

CASE STUDY

Implementation of child safety and health management system by means of FMEA method

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ABSTRACT: Every year, many accidents leading to physical injuries in kindergartens, indicates that a very large percentage of them are related to the safety concerns and lack of hygiene in these places. Families, due to their busy life style and working hours and also children needs of preschool education, are searching to find most suitable kindergartens for their children. Selecting a kindergarten with various suitable training programs, although very important criteria for selection, but is not sufficient. Indicators such as health, safety and environment issues in these places must be crucial factors in this decision making. Child safety and health management system is an integrated system, derived from health, safety and environmental management regulations which helps the kindergartens complies with relevant regulations to reduce the number of accidents occurrence. The present case study has tried, by using failure modes and effects analysis method and child safety and health management system to find the best practicable indicators to assess the relative impact of different failures in order to identify the parts of the process that are most in need of change. In this regards, 10 semi-governmental kindergartens located in Tehran District 6 of Tehran Municipality, which are supervised by municipality of Tehran were selected and evaluated. The results showed that according to the child safety and health management system and failure modes and effects analysis, all these places need massive infrastructural changes according to the preventive action list in order to be considered a safe and hygienic place for the children.

KEYWORDS: *Child safety and health (CSH); Failure mode and effects analysis (FMEA); Health, safety and environment (HSE); Risk management; Potential failure mode (PFM)*

INTRODUCTION

Health, safety, and environment (HSE) is a management system tool that is based on a dynamic and preventive approach than a reactive approach. The aim of this management system is to improve health and safety. This system is a comprehensive plan to manage the risks at all levels of life and activities. Many organizations evaluate their own health and safety

situation on the basis of HSE requirements and their organizational management system. In Iran, HSE management system is a combination of ISO 14001 and OHSAS 18001 requirements. The management system of occupational safety and health (OSH) includes all management levels in occupational environments. The child safety and health management system (CSH) is a subset of OSH. It includes health and safety issues at home, school, and playground. Therefore, the

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development of CSH management system leads to improving OSH system (Bas, 2014). CSH is a set of strategic, mental, and operational parameters to protect children against safety and health threats. According to World Health Organization (WHO) and The United Nations Children's Emergency Fund (UNICEF), millions of children are threatened by many potential risks in their environments (WHO and UNICEF, 2008). CSH approach can be discussed in terms of three levels, namely international, national, and local (home and public places) levels. This approach includes safety culture, resource assignment, and risk management. Having included these aspects, a comprehensive system is designed for CSH maintenance (Bas, 2014). Many studies have been conducted on potential hazards that threaten children from both rich and poor families, including driving accidents (not using safety belts), riding bicycles, falling from height, and playing dangerous games. CSH is a management system that should be applied at all schools and kindergartens. Therefore, educational departments, municipalities, and centers for supporting children and young adults must be responsible for it. Establishing safe places and standard pools for playing and entertainment as well as teaching children safety issues are crucial steps that must be taken to improve the culture of safety among children. Local studies have shown that potential hazards at school, classrooms, and playgrounds constitute a major part of CSH threats that can be reduced at local level (Guldbrandsson et al., 2004). By considering safety in playgrounds and parks, threats can be reduced in three fields, i.e. environmental designs, safety audit, and playing tools. The safety audit of playgrounds can be analyzed by safe method (Jafari et al., 2010). Lack of enough budgets for athletic spaces, old structure of schools, and poor hygienic conditions in toilets are major safety and health problems at schools. Threats at schools can be removed by safety and health audition checklists. Based on safety and health checklists, effective auditions can be taken to eliminate threats at schools and improve safety in physical environments (Pour Dehkordi et al., 2010). The results of studies at schools of Zabol, Iran showed that levels of safety and health are acceptable. However, there were some deficiencies in providing information about how to leave the dangerous places through emergency exits (Neshat et al., 2010). The investigations on health and safety issues at schools of Pakdasht, Iran identified lack of

proper spaces and poor conditions of playground and toilets as the main problems at schools. Results of the study were compared with health and safety policy at schools and it became clear that they were at an average level (Kermani et al., 2012).

