
Strategy for Improving the Application of Occupational Health and Safety Management System in Heat Related Illness Prevention in XYZ Industrial Area

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Abstract: In some countries including Middle East, extreme high temperatures and heat waves are a routine problem that they have to face. In summer season, the temperature can reach 50 °C with relative humidity reaching 100%. XYZ industrial area is one of area that has the summer temperatures range between 33°C -50°C with relative humidity can reach 100%. This condition affects their industry and business, especially for working outdoors. A special strategy needed to prevent the occurring of heat related illness cases, especially for workers who works outdoor. Even though the XYZ industrial area already established regulations regarding heat stress awareness, cases of heat related illness still occur every year, with non-compliance of employers to work time restrictions policy as one caused of its happen.

This study aims to find alternative strategies that can improve the application of heat related illness prevention strategies based on the Occupational Safety and Health Management System (SMK3) in the XYZ industrial area. The research method use Analytical Hierarchy Process (AHP) with four levels of hierarchy consisting of actors, criteria, factors, and alternative strategies. Data collected through questionnaires and interviews with five experts who had experiences and dealt for more than 15 years in the prevention of heat related illness. Based on the calculation of AHP using Expert Choice 11, the most dominant actor in this study is industrial city managers with a score of 0.380 (38%). The commitment and policy is the most important criteria with a score of 0.331573 (33.2%). Personal/worker factors is a first priority with score of 0.594293 (59.4%), while the acclimatization strategy is the most important strategy to implement with a score of 0.164 (16.4%).

Keywords: Occupational Health and Safety Management System; Analytical Hierarchy Process (AHP); heat stress awareness; heat related illness; heat related illness prevention strategies.

I. Introduction

The phenomenon of global warming is a problem of all the countries in the world. There are various ways have been done to deal with it. In some countries including Middle East, extreme temperatures and heat waves are a routine problem that they have to face. In summer season, the temperature can reach 50 °C with relative humidity reaching 100%. XYZ industrial area is one of area that has the summer temperatures range between 33°C -50°C with relative humidity can reach 100%. This condition affects their industry and business, especially for working outdoors. A special strategy needed to prevent heat related illness cases, especially for workers who works outdoor.

Based on the data collected from occupational health department of XYZ industrial area, heat related illness always occurred every year as shown in table below:

Table1.Heat related Illness cases in XYZ industrial area

Year	Number of Cases	Medical Treatment	
2010	85	85	
2011	50	50	Decreased 41%
2012	57	57	Increased 14%
2013	20	20	Decreased 65%
2014	28	28	Increased 40%
2015	22	22	Decreased 21%
2016	15	15	Decreased 32%
2017	25	25	Increased 67%
2018	15	15	Decreased 40%

Even though the XYZ industrial area already has rules and regulations regarding heat stress awareness, cases of heat related illness still occur every year with significant numbers, with non-compliance of employers to work time restrictions rules as one reason.

According to research of Arbury et al. (2014), they mentioned that during the 2-year period reviewed, 20 cases of heat illness or death among 18 private employers and two federal agencies. In 13 cases, a worker died from heat exposure, and in seven cases, two or more employees experienced symptoms of heat illness. Most of the affected employees worked outdoors, and all performed heavy or moderate work. Nine of the deaths occurred in the first 3 days of working on the job, four of them occurring on the worker's first day. Heat illness prevention programs at these workplaces were found to be incomplete or absent, and no provision was made for the acclimatization of new workers.

Tustin et al. (2018) mentioned that Exposure limits are lower for workers who are unacclimatized to heat, who wear work clothing that inhibits heat dissipation, and who have predisposing personal risk factors. Heat stress exceeded exposure limits in all 14 fatalities and in eight of 11 nonfatal illnesses. The comprehensive heat-related illness prevention program should include an acclimatization schedule for newly hired workers and unacclimatized long-term workers, training for workers and supervisors about symptom recognition and first aid engineering and administrative controls to reduce heat stress, medical surveillance, and provision of fluids and shady areas for rest breaks.

This study aims to find alternative strategies that can improve the application of heat related illness prevention strategies based on the Occupational Health and Safety Management System in the XYZ industrial area.

II. Literature Review

Occupational safety and health are all activities to guarantee and protect the safety and health of workers through efforts to prevent occupational accidents and occupational diseases (Indonesian Government Regulation No.50 of 2012, Article 1 paragraph 2).

Occupational Safety and Health Management System is part of the overall company management system in the context of controlling risks related to work activities in order to create a safe, efficient and productive workplace (Indonesian Government Regulation No.50 of 2012, Article 1 paragraph 1).

