INTRODUCING A NEW HSE MANAGEMENT FRAMEWORK FOR IRAN AIRPORTS (CASE STUDY: MEHRABAD AIRPORT)

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Abstract. Nowadays, demands for air travel and transportation have become one of the undeniable human needs. On the other hand, negative effects of this technology on the human health and his environment have not been thoroughly investigated. The aim of this research is to introduce a novel framework for HSE management of the airports of Iran. So, Mehrabad airport as the most important airport of the capital Tehran, was selected as the case study. In this research, by integrating William Fine's procedure with other methods, the activities and operations in the airport were evaluated and the most important risks were carefully identified and weighted. Then, by preparing a matrix and integrating the elements of environment, Health and safety management risks, four tools of "prevention, reduction, transfer, and acceptance" were introduced to manage the risks of the airport. The results of the study showed that in Mehrabad airport, noise and air pollutions are above the limits allowed by the standards. Furthermore, some other factors such as ergonomic, thermal, mechanical and physical factors of the work environment as well as personnel activities showed some standard deviations. Therefore, corrective measures were proposed based on medical reports and experts' viewpoints for each of them. By implementing the proposed framework in the airports of Iran, a major part of damaging factors will be recognized, entirely omitted or reached to the expected standard ranges.

Keywords: Mehrabad, Airport, HSE management, William Fine method.

INTRODUCTION

Accelerated trend of industrialization and insufficient attention to the industrial safety principles has led to the increase of accidents rate in developing countries [1]. In this new era, parallel to rapid development of technology and industry, there are serious concerns about bad consequences of such development which threaten human life [2]. Unfortunately, technology progress, despite of its usefulness, has resulted in some damaging consequences such as air pollution, annoying noises and environmental impacts. Considering the growth of technology, the demand for air travels and transportation has changed into one of the undeniable today's human needs. Above all, airports play an important role in all aspects and dimensions of transportation; therefore, the location of an airport may exert a strong influence on activities and utilization of the surrounding areas. At the present time, one of the problems concerning the construction and utilization of the airports, is the ignorance about all the parameters that affect the construction of an airport and the manner of using safety regulations [3]. Risk evaluation may be done in various qualitative and quantitative methods. In quantitative evaluation of risks, the results are reflected in numbers and the probability of occurrence is defined in form of probabilities [4]. This evaluation relies on statistical methods and it can recognize the focal points and factors of existing risks [5]. Among all these, the evaluation of environmental risk is a step beyond qualitative and quantitative evaluation of risks. In this method, the sensitiveness of each job and special values of the environment are taken into consideration by full recognition of affected environment in addition to the analysis of different aspects of each risk [6]. Therefore, the first and most important section in the construction of an airport is to consider environment regulations which are taken into account in the assessment of environmental impacts. Today, improper allocation of airports is one of the problems we encounter, so that such a mistake has led to a plethora of life and financial damages as well as environmental impacts [7]. Although, air transportation is the safest means of transportation, high traffic, sudden agitation of air, human mistakes (pilot, watch tower) and technical problems of airplanes, exposes people and places around airports at risk. The risk of accidents occurrence seriously threatens airports and will cause serious problems for safety management. Proper management of the operations concerning safety management requires suitable and correct implementation of risk management system so that the targets of cost, time and quality of the related operations enjoy the best effectiveness and efficiency. Therefore, the main purpose of this research is to review the weak points of safety management in Mehrabad Airport and recognize the present shortages in HSE Management and finally propose a new HSE framework for the airports of Iran. Due to the increasingly negative effects of airports activities on the surroundings, studies have been carried out in many countries resulting in similar threats. Some studies have been reported as follows: the use of a permutation model, an example of an airport locator, including various options and analyzed it based on the status and quantity of their indicators, among which, the preferred option was finally selected. Options were compared and analyzed in accordance with all the effective parameters and criteria. The main objective of their research was to achieve an airport allocation model and evaluate it by using practical examples. The results of this model showed that it is possible to use a logical and mathematical model to minimize the human error in site selection [7]. Another research

