity Suppression
CRU = Climate Research Unit
WBGT = Wet Bulb Globe Temperature
CI = Confidence Interval
Introduction

1.1 Global overview of climate change

The United Nation’s Intergovernmental Panel on Climate Change (IPCC) reported in 2007 that the global average surface temperature had increased from approximately 13.5°C to about 14.5°C since 1910. Scientific evidence indicates that global warming is occurring and it has been mainly contributed by the accumulation of greenhouse gases related to human activities in the lower atmosphere. The IPCC also predicts that the global temperature will raise about 2.4°C - 6.4°C during the twenty-first century. The broad increase in global temperatures will bring benefits in some areas such as decrease of mortality of cold exposure, and improved agricultural output in cold places like Russia and Canada, but overall it will bring much more negative health impacts especially in tropical developing countries such as increasing heat stress and mortality and morbidity of some infectious diseases. It is thought that climate change has already led to increase in the heat wave frequency. According to the forth assessment report of IPCC, the heat waves frequency will increase in most part of the world during 21st century (1).

The World Health Organization (WHO) has estimated that all populations will be affected by a changing climate and elderly people, women, children and people carrying out heavy labor in hot environments and poor people in general are more vulnerable than others. WHO is appealing to policy-makers to take the right actions as soon as possible (2).

1.2 Climate change in China

China Meteorological Administration (CMA) claim: the average land surface temperature has increased approximately by 1.1°C between 1908 and 2007 in China. The pattern of precipitation has significantly changed during the last 50 years. The frequency of the natural hazard such as heat wave, drought and flood also has increased. In the past 30 years, Chinese sea level has risen about 90mm, and the sea surface temperature has increased by 0.9°C. Scientists predict that in China (3), this situation will be exacerbated by climate change if not intervened.

The CNCC has listed out the Climate events and impacts took place every month since January 2004. It was evident from that report that the mean temperature in 2010 was 9.5°C, which is 0.7°C warmer than the expected temperature (calculated from the mean of
temperature between 1971 and 2000) and ranked the 10th warmest year since 1961. This high temperature in 2010 was the 14th consecutive year with a value above the expected temperature since 1997 (4).

The mean temperature of July 2010 in China was 22.8°C which was 1.4°C warmer than the expected value and it was the warmest July since 1961 (see Figure 1). This increase in the July mean temperature than the expected temperature occurred for the 15th consecutive year since 1995. The mean temperature of July 2010 in Fujian province was 27.8°C, which was 6.4°C warmer than the expected value (4).

![Figure 1. The change of mean temperature over China in July (4).](image)

The mean temperature of August 2010 in China was 21.4°C which was 1.1°C warmer than the expected and it was the third warmest August since 1961 (see Figure 2). This increase in the August mean temperature than the expected value occurred for the 16th consecutive year since 1994. The mean temperature in Fujian province at the same time period is 28.1°C, which is 7.8°C warmer than normal (4).
Figure 2. The change of mean temperature over China in August (4).

The figure from the above demonstrates that the climate change is taking place in China. This demands the need for Chinese government to address the issue with more dedication. The impact of climate change had gain higher and higher attention from Chinese government in recent years, the government has taken actions for fighting with climate change. In February 2005, China passed the Renewable Energy Law, to encourage development and use of renewable energies (5). In December 2006, in the 11th Five-year Plan (2006-2010), Chinese government had planned to reduce energy consumption (6). In June 2007, China’s State Council publicized a national plan for coping with climate change, in which lots of plans for coping with the impact of climate change was listed (7). In 2008, China abandoned the free provision of plastic bags in all markets and in the same year, China publicized Policies and Actions for Addressing Climate Change (8). In November 2009, China announced that by 2020, the carbon emission intensity would reduce by 40%-45% per unit of Gross Domestic Product (GDP) (9). In November 2011, China’s policies and actions for addressing climate change was publicized, in which, the Chinese government cautioned that china will be one of the country which will suffer the most from various consequences of climate change. In that policy, the government had developed some emergency response plans against many kinds of natural disaster including high-temperature and heat-stroke. Similarly many research was conducted in China to study the relationship between climate change and its diseases. This had pushed the implementation of relevant laws and policies to adopt the consequences of climate change (10). This would go a long way to reduce the negative impact of climate change on people live.
1.3 Climate change in Fujian province

Fujian province, with a population of 36.27 million, is located in the southeast China between 23.5-28.37°N and 115.83-120.67° E (11). It has a warm and wet subtropical monsoon climate. The climate of Fujian is characterized by a short dry winter and a long fully humid hot summer. So people living and working there have a high risk of getting heat stress in summer, and this is further exacerbated with climate change (12).

In 2010, the Fujian Climate-bulletin reported the mean temperature for the province as 19.6°C and the mean temperature of Putian which is the study area as 20.6°C which was 1°C warmer than the province, and 1.35°C higher than the expected temperature (13).

Figure 3 demonstrates the annual mean temperature in Fujian province from 1960 to 2010. The figure shows that the mean annual temperature of Fujian province was higher than the expected level consecutively for a period of 13 years since 1998. It was reported that in 2010 summer (July to September), there were 30 to 40 days when the daily temperature was 35°C or more which is considered to be very hot and a highest temperature of 41.2°C was recorded on 4th August in Jiangle region (13).

HOTHAPS (High Occupational Temperature Health and Productivity Suppression) program analyzed over 30 years records of the maximum annual temperature from Fuzhou city airport weather station and found out the increasing annual trend (see Figure 4 and 5). Fuzhou is the capital city of Fujian province.

The maximum annual temperature recorded at Fuzhou airport station clearly shows an increasing trend between the years 1980 and 2011. It is increasing at a temperature of 0.47 °C.
every ten years. The dotted curve for grid cell shows the mean annual maximum temperatures recorded at Climate Research Unit (CRU), clearly indicates the increasing temperature in Fuzhou at a rate of 0.2°C every ten years. (Provided by Kjellstrom Tord)

![Fuzhou Annual Temp Max [°C]](image)

Figure 4. Annual trend of maximum annual average temperature in Fuzhou. (Provided by Kjellstrom Tord)

From Figure 5, it is clearly seen that there exists an increasing trend in the annual WBGT (Wet Bulb Globe Temperature) which is the days greater than 26 °C, between the years 1980 and 2011. The number of days that the temperature exceeds 26 °C (maximum annual WBGT) is found to be increasing at a rate of 2 days every ten years.