Occupational Safety and Health Management System is part of the overall management system which includes the organizational structure, planning, responsibilities, implementation, procedures, processes and resources needed for the development of implementation, achievement, assessment, and maintenance of occupational safety and health policies in order to control risks related to work activities to create a safe, efficient and productive workplace (Indonesian Manpower Ministry Decree or PERMENAKER PER.05/MEN/1996).

The framework for health, safety, and environmental managements system is based on a continuous improvement methodology as integrated approach that align to AS/NZ 4801 Occupational Health and Safety Management Systems and ISO 14001 Environmental Management Systems. They consist of five elements cycles: commitment and policy, Planning, Implementation, measurement and evaluation, management's review and improvement.

The benefits of occupational health and safety management system are:

- a) Help company's management system run consistently, efficiently and effectively,
- b) Invest in minimizing greater losses,
- c) Occupational health and safety management system certificates can increase customer and government trust in companies,
- d) Increase employee confidence in the company,
- e) Government awards to companies,
- f) Passport to global market

According to NIOSH (2016), heat related illness is any of following terms: Heat Stress, Heat Exhaustion, and Heat Stroke, brought on by excessive exposure to heat without adequate water, shelter, and proper acclimatization. Acclimatization is a gradual physiological adjustment process that the body makes to improve an individual's ability to tolerate heat. Acclimatization usually takes several days with gradual build up to expected heat loads, workloads, and duration of job. Heat related illness occurs when heat is absorbed from the environment faster than the body can get rid of it. The resulting strain on the body comes from the combined contributions of the job (e.g. work activity), environmental factors (e.g. air temperature, humidity, air movement, radiant heat), and worker factors (e.g. extent of acclimatization and hydration).

Category of heat related illness are:

- a. *Heat Fatigue*, a factor that predisposes an individual to heat fatigue is lack of acclimatization. The signs and symptoms of heat fatigue include impaired performance of skilled mental, or vigilance jobs. There is no treatment for heat fatigue except to remove the heat stress before a more serious heat-related condition develops.
- b. *Heat Rashes*, the most common problem in hot work environment, prickly heat is manifest as red papules and usually appears in areas where the clothing is inappropriate. As sweating increases, these papules give rise to a prickling sensation. Prickly heat occurs in skin that is persistently wetted by un-evaporated sweat, and heat rash papules may become infected if they are not treated. In most cases, heat rashes will disappear when the affected individual returns to cool environment.
- c. *Heat Cramps*, usually caused by performing hard physical labor in a hot environment. The cramps are generate by an electrolyte imbalance caused by sweating and lack of water replenishment. Thirst cannot be relied as a sign to the need for water; instead, water must be consume every 15 to 20 minutes in hot environments.
- d. *Heat Collapse*, in heat collapse, the brain does not receive enough oxygen because blood pools in the extremities. As a result, the exposed individual may lose consciousness. This reaction is similar to that of heat exhaustion and does not affect the body's heat balance. However, the onset of heat collapse is rapid and unpredictable. To prevent heat collapse, the worker should gradually acclimatize to the hot environment.

- e. *Heat Exhaustion*, heat exhaustion should not be dismissed lightly, however, for several reasons. One of the reason is the fainting associated with heat exhaustion can be dangerous because the victim may be operating machinery or controlling an operation that should not be left unattended; moreover, the victim may be injured when he faints. The signs and symptoms seen in heat exhaustion are similar to those of heat stroke, a medical emergency. Signs and symptoms: headache, nausea, vertigo, weakness, thirst, and giddiness. Fortunately, this condition responds readily to prompt treatment.
- f. *Heat Stroke*, heat stroke is a form of hyperthermia, an abnormally elevated body temperature with accompanying physical and neurological symptoms. This occurs when the body's system of temperature regulation fails and body temperature rises to critical levels. Primary signs and symptoms of heat stroke: confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating (usually); hot, dry skin; and an abnormally high body temperature (106°F).

According to NIOSH (2016) factors contributed to heat related illness are:

- a. *Personal/Worker*, consist of Incomplete acclimatization, dehydration, excessive or inappropriate clothing, medical condition, and individual susceptibility (age, overweight, poor physical condition).
- b. *Activity/Task*, consist of frequency of heat exposure, duration of exposure, physically of work, and inadequate rest periods.
- c. *Environmental*, consist of high air temperature, low air movement, high relative humidity, and radiant heat from hot objects such as machinery.

