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A novel tool for preliminary risk assessment of Climate Change on workers' health and safety in outdoor worksites

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Nowadays, there has been considerable research regarding the public health and environmental aspects of Climate Change, but the literature on the potential impacts of Climate Change on the health and safety of outdoor workers has received limited attention. Outdoor workers which include, by a way of example, agricultural, construction, and transportation workers, and other workers exposed to outdoor weather conditions, are exposed at increased risk of heat stress and other heat-related ailments, extreme weather, and occupational injuries due to Climate Change-related issues. Climate Change is increasing environmental temperatures and extreme weather events, affecting air pollution and the distribution of pesticides and pathogens. The implementation of enhanced occupational health and safety measures that can cope with the effects of Climate Change on workers is a key step towards the adaptation perspective that must be embraced to ensure a safer and more sustainable future for the workers. In this paper, a new tool named Climate Change - House of Safety (CC-HoS) is designed to address new risks and to carry out in an effective way the risk assessment considering specifically the risks related to Climate Change. The CC-HoS, derived from the House of Safety (HoS), aims to investigate the direct (i.e., warming, extreme weather, ...) and indirect impacts (i.e., air pollution, UV exposure, vector-born disease, ...) of Climate Change on workers' health and safety in outdoor worksites. This tool can correctly identify and assess risks through the Risk Priority Number (RPN) in terms of Severity, Detectability, and Occurrence criteria, while determining the most suitable safety devices and preventive/protective measures to manage the previously identified risks. The proposed approach is applied to a company operating in the agricultural sector. The effectiveness and usefulness of the tool for selecting the most effective technical solutions to mitigate risks related to Climate Change are presented in the case study.

Keywords: Climate Change, risk assessment, health and safety, outdoor workers, house of safety.

1. Introduction

Human activities, particularly the release of greenhouse gases, are the primary cause of global warming. This has resulted in a global surface temperature increase of 1.1°C above the 1850–1900 baseline between 2011 and 2020, leading to more frequent and severe heatwaves (IPPC, 2023). Rising temperatures and heatwaves have already caused and will continue to cause various negative effects on human health and safety, ranging from minor discomfort to death. Numerous epidemiological studies across the globe, such as Song et al. (2017), have documented the consequences of heatwaves on human health and safety. It is predicted that this trend of rising temperatures will persist, further endangering populations.

Several recent studies have highlighted the potential health and safety hazards that workers face as a result of extreme heat (Yang et al., 2017). Unlike the general population, workers are often required to work in exposed conditions for extended periods. This can lead to heat stress, particularly among outdoor workers in industries such as agriculture, construction, or transportation. Outdoor workers are particularly vulnerable to the effects of Climate Change, including extreme temperatures, poor air quality, and disease-carrying pests. Emergency response workers, such as firefighters, paramedics, and police officers, may also face increased risks due to climate-related hazards such as wildfire smoke or flooding. The health impacts of heat stress can range from diminished work capacity and productivity to heat-related illnesses, and even death. Diminished performance and work capacity may further lead to an increased risk of occupational injuries in the workplace (Cheung et al., 2016).

Climate Change's impact on public health and the environment has been extensively researched, but limited attention has been given to how it affects outdoor workers' health and safety (Moda et al., 2019). With several variables that worsen the effects of Climate Change on workers' health, identifying its impact on occupational health and safety is crucial to protect workers (Schulte and Chun, 2009). In particular, the implementation of enhanced occupational health and safety measures that can cope with the effects of Climate Change on workers is a key step towards the adaptation perspective that must be embraced to ensure a safer and more sustainable future for the workers.

In this paper, a new tool named Climate Change - House of Safety (CC-HoS) is designed to address new risks and to carry out in an effective way the risk assessment considering specifically the risks related to Climate Change. The CC-HoS, derived from the House of Safety (HoS) (Braglia et al., 2018), aims to investigate the direct (i.e., warming, extreme weather, ...) and indirect impacts (i.e., air pollution, UV exposure, vector-born disease, ...) of Climate Change on workers' health and safety in outdoor worksites. This tool can correctly identify and assess risks through the Risk Priority Number (RPN) in terms of Severity, Detectability, and Occurrence criteria, while determining the most suitable safety devices and preventive/protective measures to manage the previously identified risks.