CSH management system is a comprehensive and standard framework that can be a reliable base for investigating CSH in various environments. As a result, teaching children safety and health at schools should be promoted. Standards of CSH management have been confirmed by UNICEF. It has been claimed that these standards can be effective in improving child safety (Bas, 2014). To create a safer environment in daycare facilities, another study discussed that a rate of 10% of moderate and severe injuries are related to kindergartens (Alkon et al., 1999). Children's injuries mostly included contusions and much fewer cuts, sprains, abrasions and fractures. The studied children most often sustained a head injury (Rock Simon, 2002). Some European studies have established that the annual incidence of injuries sustained in the playground and threatened at the hospital emergency room as between 4 and 7 per 1000 children (Sengolge and Vincenten, 2006).

From analyzing 347 kindergarten-related injuries, 47% of all accident was occurred in kindergarten (indoor) and severe accident in kindergarten exit in playground. Results of this analysis show that training program in daycare is the best way to decrease accident in kindergarten (Eberl et al., 2008). By analyzing children's injuries among 178 children during organized and unorganized sport activity in kindergartens in Ljubljana, Slovenia, results show that in two-thirds of accidents the teacher applied a compress, whereas in one-fifth of cases the injury was bandaged and some cream was applied, respectively. In one-quarter of the accidents, a child was taken to a hospital emergency room. With more than one-half of cases, the injured child was not absent from kindergarten, and in other cases only for a day or several days (Videmsek et al., 2010). Most physical activities take place in the playroom, where the majority of injuries also occur. Injuries most frequently occur when running and jumping and less frequently during other physical activities. Boys are more often injured than girls. The most common injuries are bumps on the head, especially in younger children (Videmšek et al., 2014).

Some possible techniques used for identifying root causes of hazard are fault-tree analysis (Vesely et al.,

1981), failure mode and effects analysis (Dailey, 2004), Failure Mode Effects and Criticality Analysis (FMEA), (Jorda, 1972), and Fault Hazard Analysis (FHA), (Ericson, 2005). FMEA is a useful tool for risk identification and injury prevention that RPNs in FMEA methodology can be used as risk factors for child injuries because they incorporate crucial factors for risk assessment such as the probability of injury, possible effects and the detection of injuries (Paparella, 2007).

The important risk factors of basic child injuries are defined as: (1) Drowning: children age 1-4 are at risk of drowning, (2) Burns: children under the age of are at risk of burning, (3) Falling: boys are at greater risk of falls than girls and (4) Poisoning: boys are at greater risk of falls than girls. This definition is analyzed by the RPNs in FMEA methodology that were adapted to child injury assessment and prioritization rather than addressing the deficiencies in traditional FMEA methodology (Bas, 2011). This study has been performed in kindergartens of Tehran, District 6 of Tehran Municipality in Iran during 2015.

MATERIAL AND METHODS

CSH management system, outlined below, is used as the main framework in the present study.

CSH at international level

A majority of international organizations have conducted CSH studies, such as UNICEF (WHO, 2013). With the cooperation of World Health Organization (WHO) and UNICEF, some reports have been provided on the causes of children's potential hazards and failure. Recommendations are then made to prevent such incidents (WHO and UNICEF, 2008).

CSH at national level

In this section, national policies of management system on CSH are mentioned. The aim of this system is to increase protection and reduce injuries among children as a standard planning. Safety checklists are prepared on the basis of HSE requirements. The components of a national program providing CSH are presented in Fig. 1. This system can be considered as the developed version of HSE in occupational environments. The system