Heat related illness management is a management based on occupational health and safety principles that are carry out for diseases and injuries related to heat exposure. It is consist of identification, evaluation and control of heat stress which that apply to reduce the effects of heat exposure related to diseases and injuries such as heat stroke, heat exhaustion, heat cramps due to heat, heat rashes, heat fatigue due to heat and dehydration among workers who work in hot-exposed environments. This management is based on a normal risk-based approach, which consists of hazards must be identified (Identification/Recognition); dangers must be measured (Evaluation); dangers must be reduced or isolated (Control). Preventive management of heat related illness are control management that apply to the work situation that defined as engineering control, administrative control and work practices, and personal. Apply them to fit the nature of the task depending on the specific situation.

a. *Engineering Control*

Feasible engineering controls needs to create and implemented, where it is practicable to do so, to reduce the heat load on an individual. This may include the following:

- a) Shade and shielding,
- b) Area cooling,
- c) Ventilation,
- d) Flagging system.

b. *Administrative controls and work practices*

- a) Acclimatization,
- b) Work scheduling,
- c) Work rest intervals,
- d) Self-evaluation,
- e) Employee rotation,
- f) Fluid replacement,
- g) Reduced internal heat generated by worker.

c. *Personal*

Personal protective equipment (PPE), and Training.

Heat index is an index that combines air temperature and relative humidity in an attempt to determine the human-perceived equivalent temperature. Heat index can be select to define general overall heat stress conditions for the workforce. The heat index also known as “effective temperature” is useful as a first indicator of the effect of humidity on how hot a particular exposure feels to an individual. It includes no evaluation of the effect of either convective or radiative heat exchange, and does not consider the rates of heat gained by physical

activity. The heat index combines relative humidity and air temperature. It is predictive of heat stress in circumstances in which the relationship established for a particular environment.