The proposed tool is used to assess a company operating in the agriculture sector, one of the industrial sectors most affected by fatal accidents. According to the 2019 Census of Fatal Occupational Injuries (U.S. Bureau of Labor Statistics, 2019), workers in the agriculture, forestry, and fishing (AFF) sector have a fatal work injury rate of 23.1 per 100,000 full-time equivalent workers and are seven times more likely to die on the job than non-AFF workers.

The remaining sections of this paper are organised as follows. Section 2 fully describes the CC-HoS. The effectiveness and usefulness of the tool for selecting the most effective technical solutions to mitigate risks related to Climate Change are presented in the case study reported in Section 3. Finally, Section 4 provides conclusions and future outlooks.

2. Climate Change - House of Safety (CC - HoS)

The CC-HoS consists of two houses, each of which consists of several rooms (Figure 1). The preliminary step of the CC-HoS requires the assembly of the cross-functional analysis team. Criteria such as experience in the health and safety field, problem solving skills and ability to work in a team should be considered for team selection.

Furthermore, as the tool addresses Climate Change risks, the team should include environmental managers and other environmental protection experts. The tool does not stop at identifying risks, but also provides related safety solutions, so machine designers and technical engineers should be involved. Finally, the team should also involve operations and maintenance personnel, such as workers, installers, maintenance personnel and managers, because they have a deep understanding of the activities that are carried out under regular and extraordinary conditions.

2.1. *Step 1 of CC-HoS*

Room 1 contains the behaviours that workers may adopt during the execution of their activities in both normal and extraordinary conditions. To assess how human behaviour influences the severity of risks associated with Climate Change, a similar approach is taken to that adopted by the HoS (Braglia et al., 2018).

The work process is divided into tasks. For each of these, it is possible to identify the worker's behaviours. The behaviours are divided into normal and abnormal actions. The abnormal actions are then grouped into categories. A possible classification is provided by Sutton (2015), where abnormal actions are categorised into slips, mistakes, fixations, error in emergency, violations and rule-breaking. For each task, the analysis team identifies worker behaviour and classifies it according to the specific application.

Room 1.1 quantifies behaviours in terms of the total risk potential of the accident, it is necessary to assess the weights of the severity aspects. For this purpose, the AHP is employed. Its main characteristic is its ability to minimise inconsistent expert judgements. The hierarchy tree of the AHP consists of a combination of work process tasks (criteria) and behaviours (sub-criteria). The pairwise comparison process involves two steps: the first step compares the work process tasks, while the second step compares the behaviours. The comparison is done using a rating scale from 1 to 9, where a number closer to 1 indicates little importance, while a number closer to 9 indicates high importance.

A behaviour is considered important in relation to severity when its effects can cause a very severe accident. Conversely, its importance is low when its effects are negligible in terms of severity. The numerical values assigned by several technicians are evaluated under the supervision of the team leader, who ensures that the appropriate values are entered into the matrix.

Room 2 contains the risks associated with Climate Change that the worker may encounter in working areas. Several studies can be found in the literature on how Climate Change impacts the health and safety of workers (Barry and Roelofs, 2019; Schulte et al., 2016). The CC-HoS addresses risks due to Climate Change, which are classified into five main categories.

1. *Increased Ambient Temperature*

For many workers, especially those working outdoors, exposure to heat and humidity can be a major hazard, as Climate Change leads to an increase in both heat event exposure and magnitude Specifically, heat stress can result in heat-related illnesses such as heat stroke, heat exhaustion, heat syncope, heat cramps, heat rash, or death. Furthermore, heat exposure can increase the risk of occupational injuries, such as those caused by sweaty palms, fogged safety glasses, dizziness with major probabilities of mind behaviours and lower carefulness toward procedures and risks (Jacklitsch et al., 2016). On the other hand, exposure to heat can increase discomfort and cause workers to not use Personal Protective Equipment (PPE) or not use it properly.