![Fuzhou Annual WBGT(max) [°C], Days > 26°C](image)

From Figure 5, it is clearly seen that there exists an increasing trend in the annual WBGT (Wet Bulb Globe Temperature) which is the days greater than 26 °C, between the years 1980 and 2011. The number of days that the temperature exceeds 26 °C (maximum annual WBGT) is found to be increasing at a rate of 2 days every ten years.
1.4 Factors influencing human response to thermal environments

It is well known that a normal person’s core body temperature at rest is close to 37°C. To keep the core body temperature at 37°C, the body needs to transfer metabolic heat to the surrounding environment and insufficient heat interactions will lead to raised temperature and serious health consequences (14).

Six parameters were found to have caused the heat exchange between humans being and the environment in which they live; air temperature, radiant temperature, humidity, air movement, metabolic heat generated by human activity and clothing worn by a person. The first four are the major determinants in heat interaction (14).

- **Air temperature**: The principle of thermodynamics is that the heat always flows from higher temperature bodies to lower temperature bodies. Diffusion of heat takes place between environment and human body when the temperature in environment (air temperature) is higher than one's body temperature and vice-versa. So air temperature is one of key determinate of heat interaction (14).

- **Radiant temperature**: It is nothing but heat exchange by radiation between all bodies, in line with the principle of thermodynamics, defined as the net heat exchange from hot to cold body and the amount of exchange depends on the differences in the absolute temperatures between the two bodies (14).

- **Humidity**: When sweat evaporates into vapor, heat will be transferred from the body to the environment by evaporation. So the humidity of the environment that surrounds the body would affect the degree of evaporation of sweat. Higher the degree of humidity in surrounding air, lower would be the degree of evaporation of sweat (14).

- **Air velocity**: The air movement around the body can influence the rate of heat flow away from the body. It also influences the sweat evaporation in a manner similar to the humidity in environment (14).

The clothes which people wear is the most closest to the body skin, these clothes isolate the skin from the environment. These clothes equally restrict heat flow to the environment, hence affecting the body temperature (14).
Metabolic heat production refers to the procedure of heat production in the body which mainly comes from blood flowing, vasoconstriction and vasodilatation, and the physical activities that the person does (muscular activity which is a driving factor of metabolic heat production) (16).

The metabolic heat production is a non-stop procedure which will always produce heat all the time, and the heat will flow away from the body through breathing warm air out of the body (14). If the external environment’s air temperature is lower than 35°C, most of the metabolic heat from the body will directly flow out to the environment. On the other hand, if the environment’s air temperature is higher than 35°C or if the person is doing some strenuous activities then the main way of cooling the body temperature is through secreting sweat for evaporation (16).

It is these six basic parameters which are believed to cause the metabolic heat produced in the body to be dissipated through the process of respiration, evaporation, radiation, conduction and convection (15). Insufficient dissipation of heat will lead to different heat illnesses while long term insufficient dissipation of heat will lead to chronic diseases such as cardiovascular diseases and kidney diseases and so on (16, 17).

Heat illnesses include:

a) *Heat stroke*: occur when the core temperature is over 40.5°C. The symptoms would be dry skin, core temperature keep in rising, fail of excreting sweat, lost of conscious and so on, it would lead to death if the treatment can not apply in time (15).

b) *Heat syncope*: often occur before acclimatization. The main symptom is fainting (15).

c) *Heat exhaustion*: occur after long time exposure in high temperature environment and dehydration. The main symptoms include fatigue, headache, and feeling of vomiting, small amount of urine (15).

d) *Heat cramps*: could occur after the body loss sufficient amount of salt. Cramping mainly in abdomen, arms and legs (15).

e) *Heat rash*: normally occur when skin are continuously exposed in hot wet environment (15).

f) *Heat fatigue*: occur after long time worked or live in high temperature climate area, could directly lead to lost of work capacity and concentration (15).
1.5 Acclimatization

Acclimatization means the process of adapting to the changing environment (such as change in temperature or humidity), usually last for short time (days to weeks) (15).

Physiological and behavioral adaptations are the two forms of acclimatization to the changing temperatures. For high temperature, physiological adaptation refers to the increased ability of tolerance to high temperature because of getting used to it. While behavioral adaptation refers to the change of behavior such as to avoid being exposed to heat by working during early morning before sunrise and late afternoon after sunset as well as reducing the intensity of physical activities (15).

1.6 Heat waves and public health

Due to acclimatization, each country has its own critical level for heat wave, but generally, heat wave can be defined as: “a prolonged period of excessively hot weather, which may be accompanied by high humidity”. Heat waves cause lots of heat related diseases such as heat stroke, cardiovascular diseases, respiratory diseases, and kidney diseases and so on. Thus heat wave increases the morbidity and mortality of a country and therefore, it needs attention in public health sector. (18, 19, 44)

In 2003, the heat waves caused 14802 deaths within 20 days in France, 3134 deaths within 12 days in Italy, 1854 deaths within 20 days in Portugal and 3166 deaths within 30 days in Spain. It was after the disastrous consequence of heat waves which happened in Europe in 2003, most of the western European countries had implemented health warning systems for making people aware on a heat wave day and this was a significant contribution from the public health sector of those countries (19).

1.7 Heat wave and public health in China.

Heat wave in China is defined as: continuous hot weather (usually two days or more) which make the body feel very uncomfortable, normally associate with high humidity. CMA had developed different critical temperature of heat wave for different city according to different relative humidity. But generally, 35°C is viewed as a general critical temperature for heat wave (20). So CMA defines 35°C or more as high temperature and warns people by using colorful signs: Yellow, Orange and Red. See Table 1 below for more information (21).
Table 1. Different levels of high temperature alert and the defense guideline referring to the alert (21).

<table>
<thead>
<tr>
<th>Legend</th>
<th>Interpretation</th>
<th>Defense Guidelines</th>
</tr>
</thead>
</table>
|        | Daily maximum temperature will rise above 35°C for continuously 3 days. | 1. Relevant departments and units shall be ready to perform protective measures of heatstroke.  
2. Minimize outdoor activities in the afternoon.  
3. Provide heatstroke protection guidelines to vulnerable population.  
4. Necessary protective measures should be applied for people who work under high temperature environment including outdoor workers. |
|        | Maximum temperature will rise above 37°C within 24 hours. | 1. Relevant departments and units shall perform the protective measures of heatstroke.  
2. Try to avoid outdoor activities, shorten continuous work hours for people working in high temperature environment.  
3. Provide heatstroke protection guidelines as well as the necessary protective measures to vulnerable population.  
4. Relevant departments and units should prevent fire caused by high electricity consumption as well as by overload of wires and transformers. |
|        | Maximum temperature will rise above 40°C within 24 hours. | 1. Relevant departments and units shall perform the emergency measures of heatstroke.  
2. Stop all outdoor activities (except in special industry).  
3. Perform heatstroke protective measures for vulnerable population.  
4. Relevant departments and units should specially pay attention to fire prevention. |

Heat waves in China had taken many lives. In Shanghai 2003, 19 heat waves occurred during July and August which result around 260 deaths for every day (20). In 2010 in Xian city, heat waves caused 53 deaths within 4 days and the ambulance was used for 356 times in 30th of July, 384 times in 31st of July, 287 times in 1st of August and 299 times in 2nd of August, in those 4 days (22).