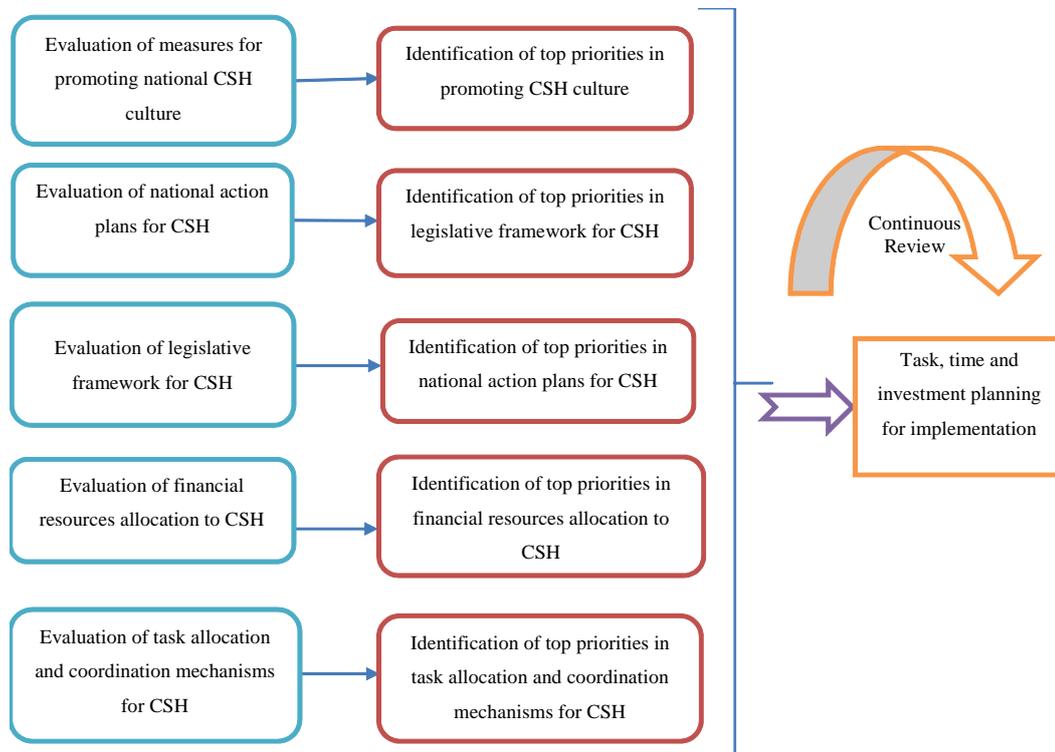


Fig. 1: National program for CSH (adapted from Bas, 2014)

Table 1: An example of CSH policy for a school (adapted from Health and safety executive, 2013)

General policy		Responsibility of actions
Risk assessment and development of hierarchy of preventive and protective measures based on the national program	Competent authority	Preliminary and detailed hazard identification.
	School manager	Development of customized hierarchy of PPM for the school
Emergency procedures	School manager	Regular review of risk assessment and hierarchy of PPM
	Class teachers	Evacuation plans are prepared and tested. Evacuation plans are updated Evacuation of each class is managed
Educating and training children and teachers based on the national program	Competent authority	Regular in-school education and training as a part of national program
	School manager	
Maintenance of safe and healthy environment by logistic measures	School manager	Routine inspection to identify the hazards. Measures for safe and healthy environment

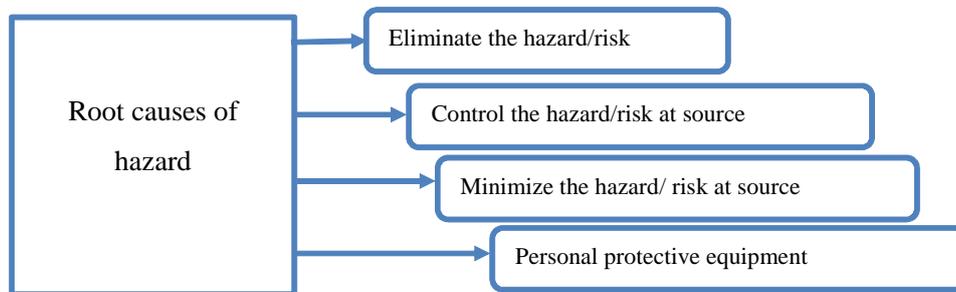


Fig. 2: Hierarchy of preventive and protective measures (adapted from Alli, 2008)

includes five dimensions, i.e. culture, evaluation, policies, finance, and task coordination.

CSH at Family and public places level

CSH at family and public places level is lower than the national level; as a result, the output of this level can be considered as the input for national level. Children under the age of 5 spend most of their time at home. Because of their curiosity, environmental problems may threaten children (Roberts, 2005). Most children spend part of their time at public places such as kindergartens, playgrounds, and schools. At the ages above ten, number of threats and their variety are increased. One of such threats is the danger of car accidents. Therefore, it is necessary to take the preventive actions within CSH framework of management system. The policies of CSH management system are based on four main components:

1) Risk assessment and development of hierarchy of preventive and protective measures

2) Emergency procedures

3) Educating and training children, teachers, caregivers
4) Maintenance of safe and healthy environment by logistic measures (Health and Safety Executive, 2013).