Many studies point out that a change in internal body temperature can alter interaction with toxic substances such as pesticides. This may be particularly relevant because increased respiration may also lead to further exposure to toxicants.

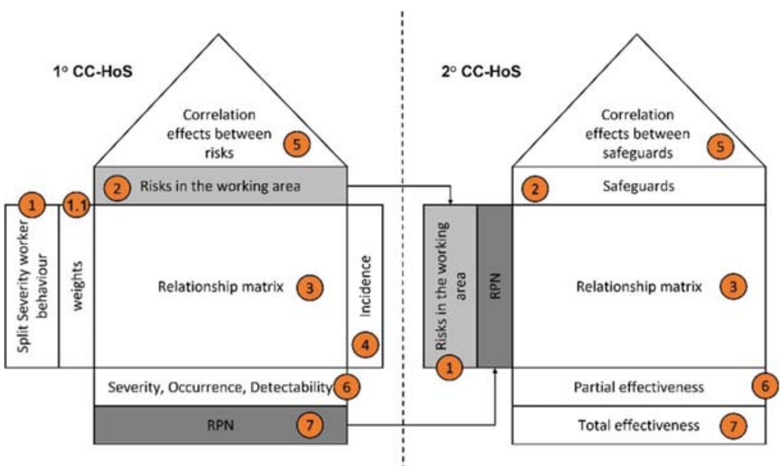

Fig. 1. Two CC-HoS, where the room numbers are reported within the circles.

2. *Air Pollution*
The relationship between Climate Change and air pollution is complex: various air pollutants increase global warming and global warming leads to the formation of various pollutants (Tibbetts, 2015). In addition, fires and droughts will worsen air pollution. The main culprits are higher ozone concentrations and pollen and PM2.5 production.

3. *UV radiation exposure*
UV radiation, which can have harmful effects on human health, is increased by the complex interplay between greenhouse gases, Climate Change, and stratospheric ozone depletion. This increased radiation can particularly impact outdoor workers, as they are more likely to be exposed to it (Williamson et al., 2014).

4. *Extreme weather*
The frequency and severity of extreme weather events such as storms, floods, landslides, droughts, and wildfires have been linked to Climate Change, which poses significant hazards to outdoor workers. In recent decades, extreme weather events such as hurricanes and wildfires have become more frequent and severe, exacerbating the risks faced by workers in outdoor occupations (IPCC, 2023).

5. *Biological hazards*
The expansion of disease vectors such as ticks, fleas, and mosquitoes due to Climate Change has resulted in increased disease risks for outdoor workers (Moore et al., 2017). As a result, there is likely to be greater use of pesticides, which could lead to increased exposure for workers.

Room 3 houses quantitative evaluations of how the i-th risk is relevant to the j-th worker's behaviour. The connection between Rooms 1 and 2 is represented by a numerical value between 1 and 9, where 1 indicates that the worker's behaviour has a low impact on the risk, and 9 indicates a high impact. The average impact of a worker's behaviour on the risk is calculated as a value of 3. The team leader usually assigns numerical values based on the collective evaluations of the team's experts involved in the risk assessment. The behaviour incidence, reported in Room 4, is the overall impact of a specific behaviour (Braglia et al., 2018).