Heat waves led to increased mortality and morbidity in China imposed a threat for country’s health situation. In response, the Chinese public health sector developed strategies for heat wave impact which were mostly protective measures (20, 21).
1.8 Occupational heat stress and its influence on health and work capacity loss

People working in high temperature environments with no sufficient cooling measures, are under the risk of getting occupational heat stress. People exposed in occupational heat stress have many negative impacts on health, even lead to the risk of developing heat related diseases such as heat stroke, heat syncope, heat exhaustion, heat cramps, heat rash, heat fatigue and so on (16).

The physiological changes taking place in the body due to exposure to occupational heat stress are as follows:

a) **Impact on circulation system**: Working in high temperature environments results in excretion of large amount of sweat which increase the heartbeat, blood pressure and cardiovascular burden of the body.

b) **Impact on digestive system**: Working in high temperature would results in loss of appetite, indigestion, and slowing down the movement of small intestine which directly lead to lots of gastrointestinal diseases.

c) **Impact on urinary system**: people working in high temperature environment need to excrete large amount of sweat which directly result to the concentration of urine, and give burden to kidney.

d) **Impact on nervous system**: Working in high temperature will decrease the ability of work, coordination, accuracy of movement and the speed of response whereas increase the distraction of attention (24).

Chinese Ministry of Health has divided occupational heat stress into 4 levels according to work intensities, work time and the WBGT indicator. Table 2, 3 and 4 demonstrate the detail content of the classification of occupational heat stress (25).

<table>
<thead>
<tr>
<th>Work intensity</th>
<th>Time of continuously work (min)</th>
<th>WBGT indicator (°C)</th>
<th>WBGT indicator (°C)</th>
<th>WBGT indicator (°C)</th>
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<tr>
<td>I</td>
<td>60-120</td>
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<td>Time of continuously work (min)</td>
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<td>(Light work)</td>
<td>121-240</td>
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<td>241-360</td>
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<td>(Medium work)</td>
<td>60-120</td>
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<td>(Heavy work)</td>
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<td>(Extremely heavy work)</td>
<td>60-120</td>
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</tbody>
</table>

Note: WBGT = Wet Bulb Globe Temperature (more detail will be explained in Material and Method section)

The WBGT index in the brackets is used for workers who are not acclimatized yet.

Table 3. Occupational heat stress level and corresponding risk of developing heat related disease (25).

<table>
<thead>
<tr>
<th>Occupational heat stress level</th>
<th>Risk of developing heat related disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Mild Hazardous Work)</td>
<td>May have negative effects on the health of workers ()</td>
</tr>
</tbody>
</table>
Working in high temperature environment not only has negative impact on health, but also affect work capacity. If the ambient temperature is high, the person working in the environment, he/she have to not only reduce the intensity of work both also have to take rest more frequently, in order to reduce the production of the metabolic heat to keep the body’s core temperature at a normal level which would result in lower labor productivity. The relationship between people’s work capacity, different WBGT level and work intensities was reported by Kjellstrom et al in 2009 based on the international standard (ISO, 1989) (Figure 6), Figure 6 demonstrates that different work intensities have different work capacity under different WBGT index. Where 200 Watts indicate light work like office work, 300 Watts indicate moderate work like work in manufacturing industry, 400 Watts indicate heavy work like construction work. (26)
While the aim of ISO standard is to protect most of workers, so, for average workers, ISO standard recommend more rest times for workers than they actually needed. Besides the standard take those workers who need to wear special heavy protective clothes into account, which again can result in over estimate the rest-recommendation for those normal workers who wear normal light clothes while working. Moreover, the ISO standard assume that workers take rest in the same environment when they work, but actually, workers tend to take rest in a cooler environment which again will recommend more rest time than actually needed by workers. So according to the standard as well as few real life studies, Tord et al develop a new work capacity and heat exposure relationship model for average workers assuming that workers all wear normal light cloth while working. Figure 7 demonstrate the relationship between the hourly work capacity, different work density and different level of heat exposure (WBGT). (Provided by Kjellstrom Tord)
The consequence of heat exposure are well known and they are mainly: heat stroke (fatal heat stroke), heat syncope (non-fatal heat stroke), heat exhaustion, heat cramps and so on as mentioned above. The studies about the relationship between quantitative heat exposure and clinical health effects are quite limit. Among the few available, Wyndham’s long time study for 6 years in South Africa’s gold mines among black mine workers was a significant study and he found out the monthly risk of fatal and non-fatal heat stroke among different temperature and humidity ranges from 1956 to 1961. Based on Wyndham’s findings, Tord et.al developed a model (exposure-response relationship model) to find out the risk of one-day heat exhaustion from monthly risk of non-fatal heat stroke among more narrow ranges and explored the relationship to estimate the risks in higher WBGT. Table 5 demonstrate the relationship between the different risk of clinical effect and different heat exposure levels (WBGTmax). (Provided by Kjellstrom Tord)
Since there are no studies done to show the difference in risks of heat stroke for women and men it is assume that the risks for women and men are the same under the same environment. The same assumptions were made for the age groups, ethic groups, social settings and societies. Tord et al used the Wyndham’s findings on monthly risks of non-fatal and fatal heat stroke, to calculate the monthly risk of one-day heat exhaustion per million workers which is shown in the table 5. (Provided by Kjellstrom Tord)

Wyndham in his study found that the risk of getting a non-fatal heat stroke increases approximately by ten times with the increase of effective temperature (same as WBGT) by five degrees Celsius. Also when the WBGT starts from a minimal temperature like 26 or 27 degree Celsius, it was found that the risk of getting non-fatal heat stroke will increase by 50 to 100 times for every five degrees increase. They found in Wyndham’s study, that an increase of five degree Celsius WBGT also increase the rectal temperature (same as core body temperature) by one degree Celsius. Here assumptions were made to calculate the monthly risk of heat exhaustion. Assuming that heat exhaustion take place at a core body temperature of 1 degree Celsius which is less than what is required to develop a non-fatal heat stroke, a 20 times increase in risk of getting heat exhaustion is assumed to occur above the occurrence of non-fatal heat stroke. Thus the monthly risk of non-fatal heat stroke is multiplied by 20 times to get the monthly risk of getting heat exhaustion. Since we want to calculate the monthly risk of one day heat exhaustion, the risk is again multiplied by number of working days per month. Here 20 working days is considered. Thus the monthly risk of non-fatal heat stroke is