As children spend around 5 to 7 hours of their daily time at school (nine months per year and six days per week), it is very important to make schools a safe place for children. In modern education, physical environments are dynamic places to educate and train students. Identifying potential causes of failure and removing them can make schools safer places for children. In Table 1, policies, responsibilities, and activities have been separately mentioned for a school. Based on CSH management system, environmental conditions are evaluated and the dangerous factors for children are identified and analyzed. Potential hazards can be prevented by eliminating, controlling, minimizing the hazard/risk through personal protective equipment (Health and safety executive, 2013). In Fig. 2, after identifying the causes of hazard/ risk, preventive

Table 2: FMEA Worksheet factors

Risk Identification	Risk Analysis	Risk Evaluation	Risk Management
I1. Place	A1. Potential Failure Mode	E1. Probability	M1. Recommended Action
I2. Item/ Function	A2. Potential Cause(s) of Failure	E2. Severity	
I3. Hazard	A3. Potential Effect(s) of Failure	E3. RPN	
	A4. Current Process Controls	E4. Ranking	
	A5. Policy		

actions can be taken on the basis of their priorities.

The CSH management system receives all hazards reports at schools, kindergartens, and playgrounds. Based on the above-mentioned model, these hazards are evaluated from various aspects. Then, high-risk places are identified and the causes of risks are investigated. Finally, some preventive actions are taken to reduce the risks. These actions include education, personal protection equipment provision, etc.

According to CSH directives, it is possible to provide the necessary information for parents, teachers, and heads of schools and kindergartens through continuous educational programs. It can lead to development of CSH culture in society. At national level, the government can account for financial matters to reduce risk factors at schools and entertainment places. Also, educational centers and child-related organizations can cooperate together to minimize risk factors. At risk management level, there are some methods to analyze risk that FMEA method is frequently used for. FMEA can be described as a systemized group of activities intended to (a) recognize and evaluate the potential failure of a product/ process and its effects, (b) identify actions which could eliminate or reduce the chance of the potential failure occurring, and (c) document the process. It is complementary to the process of defining what a design or process must do to satisfy the customer (Ford Motor Company, 2004).

In this study, we focused at micro level of CSH and considered kindergartens as public places, in addition, FMEA method was applied to explore the root causes of hazard, risk analysis, risk evaluation and risk management.

RESULTS AND DISCUSSION

In the present paper, some steps consisting of hazard identification, risk analysis, risk evaluation and risk management, based on FMEA method, were taken to control root causes of children hazards in

kindergartens. Each step included some factors that are presented in Table 2.

Also, in order to detect potential risks, we can assume kindergartens that most of them consist of 10 different parts. In each part, a FMEA worksheet must be completed including all factors of Table 2. Also Figure 3 illustrates parts of a kindergarten.

According to kindergarten's survey, FMEA worksheets have been performed in the various parts of kindergartens (Fig. 3). District 6 of Tehran has been considered as a case study where is located in west of Tehran, Iran. There are 10 kindergartens in District 6 of Tehran and all of them have been considered to be audited.

The most important factors of FMEA worksheet, outlined below, can be described:

- Failure / Hazard: The loss of a function under stated conditions.
- Potential Failure Mode: The specific manner or way by which a failure occurs in terms of failure of the item (being a part or (sub) system) function under investigation. Potential Cause(s) of Failure: Defects in requirements, design, process, quality control, handling or part application, which are the underlying cause or sequence of causes that initiate a process (mechanism) that leads to a failure mode over a certain time.
- Potential Effect(s) of Failure: Immediate consequences of a failure on operation, function or functionality, or status of some item.
- Risk Priority Number (RPN) =Severity (of the event) * Probability (of the event occurring)
- Severity: Determines the degree of injury, property damage, system damage and/or time lost to repair the failure.
- Recommended Actions: Additional info, including the proposed mitigation or actions used to lower a risk or justify a risk level or scenario.