Room 5 contains the correlation between risks. In particular, this matrix allows the team to consider the domino effect. In fact, it is possible that a risks in a specific working area affects another risks in a different working area. The correlation, ranging from -1 to 1, reported in the "roof" of the house can be both positive and negative. For example, a long period of drought (extreme climatic conditions) may increase dust respiration (air pollution), or the increase in vectors of diseases such as mosquitoes (biological hazard) may increase the use of pesticides and therefore toxicological exposure to these chemicals (increase in ambient temperature). In Room 6 Detectability and Occurrence are considered as two other criteria for the risk assessment. Detectability is interpreted as the worker's awareness of the hazards present in the area where he/she is carrying out his/her activities. The Occurrence is the likelihood that a hazard produces the expected effect on the worker. The risk is obviously higher if the Detectability and Occurrence of the harm due to the hazard are lower and higher, respectively. Finally, the severity is the overall value of the global weighted values for each risk and for each criteria. In Room 7, the RPN values are calculated without and considering the correlations obtained in Room 5 (Figure 1). The RPN allows to give a ranking of the most serious risks and uses them as input for the next step of the CC-HoS. The RPN value is calculated by multiplying the three criteria, Severity, Detectability, and Occurrence. The final ranking of the risks in relation to RPN changes if the risk correlation is considered or not.

The evaluation criteria for the Severity, Detectability, and Occurrence, as well as the calculation of RPN, both without and with consideration of correlations, are the same as those reported in Braglia et al. (2018).

2.2. *Step 2 of CC-HoS*

The first step of CC-HoS produces a quantitative risk assessment that includes the impact of human behaviour on risks associated with Climate Change that workers may encounter in their working areas. To evaluate the effectiveness of safeguards with respect to the risks in the working areas, a second step is necessary.

Room 1 contains the prioritized risks located in working areas that were reported in Room 2 of the first step and are represented directly by their correlated RPN weight. Room 2 contains the most suitable safeguards divided into protective devices and personal protective equipment and worker support systems. Room 3 is the relationship Matrix, which shows the effectiveness of the j-th safeguard on the i-th risk. Strong, medium, and weak relations between Room 1 and Room 2 are determined as in the first step. For each risk, at least one safeguard must be included in the assessment as an effective tool for reducing risk criticality. Room 5 is the correlation matrix, which allows considering interactions, i.e. if safeguards may interfere with others in cascade. The decision to fill Room 3 in two consecutive steps, but to work with a full Room 2, is aimed at assessing the correlations among all safeguards at the same time. Room 6 calculates the partial effectiveness of safeguards in relation to the risks, while Room 7 calculates the overall values of effectiveness, considering the correlations among safeguards. The calculation formulas and the selection process of safeguards are fully described in Braglia et al. (2018).

3. Case study

This section presents the implementation of the CC-HoS to an Italian company dedicated to the cultivation and harvesting of wheat. Recognising the health and safety of workers as a prerogative, the company decided to carry out a risk assessment specifically geared to the risks of Climate Change. Thanks to our long-term collaboration, the owner of the company entrusts CC-HoS to carry out the activity, believing that he is able to determine the most suitable devices and measures to manage the risks detected. Wheat production and harvesting follow these milestones:

- *Phase 1: Land Preparation*. The soil must be cleared of unwanted debris, rocks, weeds or plants before planting. The soil is then worked to create a flat seedbed without large clods of soil. These activities are carried out by tractors.
- *Phase 2: Sowing*. The seeds are machine planted on the prepared soil (typically between October and November).
- *Phase 3: Fertilization*. Wheat requires several essential nutrients to grow, including nitrogen, phosphorus, and potassium. These nutrients are scattered on the fields by tractor just after planting and additionally during spring.
- *Phase 4: Irrigation*. To ensure the cultivation of wheat, the crop is irrigated depending on climatic conditions and soil. This step is performed automatically by a timer irrigation system.
- *Phase 5: Weed control*. Weeds can compete with wheat for nutrients, sunlight and water. To ensure optimal grain growth, herbicides are adopted to control weed growth.
- *Phase 6: Pest and disease control*. Wheat may be susceptible to pests and diseases, which may impact crop yields. To prevent and control damage from parasites and diseases, various insecticides and fungicides are applied.
- *Phase 7: Harvesting*. When the wheat is ripe, it is harvested using a combine harvester. It is then transported to storage facilities for further processing (typically between June and July).