<table>
<thead>
<tr>
<th>WBGT (°C)</th>
<th>A. Risk of one-day heat exhaustion per working month, per million workers (estimated at 400 times B values) (assuming 20 work days/month or 240 work days/year)</th>
<th>B. Monthly risk of non-fatal heat stroke/million workers (health damage lasts a week)</th>
<th>C. Monthly risk of fatal heat stroke/million workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>40</td>
<td>0.1</td>
<td>0</td>
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<tr>
<td>27</td>
<td>120</td>
<td>0.3</td>
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<tr>
<td>29</td>
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<tr>
<td>30</td>
<td>3200</td>
<td>8</td>
<td>2.5</td>
</tr>
<tr>
<td>31</td>
<td>4000</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>32</td>
<td>6000</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>33</td>
<td>8800</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>34</td>
<td>16000</td>
<td>40</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 5, The relationship between the different heat exposure levels and risk of clinical effect for physiologically acclimatized working people. (Provided by Kjellstrom Tord)
multiplied by 400 (20 working days * 20 times risk for heat exhaustion) to get the monthly risk of one day heat exhaustion approximately. (Provided by Kjellstrom Tord)

Because of climate change, the average land surface temperature has increased, especially in some regions which have subtropical and tropical climate with hot summer. Climate change can exacerbate both the general living environment and the working environment (23).

1.9 Relevant policies regarding to occupational heat stress in China

“Heat Allowance” is a policy which directly refers to the occupational heat stress in China in which the Chinese government requires all employers to provide best working conditions for all workers to prevent occupational heat stress and prevent heat related diseases in summer. Providing heat allowance is one of the ways to guarantee workers’ health especially those who work in high temperature environment. Since there is no national standard about how much allowance should be paid for employees, the amount allocated for the allowance appears to be largely diverse in time period and across cities or provinces. The rationing of the allowance is mainly base on two ways: pay by month and pay by the number of working days under high temperature condition. Employees who benefit from this policy include only those who have signed long-term contracts with their employers. Temporary workers such as migrant construction workers with temporary contracts and self-employ workers (farmers and fishers) are excluded from the policy (27).

The heat allowance policy for Fujian province for outdoor employees was 8 to 10 Yuan per person per day, between May and September, when the daily maximum temperature reach 35°C or more. For indoor workers where effective measures can not be applied to reduce the temperature of their workplace, they will equally get 8 to 10 Yuan allowance per person per day when the temperature is above 33°C. This policy is executed since 1st of August 2011 (28).

Since the heat allowances policy is not applied as law and it is not compulsory, so many employers do not attach much importance to the policy. So in June 2007, the Chinese government promulgated “on further strengthening the workplace a notice in the summer of heatstroke prevention work” bulletin to address the importance of the heat policy and to gain more attention from employers. Although government had emphasized the importance of the policy, it seems that the bulletin didn’t work well. Still media outlets had reported that lot of factories had ignored the policy and even some employers and employees had never heard about the policy (29).
It is reported by Sina News that in Jinan city, between 30th of July and 1st of August 2010, 8 outdoor workers (mostly farmers and street sweepers) died from heatstroke. Also at Xinjiang Uygur Autonomous, on mid-June 2010 the temperature had rose above 40°C, causing heat stroke among 20 farmers and even lead to death of 3 farmers who suffered those heat stroke (30). Thousands of relevant news could be easily found from different medias, which shows that the heat policy is not applied well. This resulted in motivating people and professors to appeal for a better allowance policy and to change the policy into law. “Heat allowance are not compulsory nationwide and are especially unlikely to be provided for migrant construction workers, the government should issue regulations protection outdoor workers’ health, especially because the extreme weather is becoming more common.” said by professor Lu Xuejing Capital University of Economics and Business when having interview by Xinhua News (one of the most famous and authentic media in China) (31).

1.10 Statistic information of Putian city Fujian province

According to Fujian Provincial Bureau of Statistics in Fujian Statistical Yearbook-2011, the GDP in manufacturing sector in Fujian province is growing year by year, from 142.2 billion in 2000 to 639.7 billion in 2010. The number of self-employed or employed persons in private enterprises in urban areas in this sector had increased from 361152 in 2005 to 654265 in 2010. The number of staffs and workers in urban units of manufacturing sectors had grown from 1521400 in 2003 to 2389900 in 2010 whereas the number of employees joined between 2009 and 2010 was 149900, indicating the manufacturing industries recent mega growth and huge population working in this sector (32).

Putian city, a population of 3.03 million, is located in the central of Fujian Province, has subtropical monsoonal climate. The industries in Putian are mainly shoe-making, electronic devices, food, arts and crafts. Putian is famous for shoe factories (33).

The National Economic and Social Development Statistics Bulletin in 2010 showed that clothes, shoes and hat manufacturing industry output had increased by 30.5% compared to 2009 in Putian city. 14.2234 million pairs of leather shoes had been produced in 2010 which had increased by 2.6% compare to 2009 and in the same time period, 29.7849 million pairs of gumshoes had been produced which had increased by 17.2% compare to 2009 (34). This increase in production was made possible with increased number of employees. In Putian, there were 179700 people working in manufacturing sector which an increase of 22500 people (14.3%) had compared to 2009 (35).
There was no direct figure to show increasing trend in the number of people working in shoes factory over the years. But generally, the number of people working in manufacturing sector is growing in the whole province and the production of shoes had grown a lot in Putian city. This implied that the number of people working in shoe factory in Putian is increasing.

With the impact of climate change, the global average surface temperature is rising. China is not an exception, the average temperature in China has increased as well as in Fujian province (including Putian city) which is located in southeast of China. With serious consequences of heat stress, hotter summers, increasing number of people working in shoes factories, insufficient heat safety policy measures, and increasing pressure from employees, professors and the media, there is a need to conduct more study to assess higher temperatures in the working sectors and explain the occupational heat stress associated with the higher temperatures in line with the global standards. Since there is no existing study available on the assessment of temperatures in work place and describe the occupational heat stress situation particularly at Putian city and that too in the growing shoe factory, the researcher motivated to conduct a study.
2. Aims

2.1 Overall aim

To find out whether the workers working inside shoe factory in Putian city Fujian province of China are exposed to occupational heat stress during the study period.