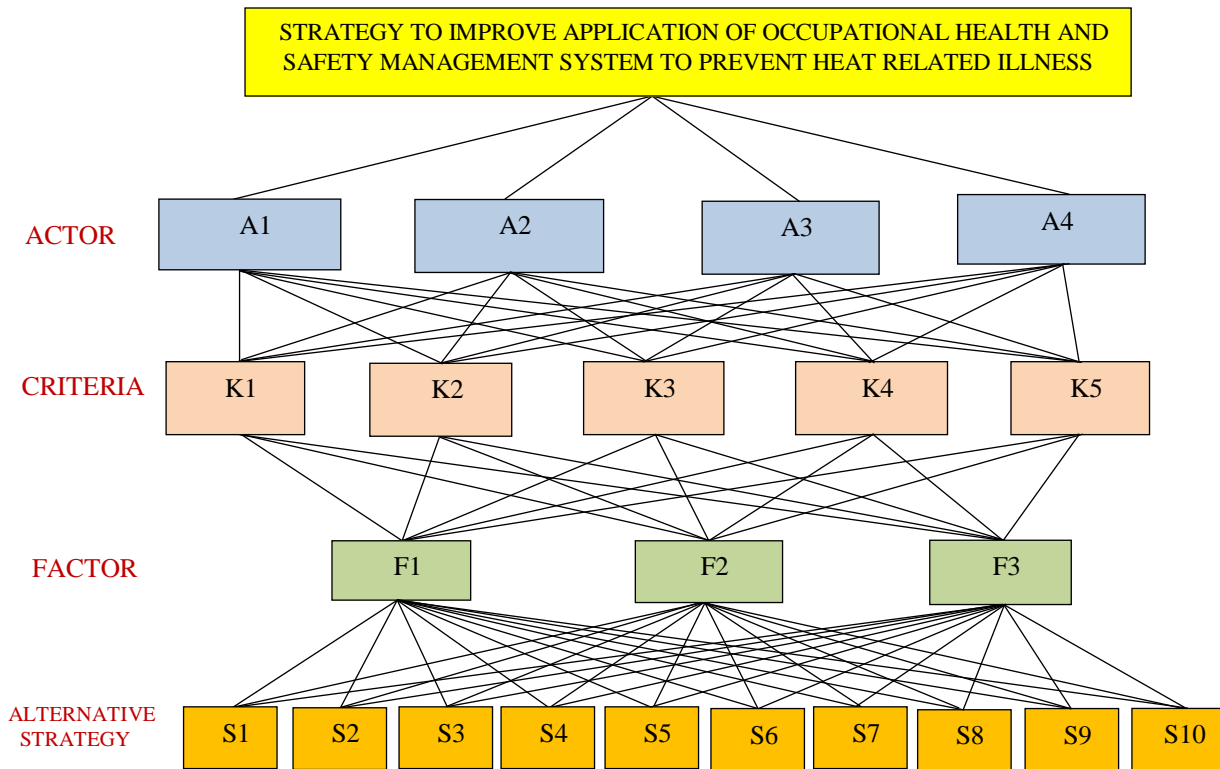
GENERAL HEAT STRESS INDEX										
DANGER CATEGORY		HEAT INDEX		HEAT SYNDROME						
IV. Extreme Danger		> 54		Heat Stroke or Sunstroke imminent						
III. Danger		39 - 53		Sunstroke, Heat Cramps or Heat Exhaustion likely. Heat Stroke possible with prolonged exposure and physical activity						
II. Extreme Caution		32 - 38		Sunstroke, Heat Cramps or Heat Exhaustion possible. Heat Stroke possible with prolonged exposure and physical activity						
I. Caution		27 - 31		Fatigue possible with prolonged exposure and physical activity						
* Note: Degree of Heat Stress may vary with age, health and body characteristics.										
RELATIVE HUMIDITY (Rh)										
		10%	20%	30%	40%	50%	60%	70%	80%	90%
AIR TEMPERATURE (°C)	50	44	52	54	>54	>54	>54	>54	>54	>54
	49	43	51	54	>54	>54	>54	>54	>54	>54
	48	43	50	53	54	>54	>54	>54	>54	>54
	47	42	48	52	54	>54	>54	>54	>54	>54
	46	41	47	50	54	>54	>54	>54	>54	>54
	45	41	46	50	54	>54	>54	>54	>54	>54
	44	40	45	49	54	>54	>54	>54	>54	>54
	43	39	44	48	54	>54	>54	>54	>54	>54
	42	38	43	46	54	>54	>54	>54	>54	>54
	41	38	41	45	52	54	>54	>54	>54	>54
	40	37	40	43	49	54	>54	>54	>54	>54
	39	36	38	42	47	52	54	>54	>54	>54
	38	35	37	41	43	49	54	>54	>54	>54
	37	34	36	38	41	43	54	54	>54	>54
	36	33	35	37	40	42	49	53	54	>54
	35	32	34	36	39	42	46	52	54	>54
	34	32	34	35	38	41	44	50	53	54
	33	31	32	33	36	38	41	46	50	53
	32	29	31	32	33	36	38	41	46	50
31	28	30	31	32	34	35	38	41	46	
30	27	29	29	31	32	33	36	38	43	
29	26	27	28	29	30	32	33	35	37	
28	25	26	27	27	29	30	32	33	35	
27	24	25	26	26	27	28	29	30	32	
26	22	24	25	26	26	27	27	28	29	

Picture 1. Heat stress index chart (NIOSH, 2016)

The heat index indicates thermal comfort. When the relative humidity is, elevated the evaporative process is restricted which reduces the cooling effect of perspiration. The heat index does not take into account the radiant heat load, which is primarily attribute by working in direct sunlight. It also does not take into account the nature of the work (heavy manual work or light work) nor the clothing worn by the worker. The heat index can be obtain by directly measuring the dry bulb temperature and relative humidity and reading the corresponding heat index from the heat stress table. When the heat index reaches levels to produce heat illness, additional work practices to reduce the heat stress should be done to reduce the effects of the radiant heat load, physical activity, and insulates effect of the clothing and personal protective equipment. Refer to the work practices in the "Control" section. Instrumentation to determine the heat index must be utilize to measure the air temperature in full shade conditions and measure or calculate the relative humidity. The heat index will be determined using properly calibrated instruments and in accordance with manufacturer's recommendations.

III. Method

The type of research are conceptual research, to create a concept, strategy, or program to improve application of occupational health and safety management system to prevent heat related illness in XYZ industrial area. Concept and strategies created based on experts justification (expert base). Research was conducted in XYZ industrial area on the month of June 2019 until August 2019. The data consists of primary and secondary data. Primary data obtained through observation, questionnaire and interview, while secondary data obtained through literature study. Data collected from experts by interview and questionnaire involved five expert who had experience and expert in heat related illness prevention program (Head of Occupational Health, Head of HSSE, Industrial Hygienist Specialist, Health & Hygiene Inspector and Material Field Supervisor). Data analysis using AHP (Analytical Hierarchy Process) method developed by Saaty (2012) to determine the prioritize strategy based on Expert's response to question in questionnaires with data analysis using Expert Choice 11. According to combination of expert discussion and literature review, generally AHP structure as follow:



Picture 2. AHP Structure of strategy to improve application of occupational health and safety management system to prevent heat related illness in XYZ Industrial Area

Legends:

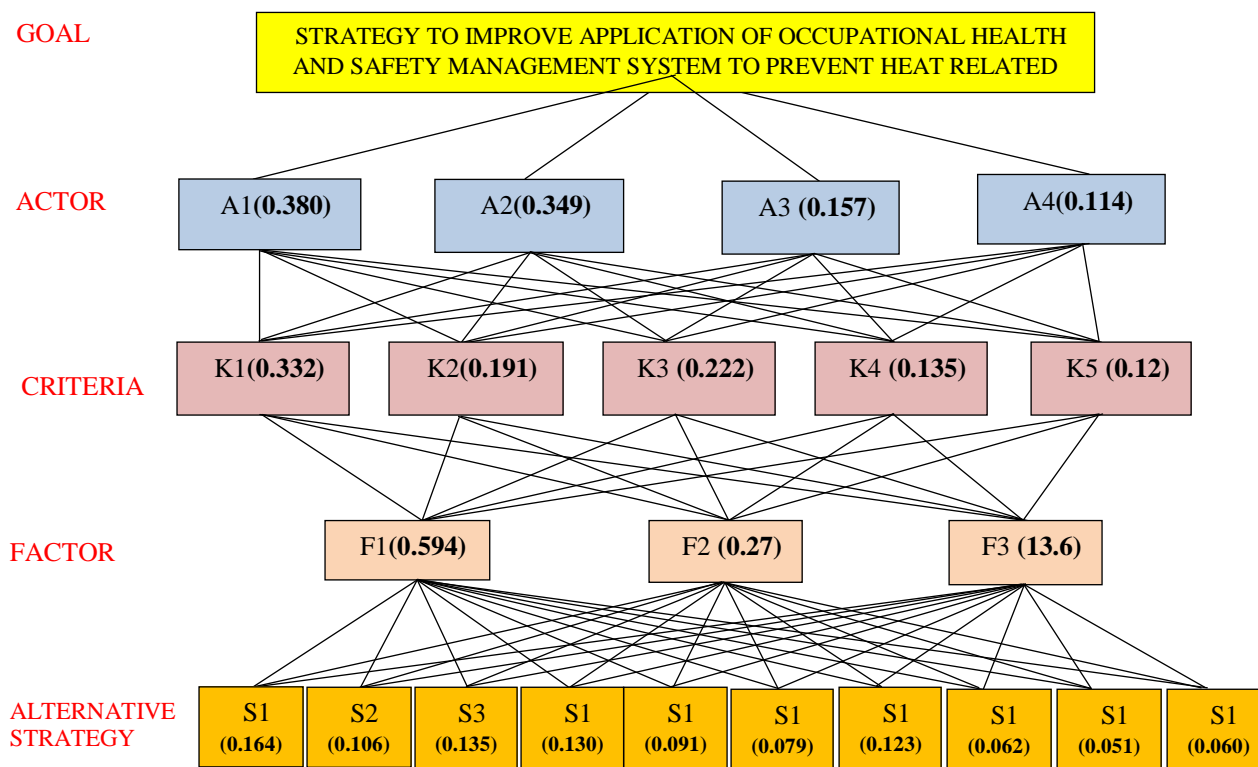
- A1: Industrial City Manager
- A2: HSE Manager
- A3: Safety Officer
- A4: Field Supervisor
- K1: Commitment and policies
- K2: Planning
- K3: Implementation
- K4: Measurement and evaluation
- K5: Management's review and improvement
- F1: Factor personal/worker
- F2: Factor task/activities
- F3: Factor environmental
- S1: Acclimatization
- S2: Training and Campaign
- S3: Work, rest, and rotation
- S4: Air Coolant System
- S5: Shade and Shielding
- S6: Fit and Proper PPE
- S7: Rehydration
- S8: Buddy system
- S9: Flagging system
- S10: Emergency Plan Program

IV. Result and Discussion

Based on the observation from data collected from occupational health department of XYZ industry area, heat related illness always occurred every year. It is happen due to some reason such as in compliances of company to restriction working hour policies shown by more than 40% of heat related illness cases occurred every year was happen during restricted working hours, 2 casualties found working as supervisory level, and 2 casualties were in sport activity and driving his car without air condition.