The first CC-HoS is summarised in Fig. 2, where all filled rooms are reported, and is briefly described below. Behaviour categories that are critical for the health and safety have been identified. The category identification was made through worker observation during working activities. The weights have been obtained using the AHP where the analysis team assigned the judgments. Risks related to Climate Change have been classified into five main categories. In the case of normal behaviour, the risks are characterized by low severity, while the worker's misbehaviour causes a significant increase of the risk impact.

For outdoor workers, especially those working in cultivating and harvesting wheat, exposure to heat and humidity can be a major risk. Also, storms and wildfires may result in significant hazards to workers. Both of them can lead to the formation of various pollutants, and the increase of disease vectors such as ticks, fleas, and mosquitoes. Consequently, considering the correlations among risks, risks due to increased ambient temperature and extreme weather are positively correlated to the risks due to air pollution and biological hazards, but not vice versa. There are no negative correlations. Regarding Occurrence and Detectability, to consider the difference between correct behaviour and misbehaving (cause), two possible behaviour categories are considered: normal and hazardous actions. In addition, a relative weight regarding Occurrence and Detectability is assigned to the two cases. Generally, normal behaviour presents lower values of Occurrence and Detectability. Where values between normal and abnormal behaviour/hazardous action are equal means that the behaviour has no influence on the level of awareness or probability. The most critical risk is exposure to increased ambient temperature. Inadequate hydration and incorrect setting of air conditioning in scorching seasons have the highest incidence and imply the most critical effect on the worker. Considering only the normal behaviour the RPN is practically negligible.

The second CC-HoS is reported in Fig. 3, where the rows show the risks related to Climate Change, while the columns show the safeguards divided into protective equipment and personal protective devices and operator support systems. The correlation between safeguards is analysed in the "roof" (correlation matrix) of the house. In particular, the instructions for use positively affect all other safety measures. As for the negative correlation, operators are not able to wear respirators and other face protection devices such as goggles and visors at the same time. Also, light clothing is not compatible with heavy body covering and aprons. The effectiveness of the safeguard is assessed by analysing its impact on the detected risk. Thanks to the correlation matrix, it is possible to quantify the total effectiveness of safeguards and thus assess their adequacy on specific risks. By following the process of selecting proposed in the HoS (Braglia et al., 2018), the analysis team identifies the protective devices characterized by the greatest effectiveness and having at least one “Strong” relationship. So, in the first place the system for monitoring working conditions is located. This system automatically alerts workers on Climate Change events such as extreme heat and heavy rain, and other safety issues such as air quality or the presence of fires Next, since there are no protective devices with “Strong” relationship, the selection goes on the choice of PPE and worker support systems. In this direction, hydration is the second most effective safeguard specifically aimed at mitigating increased ambient temperature. Workers should regularly take breaks and hydrate away from exposure to the sun. Thirdly, providing medical surveillance is a crucial aspect for outdoor workers. It enables the company to optimize workers' health by controlling working conditions and reducing exposure to air pollution and biological hazards. Among the PPEs, respirators are the fourth most effective way to protect workers in many conditions such as chemical and smoke exposure. Finally, the fifth safeguard selected is the application of sunscreen. It is well recognized as an effective way to block the absorption of UV rays by the skin and thus prevent skin cancer.

4. Conclusions and future outlooks

This paper introduces the Climate Change - House of Safety, which is an extension of the House of Safety designed to effectively assess risks related to Climate Change and support the identification of a suitable set of risk mitigation measures. To this purpose, the CC-HoS approach employs the RPN to evaluate risks based on Severity, Detectability, and Occurrence criteria. The CC-HoS offers several benefits, such as being a structured and integrated approach that enables the handling of multiple risks simultaneously and being adaptable by experts from various fields involved in risk assessment. Additionally, it considers the inter-relationships between risks and safeguards, integrates risk assessment with the selection of protective measures, and is easy to implement using interconnected electronic worksheets. The proposed approach has been applied to a company operating in the agricultural sector. The effectiveness and usefulness of the tool for selecting the most effective technical solutions to mitigate risks related to Climate Change are presented in the case study. The tool identified and classified the most suitable safeguards. Specifically, systems for monitoring working conditions, hydration, providing medical surveillance, respirators, and sunscreen’s application resulted in the most effective protective equipment to be adopted.