2.2 Specific aims

1) To find out the temperature difference on hourly basis between factory and the house in the study area in Putian city.

2) To quantify the working hours that the workers are exposed to different occupational heat stress level during the study period.

3) To estimate and quantify the workers’ work capacity lost during the study period.

4) To estimate the health risk corresponding to different level of heat exposure.
3 Materials and methods

3.1 Background of this study

The “High Occupational Temperature Health and Productivity Suppression” (HOTHAPS) is a research program conducted globally to find out the influence on occupational health and work capacity by occupational heat stress in many areas of the globe after having taken the climate change into consideration. In addition, the program has an objective to find out and evaluate the interventions which are employed to prevent occupational heat stress in various social and economic environments. The program is led by Professor Tord Kjellstrom. The program stresses the importance of mitigation policies to reduce climate change, emphasize the need for relevant preventive measures in addition to provision of powerful public and occupational health programs in order to protect individuals at risk. The information from Hothaps field studies will be provided for the next report by IPCC in 2013 (36).

Since Fujian province is becoming warmer in summer, people (especially working class) in the province are suffering more and more serious heat stress. It is urgent for them to have appropriate preventive interventions for coping with hot summer, and also powerful policies and programmes which can prevent them from suffering from heat stress during summer. So HOTHAPS program study is urgently demanded in Putian city.

3.2 Study setting

The study was carried out at Dongying shoes factory in sewing sector in Putian City Fujian Province, China, and at one purposively selected house in the study area. In the factory, there were around 100 people carrying out their work through a manual sewing machine with stationary foot presser. Their work involves movement of the leg and hand for a period of 12 and half hours in a day at a single place around 200m². While at the house, there are 4 people living inside. No effective cooling measures such as air-conditioner were available in both study places. The factory where study was conducted is similar to other shoe factories in Putian (there are similar factories with insufficient cooling measures locate Putian city). The house type is also similar to other houses in that place and it is common that air-conditions are not available. The two study site located at a distance of about one kilometer. See Figure 8, the green star indicates the house, and the red star indicates the factory.
3.3 Study design

A cross-sectional study design is used for this study, where the hourly air temperature and dew point were recorded for a period of two months both in the factory and in a resident house.

3.4 Study samples

Air temperature and dew point were recorded hourly at the factory and the house from 1st of July to 31st of August 2010. 1488 records of hourly air temperature and dew point both from the factory and the house taken for the analysis.

3.5 Variables

As mentioned above, there are six basic parameters mainly determinate the heat interaction: air temperature, radiant temperature, humidity, air movement (wind speed), metabolic heat generated by human activity and clothing worn by a person. Since workers were not exposed to sunlight, and all workers wear normal summer T-shirt, so in this situation, the air
temperature, humidity, the person’s work intensity and wind speed are the main factors determined the heat interaction procedure.

Air temperature usually is measured at 1.2-2 meters height above the ground where sunlight cannot directly reach and have good ventilation. It is usually expressed in Celsius. In this study, air temperature was recorded at about 2 meters height above the ground where there was good ventilation and no sunlight (38).

A dew point record shows the amount of moisture in air, high dew point indicates high amount of moisture which means it will not ease the evaporation of sweat to release heat from the body. It is usually expressed in Celsius. When the air temperature is high, human body needs to evaporate sweat for cooling down the body and if the dew point is also high in an increased air temperature surrounding, then the sweat evaporation don’t take place leaving heat within the body. So it is uncomfortable for people who work under high temperature and high dew point. Normally, people will feel uncomfortable when the dew point is over 16°C. Occupational heat stress occurs when people working in high temperature and high dew point environment (39).

Wet Bulb Globe Temperature (WBGT) is a index used for assessing heat stress, it is calculated from three measurements: Natural wet-bulb temperature (Tnwb), Global temperature (Tg) and Air temperature (Ta). There are different formulas for calculating the WBGT outdoors and the WBGT indoors. Outdoor WBGT is calculated by: 0.7Tnwb + 0.2Tg + 0.1Ta, while indoor WBGT is calculated by: 0.7Tnwb + 0.2Tg. Since WBGT values can not get directly from weather station and the measurement of WBGT is very complicate, many formulas for calculating it were developed. Australian Government Bureau of Meteorology had developed a simplified formula to calculate WBGT from air temperature and relative humidity (RH) under some assumptions. Bernaid and Pourmoghani developed a formula which allows calculating the indoor WBGT index from air temperature, wind speed and dew point. The formula is:

Indoor WBGT = 0.67*Tnwb + 0.33*Ta - 0.048*log (ws)*(Ta - Tnwb)

Where Tnwb is calculated from dew point (Td) by iteration, ws is the indoor wind speed and limit up to 3m/s, Ta is the ambient temperature. VBA macro (a function of windows excel) was developed from this formula, which gives approximate indoor WBGT value, where the global temperature was set equal to the ambient temperature and indoor wind speed was limited to 3m/s. (40, 41, 42)
This study is conducted at a single close place around 200m\(^2\) with fan running all the time. The employees of the study site told the researcher that they feel breeze inside the factory. According to Chinese standard for grades of wind, when wind speed is in a range of 1.6 - 3.3 m/s, people can feel the wind. Keeping this in mind the researcher calculated the WBGT range with a wind speed of 1.6 m/s and 3 m/s (43).

### 3.6 Study tool and data collection

To measure the hourly temperature, dew point and relative humidity in the factory and the house, two data loggers were kindly borrowed from Umeå University Sweden.

Data loggers are small electronic device that records the information about air temperature and humidity within different time intervals. There is a USB memory card in the device where information can be stored. The USB can use for connecting with computer in order to transform data and pre-programming. Pre-programming before data loggers start recording is needed. The frequency of recording information can be chose during the pre-program procedure.

In this study, the data loggers were set up to record the temperature, the dew point and every hour during pre-programming. At the end of June, one data logger was hanged in the factory at about 2 meters height above the ground where no sunlight can reach and have good ventilation. At the same time, another data logger was hanged inside the house at the same height where no sunlight could enter and have good ventilation.

### 3.7 Statistical analysis

The data was transferred from data loggers to Windows Excel 2003, where data was analyzed thoroughly.