Thus, The failure and hazards effects were identified according to these factors. The RPN were also

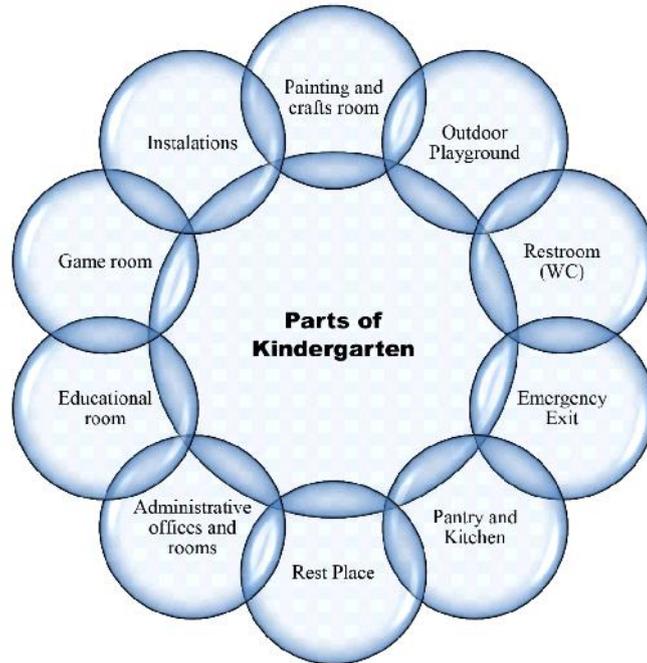


Fig. 3: The observed parts of kindergarten

Table 3: An example of FMEA worksheet (a section of painting and crafts room)

Description of FMEA worksheet												
Risk identification		Risk analysis				Risk evaluation				Risk management		
Place	Item/ Function	Hazard	Potential failure mode	Potential cause(s) of failure	Potential effect(s) of failure	Current process controls	policy	Prob.	Sev.	RPN	Ranking	Recommended action
Painting and crafts room	Painting and crafts table and chairs	Inappropriate Posture	Pressure musculo-skeletal	-Unsuitable tables or chairs -Standing for a long time	Hurting in neck, shoulders, back and legs	Using suitable chair	*	3	3	9	LOW	Training ergonomics (avoid to sit or stand for a long time)
	Playing	Bacteria	Contact with dirty objects	irregular cleaning of objects	Disease	-	*	4	4	16	ALARP	Regular cleaning of places and objects Periodic disinfection equipment Training healthy topics Separating trash from toys
	Balcony/ windows	Height	Fall from height	Lack of poundage Lack of access restrictions	Breakage death	-	*	4	6	24	HIGH	Installing guards for windows and balconies

calculated along with risk evaluation ranking. RPN ranking includes three levels i.e. LOW, ALARP, and HIGH. In high risk mode, action plans should use to remove the causes of failure and prevent hazards and their effects. A section of painting and crafts room worksheet is described in Table 3. Having analyzed

the worksheets, some current process control and preventive actions were recommended to eliminate or minimize high-risk hazards. Some high-risk potential failure modes are listed as below:

- Falling down
- Electrical shock

- Injuries
- Hitting with something

The following are some recommended actions (as preventive actions) corresponding to risk potential failure modes above including:

- Use soft flooring
- Fencing balcony and window
- Repair defective electrical outlet / using outlet shield
- Installing soft shield on radiators
- Using appropriate heating and cooling appliances

The results of this study show that electrical shock and hitting with something are the most hazards can injure children. Moreover, children accessibility to balcony and window without fencing lead to high risk hazard. According to risk management, children can be protected against hazards in kindergarten by identifying and controlling potential failure causes.

CONCLUSION

In this study, a framework for CSH management system was investigated at three levels, i.e. international, national, and family and public places. In this approach, international organizations can have an effect on national level policies. Also, family and public places level, as a micro level, can receive feedback from macro level, namely national level.

Having defined CSH management system, the relevant studies were discussed as literature review. Later, the three levels of CSH management system were explained. The executive steps of CSH management were explained using relevant examples. Finally, according to FMEA results, some preventive actions to reduce potential risks for children in kindergarten were presented. Of course, this cannot be achieved unless parents, school managers, and trainers have enough knowledge and awareness of potential risk factors. Culture of safety and health can grow by increasing knowledge and awareness among parents, school managers, and trainers. Children are one of the most vulnerable groups of people that must be protected against unpredictable incidents. In this way, children must spend their childhood period in a safe environment and experience delightful future.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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Kindergarten HSE Management system

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