Future work could include risk assessment, in particular considering climate change risks while performing tasks that require the interaction of multiple operators. Finally, the tool can be integrated with risks not associated with Climate Change to study their interaction.

1.0					1
0.3	1.0		0.3		2
		1.0			3
			1.0		4
0.3			0.2	1.0	5

		Behaviours	Weights	Normalized weight	1 Increased Ambient Temperature	2 Air Pollution	3 UV radiation exposure	4 Extreme weather	5 Biological hazards	Behaviours Incidence
Severity (operator behaviours)	Phase 1: Land Preparation	Normal	4.48E-03	8.68E-04	1	1	3	3		6.95E-03
		Slips: Incorrect setting in air conditioning	3.78E-02	7.32E-03	3			3		4.39E-02
		Slips: Inadequate hydration	1.79E-01	3.47E-02	9			9		6.25E-01
		Mistake: Tractor speed out of specification	2.30E-01	4.46E-02	3			3		2.67E-01
		Mistake: Assembly error	5.93E-01	1.15E-01	3			3		6.90E-01
		Rule breaking: Non-use of seat belt	1.62E-01	3.15E-02				1		3.15E-02
		Rule breaking: The operator is non wearing PPE	3.52E-01	6.82E-02	1	3	3	3		6.82E-01
	Phase 2: Seed planting	Normal	2.98E-03	5.78E-04		1	3	3		4.04E-03
		Slips: Environmental condition underestimated	2.67E-02	5.17E-03	3			9		6.21E-02
		Mistake: Tractor speed out of specification	1.48E-01	2.87E-02	1					2.87E-02
		Mistake: assembly error	3.70E-01	7.17E-02	3					2.15E-01
		Rule breaking: Non-use of seat belt	1.13E-01	2.19E-02				3		6.57E-02
		Rule breaking: The operator is non wearing PPE	2.29E-01	4.43E-02		3	3	1		3.10E-01
	Phase 3: Fertilization	Normal	1.32E-03	2.56E-04		1		3		1.02E-03
		Slips: Environmental condition underestimated	3.81E-02	7.37E-03	3			9		8.85E-02
		Mistake: assembly error	5.44E-01	1.05E-01	3					3.16E-01
		Rule breaking: Non-use of seat belt	1.66E-01	3.21E-02				3		9.63E-02
		Rule breaking: the operator is non wearing PPE	3.61E-01	7.00E-02		3		1		2.80E-01
	Phase 4: Irrigation	Normal	6.79E-05	1.31E-05	1	1	3			6.57E-05
		Slips: Maintenance operations underestimated	1.24E-03	2.40E-04	3			1		9.59E-04
		Slips: Inadequate hydration	1.89E-03	3.66E-04	3			3		2.19E-03
		Mistake: assembly error	7.81E-03	1.51E-03	1					1.51E-03
		Rule breaking: Non-use of seat belt	2.30E-03	4.46E-04				1		4.46E-04
		Rule breaking: the operator is non wearing PPE	4.61E-03	8.94E-04		3	3	3		8.04E-03
	Phase 5: Weed control	Normal	2.36E-03	4.56E-04		3			3	2.74E-03
		Slips: Environmental condition underestimated	2.10E-02	4.06E-03				9		3.65E-02
		Mistake: assembly error	3.00E-01	5.80E-02	1					5.80E-02
		Rule breaking: Non-use of seat belt	9.12E-02	1.77E-02				3		5.30E-02
		Rule breaking: The operator is non wearing PPE	1.99E-01	3.85E-02		9			9	6.94E-01
	Phase 6: Pest and disease control	Normal	2.57E-03	4.98E-04		3			3	2.99E-03
		Mistake: assembly error	2.95E-01	5.72E-02	1					5.72E-02
		Rule breaking: Non-use of seat belt	7.21E-02	1.40E-02				3		4.19E-02
		Rule breaking: The operator is non wearing PPE	1.21E-01	2.34E-02		9			9	4.21E-01
	Phase 7: Harvesting	Normal	1.88E-03	3.64E-04	3	1	3	1	3	4.00E-03
		Slips: Incorrect setting in air conditioning	7.32E-02	1.42E-02	9					1.28E-01
		Slips: Maintenance operations underestimated	3.28E-02	6.36E-03	3					1.91E-02
		Slips: Inadequate hydration	6.26E-02	1.21E-02	9			3		1.46E-01
		Mistake: assembly error	2.11E-01	4.08E-02	3					1.22E-01
		Rule breaking: Non-use of seat belt	6.05E-02	1.17E-02				1		1.17E-02
		Rule breaking: The operator is non wearing PPE	4.01E-02	7.77E-03	1	3	9		3	1.24E-01
Detectability		Normal		0.4	4	5	3	5	5	
		Hazardous Action		0.6	8	5	7	9	6	
Occurrence		Normal		0.3	6	5	4	7	4	
		Hazardous Action		0.7	9	6	8	9	6	
Severity					1.985	1.135	0.415	1.627	0.584	
Detectability					6.4	5	5.4	7.4	5.6	
Occurrence					8.1	5.7	6.8	8.4	5.4	
RPN* not correlated					102.9	32.4	15.3	101.2	17.7	
RPN					102.9	93.6	15.3	101.2	68.8	
RPN* not correlated with normal behavior					0.10	0.14	0.20	0.34	0.12	
RPN with normal behavior					0.10	0.27	0.20	0.34	0.22	