Descriptive analysis had been done for finding out the mean temperature with 95% CI for the two study sites. The indoor WBGT index was calculated by Micro function of Excel. The frequency distribution of air temperature and indoor WBGT index were showed using different types of charts.
3.8 Ethical Consideration

Permission to conduct study and written informed consent was taken from the factory owner. In addition, all workers of the sewing sector were explained about the study and informed about the data logger temperature recording. Besides, people living in the house were all informed and they all agreed to the data collection.
4 Results

1488 each records of air temperature, dew point and relative humidity from the factory and house were taken in to the analysis.

To test temperature variation between the factory and house, the researcher used the function of descriptive statistics in Windows Excel.

Table 6 illustrates the descriptive information of air temperature recorded from the factory.
- A total of 1488 hours from the factory were included in this study.
- Mean temperature of the factory was 31.5°C with 95% CI being 31.43°C to 31.57°C during July and August 2010.
- There were 744 hours either equal to or hotter than 31°C in factory during the study period.
- 29.5°C was the temperature that appeared the most frequently in the factory during the study period.

Table 6. Descriptive information about air temperature inside the factory during July and August 2010 in Putian city Fujian province, China.

<table>
<thead>
<tr>
<th>Factory air temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>31.5</td>
</tr>
<tr>
<td>Median</td>
<td>31</td>
</tr>
<tr>
<td>Mode</td>
<td>29.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>26.5</td>
</tr>
<tr>
<td>Maximum</td>
<td>39</td>
</tr>
<tr>
<td>Count</td>
<td>1488</td>
</tr>
<tr>
<td>Standard error (at a confident level of 95.0%)</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Table 7 illustrates the descriptive information of air temperature recorded from the house.
- A total of 1488 hours from the house were included in this study.
- Mean temperature of the house was 31.1°C with 95% CI of being 31.08°C to 31.12°C during July and August 2010.
- There were 744 hours either equal to or hotter than 31°C at the house during the study period.
- 31.5°C was the temperature that appeared the most frequently at the house during the study period. (44)

Table 7. Descriptive information about the air temperature inside of the house during July and August 2010 in Putian city Fujian province, China.

<table>
<thead>
<tr>
<th>Air temperature in the house</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>31.1</td>
</tr>
<tr>
<td>Median</td>
<td>31</td>
</tr>
<tr>
<td>Mode</td>
<td>31.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>28.5</td>
</tr>
<tr>
<td>Maximum</td>
<td>33.5</td>
</tr>
<tr>
<td>Count</td>
<td>1488</td>
</tr>
<tr>
<td>Standard error (at a confident level of 95.%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

The values of 95% CI of mean temperature from the two groups of study sample have no overlap, so the mean temperature inside factory is not the same with the mean temperature inside the house.
In order to compare air temperature from the two study sites, the researcher produced a Scatter Plot Diagram to see the distribution of them. Diagram 1 shows the distribution of temperature of the two samples. Temperatures inside the house mostly distributed between 29°C to 33°C, and not exceeded above 35°C. 35°C is the borderline for getting high temperature alert. While the distribution of temperatures inside factory had wide range, almost half of study hours raised to 33°C or more. 33°C is the borderline for getting heat allowance. But the workers didn’t get any allowance from their employer.

Diagram 1. Comparison of temperature inside factory temperature and inside the house during July and August in Putian city Fujian province, China.

Schedule for workers in the factory in summer is:
7:30-11:30: 4 hours continuously work
11:30-13:30: 2 hours lunch break and day nape
13:30-17:30: 4 hours continuously work
17:30-18: half hour dinner break
18-22:30: 4 and half hours continuously work
Twelve and half hours work hour per day, seven workdays per week. Every Saturday night was free.
To compare the temperature of the two samples during work hours, the researcher calculated the mean temperature for every hour between July and August (see Figure 9). During the whole work day, only one and half hours of the mean temperature in factory were lower than the temperature in the house, which were between 7:30 to 8:30 in early morning when they just started work, and between 22:00 to 22:30 at night when they almost stop working. Therefore, during work hours mean temperature in factory was higher than at the house.

![Mean temperature at factory and at the house for every hour during July and August months in Putian city Fujian province, China.](image)

Figure 9. Mean temperature at factory and at the house for every hour during July and August months in Putian city Fujian province, China.
In order to see the duration of different temperature intervals inside factory and the house, the researcher picked up the data of work hours alone. Number of hours existed in different temperature intervals were showed in Figure 10 (see Figure 10). There were only 3 hours which were above 33°C in the house, and all of the 3 hours appeared at the same day in fourth of August. In case of factory, there were 332 hours warmer than 33°C, distributed in 56 days. Therefore, the temperature was over 33°C almost every day during study period (except 7th, 9th, 26th and 27th of July). As the heat allowance policy is not compulsory, so either employer ignores it or none of them know about the policy. Therefore, workers exposed much more high temperature in factory than at the house during work hours.

Figure 10. Number of hours each temperature interval exists in factory and in the house during work hours between July and August 2010 in Putian city Fujian province, China.
Diagram 2 gives a rough picture about the distribution of dew point at each temperature inside factory. Dew point records of the factory were above 22°C and the corresponding air temperature ranges between 26.5°C and 39°C, which indicate people working in this environment would feel uncomfortable to work and have the high risk of develop occupational heat hazards.

Diagram 2. Distribution of air temperature and dew point inside factory during July and August 2010 in Putian city Fujian province, China.
The number of hours each WBGT interval existed in factory for working hours alone was calculated with a wind speed of 1.6m/s and is shown in the Chart 1.

It was found that the WBGT interval of 29°C-30°C occurred for a period of 387 hours which is 45% of study time. WBGT interval of 31°C-32°C for 221 hours comprising, which counts 24% of study time. WBGT interval of 33°C-34°C for 4 hours constitutes only less than a percentage, and these 4 hours distributed in 3 days which were 5th of July, 3rd of August and 4th of August. It is clearly evident from this data that the factory workers had went through occupational heat stress for a long period of about 70% of study period.

Chart 1. Number of hour each WBGT interval exist in factory for working hour (calculated with ws=1.6m/s) during July and August 2010 in Putian city Fujian province, China.
The number of hours that each WBGT interval occurred in factory for working hours alone was calculated with a wind speed of 3 m/s as shown in the Chart 2. The results found to similar to the calculation with 1.6 m/s. The WBGT interval of 29°C-30°C existed for a period of 399 hours which is 47% of study time (almost half of study period), WBGT interval of 31°C-32°C for 194 hours constituting 22% of study time and WBGT interval of 33°C-34°C below 1% of whole study period which is only 2 hours.