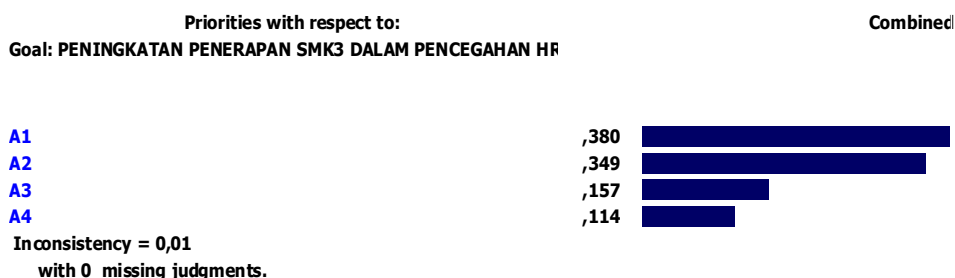
AHP method chosen to select strategic priorities to improve application of occupational health and safety management system to prevent heat related illness. AHP method can accommodate the complexity of the existing problems and combine the differences of opinion from experts. Based on the results of expert discussions and analyzed using Expert Choice 11 software will show the highest value given for actor, criteria, factor and alternative strategy is mean highest influence and weight. The highest value for alternative strategy is mean considered the most the priority of strategy with respect to actor, criteria, and factor.

Result of data analysis according to AHP hierarchy from *Expert Choice 11* shown below:



Picture 3. Result of data analysis according to AHP hierarchy from *Expert Choice 11*

The result AHP analysis for prioritize actor for the successful of application of occupational health and safety management system to prevent heat related illness in XYZ industrial area are shown below:



Picture 4. Result of priority actor based on AHP analysis

Legends:

- A1: Industrial City Manager
- A2: HSE Manager
- A3: Safety Officer
- A4: Field Supervisor

As per picture above, shown industrial city manager is the most influential and weighs actors with a value of 0.380, followed by HSE manager (0.349), safety officer (0.157), and field supervisor (0.114); also shown in the picture above the consistency value ratio (CR) is 0.01 (0.1%) less than 0.1(10%) and is mean the data is considered consistent and logic. In other word, the industrial city manager is the most influential actor in implementing a strategy to improve occupational health and safety management system to prevent heat related illness in XYZ industrial city area.

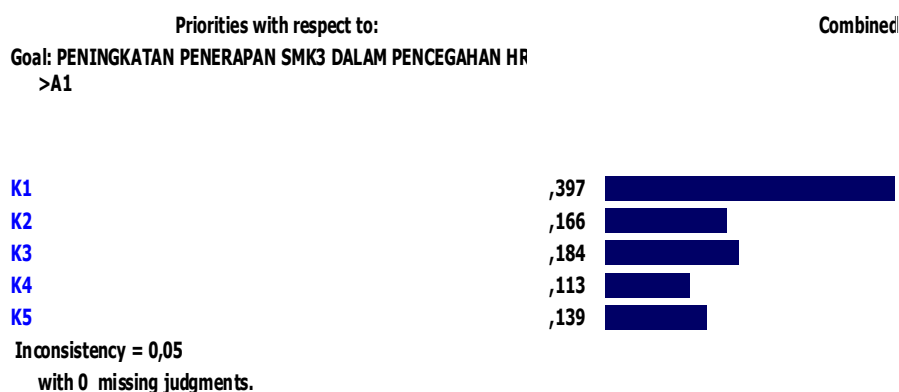
The criteria of occupational health and safety management system as per expert justification and opinion according to AHP analysis in respect to actor are can be seen on below table and picture:

Table2. Result of criteria priority based on AHP analysis

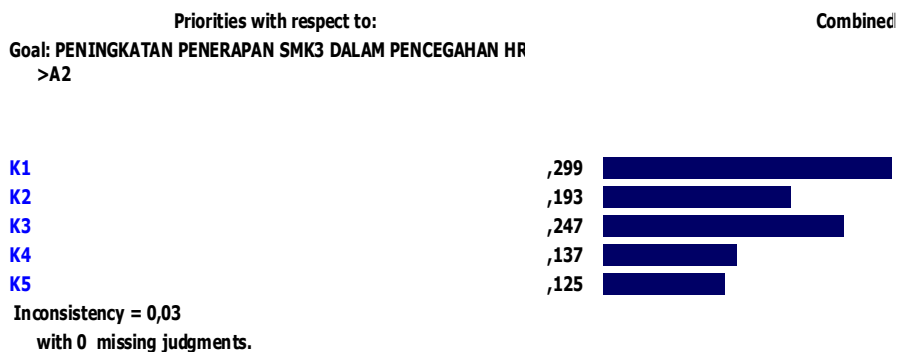
	A1	A2	A3	A4	Value
K1	0.397	0.299	0.27	0.298	0.331573
K2	0.166	0.193	0.223	0.223	0.19087
K3	0.184	0.247	0.265	0.215	0.222238
K4	0.113	0.137	0.154	0.175	0.134881
K5	0.139	0.125	0.087	0.089	0.12025