Fig. 2. The first CC-HoS of the industrial application.

	Seat belt warning	Obstacle detection sensor	System for monitoring the working conditions	Gloves	Body covering	Apron	Non-slip boots	Goggles	Face shields	Sunscreens	Respiratos	Instructions for Use	Augmented reality on tablets or smartphones	Training system based on virtual reality	Medical Surveillance	Planning and testing emercency plans	Scheduling	Hydratation	Lightweight and light-colored clothing
Seat belt warning	1											0.2							
Obstacle detection sensor		1										0.3		0.3					
System for monitoring the working conditions			1									0.4		0.3					
Gloves				1								0.2							
Body covering					1							0.2							-0.2
Apron						1						0.2							-0.4
Non-slip boots							1					0.2							
Goggles								1	-1			0.2							
Face shields								-1	1		-1	0.2							
Sunscreens										1		0.2			0.4				
Respirators									-1		1	0.2							
Instructions for Use												1							
Augmented reality on tablets or smartphones												0.4	1	0.4					
Training system based on virtual reality												0.4		1					
Medical Surveillance												0.3			1				
Planning and testing emercency plans			0.4									0.3		0.4		1			
Scheduling			0.3									0.3					1		
Hydratation															0.4			1	
Lightweight and light-colored clothing												0.3							1

			Protective devices			Personal protective equipment and operator support systems																
			Seat belt warning	Obstacle detection sensor	System for monitoring the working conditions	Gloves	Body covering	Apron	Non-slip boots	Goggles	Face shields	Sunscreens	Respiratos	Instructions for Use	Augmented reality on tablets or smartphones	Training system based on virtual reality	Medical Surveillance	Planning and testing emercency plans	Scheduling	Hydratation	Lightweight and light-colored clothing
1	Increased Ambient Temperature	102.9			3	3								3	3	3	3		9	9	9
2	Air Pollution	93.6			3								9				3				
3	UV radiation exposure	15.3					9					9					1		3		
4	Extreme weather	101.2	3	3	9				3				3	3	3	3		9	3	3	
5	Biological hazards	68.8				3	3	3	3	9	9		9	3	3	3	9				
Partial effectiveness			303	303	1500	515	344	206	510	619	619	137	1765	819	819	819	1224	910	1275	1230	926
Total effectiveness			467	795	2073	679	322	0	674	164	-1601	790	1309	819	1473	1146	1469	2083	2083	1719	1172

Fig. 3. The second CC-HoS of the industrial application.

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