Chart 2. Number of hour each WBGT interval exist in factory for working hour (calculated with ws=3m/s) during July and August 2010 in Putian city Fujian province, China.
Factory's Hourly mean WBGT for working periods alone is shown in the Figure 11. It is evident from the figure that almost 8 hours in a day; the workers were exposed to occupational heat stress. It was also found that the heat stress occurred from morning to evening 5:30 PM continuously which increased the level of occupational heat stress and indicated high risk of having heat related disease. In addition, there was no significant difference in the value found for WBGT when calculated with a wind speed of 1.6 and 3 m/s.

Figure 11. Mean indoor WBGT at factory for every working hour calculate with ws 1.6 and 3m/s during July and August in Putian city Fujian, China.
In addition, work capacity lost is also estimated in this study. The estimation is similar to what Tord did in his study and in this study, the work performed in sewing sector comes under moderate work. If WBGT value is calculated with \(ws=1.6\text{m/s}\), it was found from the data that the WBGT under 28°C occurred for a period of 266 hours a total of only 266 hours during the whole study period, the workers are recommended to work for full hours. With the WBGT interval of 29°C-30°C occurred for a period of 387 hours, a total of 387 hours during the study period, workers should be recommended to work only for 55 to 50 minutes per hour (Figure 7) and as the workers worked for full one hours, there would be 9%-17% of work capacity reduction in those 387 hours. Similarly with the WBGT interval of 31°C-32°C occurred for 211 hours, a total of 211 hours workers should be recommended to work only 39-45 minutes per hour and as the workers worked complete one hours, this might have caused 25%-35% of work capacity reduction in those 211 hours. Also with the WBGT interval of 33°C-34°C occurred for a period of 4 hours, a total of 4 hours of the working time during the study period, the workers should be recommended to work only 27-33 minutes per hour and as the workers worked complete one hours, there might have been 45%-55% of work capacity reduction in those 4 hours.

If WBGT value is calculated with \(ws=3\text{m/s}\), there would be 273 hours, that the workers should be recommended to work for fully hours, 399 hours workers should be recommended to work only 55 to 50 minutes per hour, 194 hours workers should be recommended to work only 39-45 minutes per hour and 2 hours workers should be recommended to work only 27-33 minutes per hour.

This study also estimated the health risk associated with each WBGT levels similar to the one estimated in Tord's study. The monthly average WBGTmax for July 2010 is 29.9°C and 29.8°C calculated with wind speed of 1.6m/s and 3m/s respectively. So the monthly risk of fatal heat stroke for July is 2.5 per million workers, and the July month risk of non-fatal heat stroke is 8 per million workers. While the risk of one-day heat exhaustion is 4800 (8 x 20 x 30, workers in the factory work 30 days a month) per working month per million workers.

Similarly, the monthly average WBGTmax for August is 29.9°C for both wind speed of 1.6m/s and 3m/s. So the monthly risk of fatal heat stroke is 2.5 per million workers, and the montly risk of non-fatal heat stroke is 8 per million workers. While the risk of one-day heat exhaustion is 4800 per working month per million workers.
5 Discussions

5.1 Key results of the study

1488 records of hourly air temperatures and dew points each for factory and the selected house were taken into consideration for analysis. The mean values of temperatures at factory and house were not overlapped, which statistically denote the temperature at factory and the house were not the same during the study period (44). Moreover, there was no high temperature existed at the house while many hours of high temperature existed in the factory (21).

The temperature was above 33°C for 332 hours during the study period distributed over 57 days in the factory, while in the house, there were only 3 hours the temperature exceeded 33°C and distributed in the same day. According to the occupational heat allowance policy in Fujian province, the employer of the factory needed to pay 456 to 570 Yuan heat allowance for each worker during the study period. If in case, the employer applied some cooling devices which could draw the temperature in the factory to the same level as the house temperature is, then the employer will need to pay only 8 to 10 Yuan heat allowance for the same period. So applying an effective cooling device in the factory will bring benefit for employers and for employees while it would decrease the occupational heat stress problem on a large scale which is a huge release of the problem in public health sector.

The work in sewing sector involves the movement of hand and leg which is classified as level I light work by the Chinese Ministry of Health in their classification of Occupational heat stress (25).

It was found that the WBGT (calculated from ws=1.6m/s) interval of 29°C-30°C occurred 45% of study time. So almost half of their working time during the study period, workers were exposed in level I occupational heat stress. This indicate that workers had high risk of increased blood pressure, increased cardiovascular and kidney burden, decreased appetite and movement of small intestine, decreased ability of work, coordination, accuracy of movement and speed of response and increased distraction of work (24, 25).

WBGT interval of 31°C-32°C existed 24% of study time, in which, workers were exposed in level I and level II occupational heat stress for 33 and 178 hours respectively. This indicates workers in the factory had the risk of getting negative health impacts or developing heat related disease such as heat stroke, heat syncope, heat exhaustion, heat cramps, heat rash,
and heat fatigue and so on for 24% of total study period (15, 25).

WBGT interval of 33°C-34°C existed less than a percentage of the study time. This means workers were exposed to level III occupational heat stress for 4 hours during the study period had the higher risk of developing heat related diseases (15, 25).

The WBGT value calculated from wind speed 3m/s and wind speed 1.6m/s are quite similar, so fans will not be an effective way for cooling down the environment when the air temperature and humidity is high.

The situation of occupational heat stress is very bad, and climate change will make it even worse in future if no intervention is done from now on. There are actually many ways of addressing the problem such as:

1) Provision of heat allowance should be a law rather than a mere policy which can force employers to pay it.
2) Develop a law to restrict the temperature inside of factory below 33°C.
3) Use of air conditioner instead of fan in the factory.
4) Introducing a short break every hour while working, thereby avoid working continuously.
5) Provide special heat prevent uniform for workers.
6) Shorten the working hours.

5.2 Strengths of this study

1488 records of hourly air temperature and dew point each for factory and resident house used for analysis, denoting the study sample was big enough.

The mean value of factory temperature and house temperature, were statistically significant shown by 95% Confidence Interval has added strength to the study.

Indoor WBGT index was used as indicator to assess the occupational heat stress rather than using only air temperature, which is an appropriate way to assess the heat stress.

The factory and the house were about one kilometer away from each other, which ensures that both the study sites were exposed to similar weather, which has avoided the intervention bias.
The data from the factory and from the house were recorded by the same device – data logger. The data loggers were pre-programmed at the same time with the same time interval of recording the data. Besides, both data loggers were hanged on the wall about 2 meters above the ground where sunshine could not reach and had good ventilation which has avoided the measurement bias.