Legends:

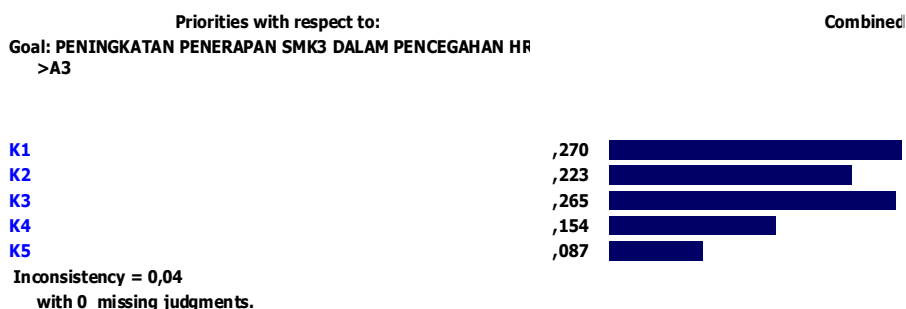
- K1: Commitment and policies
- K2: Planning
- K3: Implementation
- K4: Measurements and evaluation
- K5: Management's review and improvement



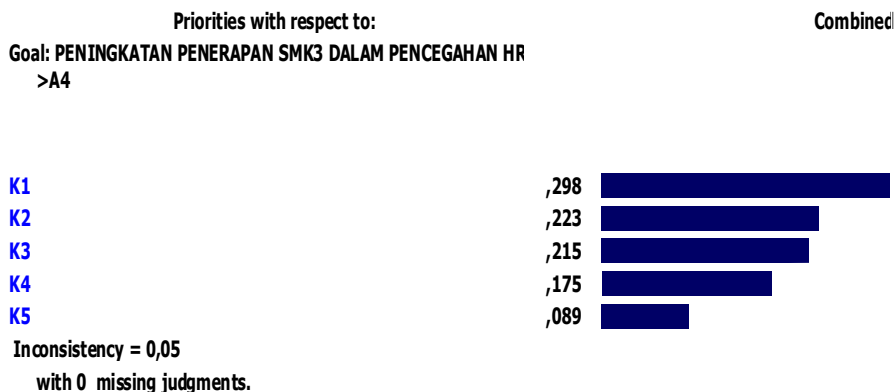
Picture 5. Result of priority criteria based on AHP analysis with respect to actor industrial city manager



Picture 6. Result of priority criteria based on AHP analysis with respect to actor HSE manager



Picture 7. Result of priority criteria based on AHP analysis with respect to actor safety officer



Picture 8. Result of priority criteria based on AHP analysis with respect to actor field supervisor

As per table 2 and combine of picture 5 to picture 8 above, shown commitment and policies is the first priority criteria with value of 0.332, followed by implementation (0.222), planning (0.191), measurement and evaluation (0.135), and management’s review and improvement (0.120); also shown in the picture 5 to picture 8, consistency value ratio (CR) less than 0.1, means data considered logic and consistent.

The factors that influenced to heat related illness as per expert justification and opinion according to AHP analysis in respect to combined of actor and criteria can be seen on below table and picture: The criteria of occupational health and safety management system as per expert justification and opinion according to AHP analysis in respect to actor are can be seen on below table and picture:

Table 3.Result of criteria priority based on AHP analysis

	A1	A2	A3	A4	Bobot Nilai
F1	0.594293	0.594293	0.594293	0.594293	0.594293
F2	0.269	0.269	0.269	0.269	0.269
F3	0.136274	0.136274	0.136274	0.136274	0.136274

Legends:

F1: Factor Personal/worker

F2: Factor task/activity

F3: Factor environmental

As per table 3 shown factor personal/worker is the first factor that important in order to improve the application of occupational health and safety management system to prevent heat related illness in XYZ industrial area with value of 0.594, followed by factor task/activity (0.27), and factor environmental (0.136).