Efficient cooling measures were neither available in the factory nor in the house, which is common for Putian city. Also, the weather in Fujian province during the study period was a normal summer that was not dramatically hot than the past few years which ensured absence of selection bias.

5.3 Limitations of this study

Selection bias might exist in this study, due to the limit number of data loggers, only 1 factory and 1 house (purposively selected in the study area) in the study area are included, although both the factory and the house were most common types in Putian, but it is weak to represent the whole Putian city.

The indoor WBGT values were calculated from approximation formula so that is approximate value not accurate.

The health risk is estimated with logical assumptions and the risk estimated in this study is not the accurate value but an approximate value to understand health risks.

The work capacity lost is estimated based on some assumptions, and the work capacity lost estimated in this study is not the accurate value but an approximate value.

The way of getting the WBGT value used by Chinese Ministry of Health are different, so the situation of the occupational heat stress that this study described is an approximate situation.

5.4 Comparisons with existing studies

A big cohort study was conducted in Thailand, 37816 workers were taken for the study to find out the association between occupational heat stress and kidney disease. It was found that the odds of male workers exposed to occupational heat stress had 1.48 times higher risk of getting kidney disease compared to those who were not exposed to the occupational heat stress. Also male workers who were exposed for a prolonged period to occupational heat
stress, the odds of getting kidney disease for them was 2.22 times higher compare to those who didn’t exposed to heat stress. Male worker who were 35 years or older and who were exposed for prolonged period to occupational heat stress, had the odds of getting kidney disease 5.3 times higher than those who didn’t exposed to heat stress. The results of this study calls for the necessities to address problem of occupational heat stress in tropical climates (45).

400 workers of a steel enterprise were included for a study in China to find out the quality of steel workers’ life quality and its related factors by using self-regulating questionnaire and WHOQOL (WHO quality of life). The results shows workers who worked in high temperatures in steel enterprises in China have low quality of life, and the key finding were workers dissatisfaction to sleep & sleep time, work shift and work pressure (46).

In Taiwan, data about meteorology, population, the labor force and economy were used to identify the occupations that are under the risk of heat stress and the corresponding impacts on health by measuring WBGT in different workplaces. The result found out that all most all kinds of physical labors both indoor and outdoor workers were under risk of heat stress. The study also emphasizes the need of effective prevention strategies for worker in Taiwan (47).

In Okayama prefecture, Japan, a study recorded the daily data on the number of ambulance transports used for heat stroke patients from July to September in 2010 and also the corresponding daily air temperature. The study found out a positive association between the air temperature and ambulance transport of heat stroke patients (48).
6 Conclusions

6.1 Recommendations

Summer is hot in Putian, Fujian Province, China. People working in the factory exposed to occupational heat stress up to 69% of the study period, only 31% of July and August they were free from occupational heat stress. Heat Allowance policy was not implemented according to the regulations. There is no effective cooling measure practiced in the factory. Workers didn’t have any occupational health training for working in heat stressful environment. The temperature is rising every year due to climate change; summer in Putian city is hotter and hotter, which indicate that workers working in the factory will be exposed to more and more serious occupational heat stress. This occupational heat stress problem will become more and more serious which need to be addressed as soon as possible not only quantitatively but also qualitatively. Here are some recommendations obtained from this study:

1) More quantitative and qualitative researches about occupational heat stress are recommended to conduct in the factory to assess the actual health impact and to get the perception of workers about working during the hot summer.

2) More relevant researches (such as HOPATHS) were recommended to carry out in Putian to find out appropriate preventive interventions which are urgently needed by the workers.

3) There are several relevant heat stress policies (e.g., heat allowance, recommendations attached with classification of occupational heat stress) in China, but the applications of them are poor, so more information are recommended to be carried out for general knowledge of relevant policies. So that employers know what kinds of responsibilities that they have regarding to employees, and for employees to know what kinds of rights they have.

4) More powerful policy and occupational health program for protecting individuals at risk are recommended to be developed in the immediate future.

5) It would be important that government and society pay more attentions on occupational heat stress.

6) As the WBGT values calculated from 1.6m/s and 3m/s are quite similar, fans along are not sufficient in cooling the work environment. Effective cooling measures are strongly recommended in the factory, which would not only protect the workers from heat stress but also improve the productivity. Moreover this will reduce the burden of public health sector.
7) It is recommended that the Chinese heat wave warning guidelines adapt a more complex and comprehensive version that targets not only protective measures of heat stroke, but also other heat related illness and health indicators, such as, air pollution, mortality and morbidity as the one used in Europe. (49)

6.2 Application

This study may be useful to the following people or sectors:

1) Potential stakeholders in public health sector to gain their support for more researches and to set up more intervention.
2) Relevant government agency or policy makers to gain their attention on the problem and on appropriate preventive interventions and better policies on the implementation.
3) Workers in the factory so that they are aware of the risk that they are exposed at work.
4) Researchers in Hothaps program to identify the potential China study sites (sites with temperatures that frequently exceed 30°C during the summer months).
5) Other researchers who may be inspired to set up and continue the Hothaps program or other relevant study in Fujian Province China.
6) Business association to inform employers on how to improve the productivity of the factory.

In summary, workers in the studied factory were exposed to occupational heat stress at different levels up to 69% of the study period; they were likely to be suffered from heat stress. The situation would be worsened if the climate change continues. Relevant interventions are urgently needed to address the problem.
7 Conflict of interest and funding

The author has not received any funding or benefits from industry or university to conduct this study, two data loggers used for this study were from Umeå University.
8 Acknowledgments

I would like to thank to a number of people who have directly or indirectly contributed to the work of this thesis.

Thanks to all the staff of Department of Public Health and Clinical Medicine, Umeå University for giving me two wonderful academic years.

Thanks to my supervisor Tord Kjellstrom for his valuable suggestions and for his patient.

Thanks to Karthikeyan Kandasamy, Yien Ling, Jing Helmersson and Nawi Ng for their kindly suggestions.

Thanks to my best friend Xiaobing Song for putting one of the datalogger for me in the factory where she works and give me relevant informations about the factory.

Thanks to my cousin Bijuan Song and Rong Song for putting another datalogger at the house with my instruction, and applying the Power of Proxy from the factory for me.

Thanks to my friend Chunbing Bian, Feilong Zheng and Wei Zhu for helping me to find the relevant literatures from China.

Thanks to the owner of Dong Ying Shoes Co., Ltd Zheng Amin for allowing me to conduct this research in her factory.

Thanks to all workers working in the sewing sector of the factory for understanding and supporting my research.
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10 Appendix

Appendix 1: Power of Proxy from Dongying shoe factory.