The alternative strategy to improve the application of occupational health and safety management system to prevent heat related illness in XYZ industrial area as per expert's opinion and AHP analysis in respect to combined of actor, criteria, and factor can be seen on below table and picture:

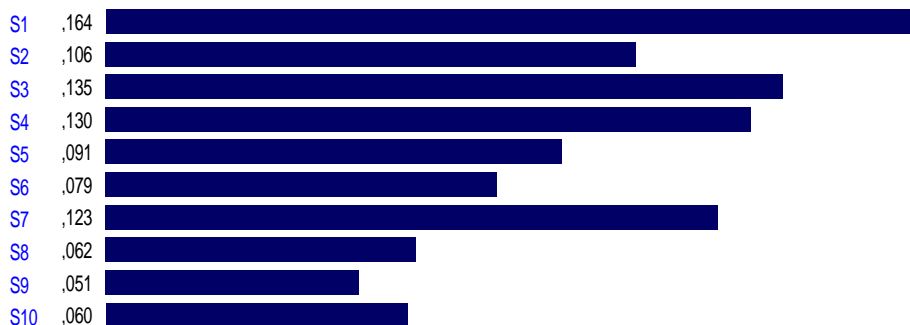
Table 4.Result of alternative strategy priority based on AHP analysis

Alternative Strategy	Bobot Nilai
S1	0.164
S2	0.106
S3	0.135
S4	0.130
S5	0.091
S6	0.079
S7	0.123
S8	0.051
S9	0.060

Synthesis: Summary

Combined instance -- Synthesis with respect to: Goal: PENINGKATAN PENERAPAN SMK3 DALAM PENCEGAHAN HR

Overall Inconsistency = .03



Picture 9. Result of alternative strategy based on AHP analysis with respect to combined of actor, criteria and factor

Legends:

- S1: Acclimatization
- S2: Training and Campaign
- S3: Work, rest, and rotation
- S4: Air Coolant System
- S5: Shade and Shielding
- S6: Fit and Proper PPE
- S7: Rehydration
- S8: Buddy system
- S9: Flagging system
- S10: Emergency Plan Program

As per table 4 and picture 9 above, shown strategy acclimatization is the first priority of alternative strategy with value of 0.164, followed by work, rest and rotation (0.135), air coolant (0.130), rehydration (0.123), training and campaign (0.106), shade and shielding (0.091), fit and proper PPE (0.079), buddy system (0.062), emergency plan program (0.060), and the last strategy is flagging system (0.051); also shown in picture above the consistency value ratio (CR) is 0.03 less than 0.1 (10%). This means the justification and opinion of experts are logical and consistent.

V. Conclusion

Comprehensive heat related illness prevention strategies are important and need to implement in XYZ industrial area to avoid and reduce the number of heat related illness cases. Based on AHP analysis, industrial city manager as a first priority actor with a value 0.380 (38%), especially in the establishment of rules and policies, and sanctions for companies or workers who violated the policies. Commitments and policies are the criteria in occupational health management system as the first priority criteria with a value 0.332 (33.2%), to improve the implementation of prevention of heat related illness. Personal/worker factors as the most important factor that must be consider with a value 0.594 (59.4%).

Acclimatization strategy is a first priority strategy with a value 0.164 (16.4%), that must be apply in gradually and correctly, followed by work, rest, and rotation with a value 0.135 (13.5%), air coolant system with a value 0.130 (13%), rehydration with a value 0.123 (12.3%), training and campaign with a value 0.106

(10.6%), shade and shielding with a value 0.091 (9.1%), fit and proper PPE with a value 0.079 (7.9%), buddy system with a value 0.062 (6.2%), emergency plan program with a value 0.060 (6%), and the last strategy is flagging system with a value 0.051 (5%).

VI. Suggestion

Based on the results of research, the recommendations of this study are:

- a. XYZ industrial area needs to conduct a study and review of the priority of heat related illness prevention strategies using the Occupational Health and Safety Management System (SMK3) and carry out the overall strategy suggested in this study in a comprehensive, comprehensive, measurable, and well-coordinated manner with all communities and stakeholders in the XYZ industrial area.
- b. The results of the analysis of the problem show that there is non-compliance from the company regarding the prohibition of working outside the room during the summer and that there are two supervisor levels who are victims of heat related illness. The firmness of the authorities of XYZ industrial areas is required to apply punishment for violations that committed by companies who did not comply with the policies. Training for level supervisory also needed related to the heat related illness prevention strategies because they are actors who play an important role and spearhead in preventing and reducing the occurrence heat related illness cases in the field.
- c. It is necessary to conduct research relating to factors relating to the attitudes, knowledge, and compliance of workers and companies to the strategy of preventing heat related illness in the XYZ industrial area.

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