was done to evaluate the Sound Pressure Level (SPL) in the closest aprons to Ground Safety department at Mehrabad airport and to investigate the effect of airport noise on the employees of this department. The noise exposure was higher than the permissible limit, which implies the necessity for use of earmuffs and implementation of noise reduction programs [8]. The measured equivalent for 8 hours' noise exposure was obtained 94 dB(A) and no relation was observed between octave band sound of aircraft and recorded eudiometry. Analysis of the questionnaire showed that people with more knowledge about noise pollution used more hearing protective equipment. Subsequently by using more earmuffs, the level of hearing loss was reduced significantly *($p<0.05$).* There was a significantly negative correlation between noise exposure and job satisfaction; that is to say, ($P<0.05$). Also there was a significant and negative correlation between using ear muffs and catching Noise-Induced Hearing Loss ($P<0.1$). The percentage of noise-induced hearing loss was calculated 51.4% among study samples [8].

The rate of hearing loss in the study of 80 employees of Shahid Beheshti airport, aged 29 to 49 years showed that air and bone audiometry on agreed frequencies have meaningful differences in right and left ears. Also in this study, almost none of the subjects used hearing protectors [9]. Above-mentioned study included 4 different operating and control groups consisting 18 airport office workers (low exposure group) and 32 employees of administrative centers of Isfahan (unexposed group). In line with this research, the annoyance of workers from Cairo international airport comprising 260 workers at 13 different locations with different noise levels were evaluated. The goals of this study were to carry out measurements to evaluate airport noise levels inside its offices, arrival, departure halls, and places of workers who guide airplane to stop in its own place. The results of the measurements in L dn of 90 dB and higher were recorded. The findings showed that 42.8% were highly annoyed, 46 % hearing of which were harmed. There was a strong relationship between airport noise levels and percentage of highly annoyed respondents. By increasing airport noise level possibility of workers to make mistake in their work was also increased [10].

In another study, mean age of 37 years were examined, (respondents with a range age from 22 to 62), SD 8.98. Mean duration of exposure to noise was 10.7 years with range 1 to 40, SD 8.15. Prevalence of NIHL was 15.3%, with ground crew at 14.8% and aircrew 16.1%. Ground crew had significantly poorer mean hearing threshold level at 3, 4 and 6 kHz than aircrew ($p = 0.015$). Male workers were affected more than female counterparts with a male to female ratio of 4:3. 97% of those affected were non-managers, 3% managers while 68% of those affected resided in Embakasi Division close to the airport. Hearing threshold level at 4 kHz deteriorated with increasing age whereby those aged 50 years and above had a 13.7 times higher relative risk than those aged 20 to 29 years. Duration of exposure more than 10 years also had significantly higher risk ($p < 0.01$) for hearing loss at 4 kHz [11]. More over by conducting the study of the impact of airborne air space noise on the staff of the airport at the International Airport Queen Alia in Jordan through measurements in 3 weeks of work and at the loudest points of the airport, it was found that 46% of sample group of which often didn't use earmuffs suffered from hearing loss. In addition, the airside sound is about 5 dbA to 15 dBA higher than the international standard stipulated by Niosh [12]. Apart from noise pollution and its complications, the air pollution caused by the airport and air activities and its complications are as important as noise pollution. Specialists from various medical sciences claim that the air pollutants have many harmful effects on the body and soul of the people. According to physicians, health professionals and practitioners, the phenomenon of air pollution has affected on the internal organs of the body such as the cardiovascular and respiratory system as well as external organs such as the eyes and skin, which are directly exposed to air pollution. According to some experts of different medical sciences, the progression of chronic diseases including asthma and skin allergies, and sometimes severe diseases like cancer is one of the most destructive and irremediable effects of air pollution on the health of the community.

In this study, two groups are investigated, the first group of suspended particles is 2 microns in size. The first-generation emission rate is based on the first-order SO and CO2, N2O, NOX, CO and the second group of particles is smaller than 2 microns, comprising smoke numbers and smoke diffusers (FAAs) released in The United States Federal Aviation Organization which is approximately one of the characteristics of all engines. According to the report of the Committee on Environmental Protection with respect to the statistics of the annual flying of the Mehrabad airport and the type of fleet arising at this airport, the approximate amount of pollutants emission in the region, in both categories were calculated separately. In the end, the amount of consumed fuel by an airplane in a typical day was compared with that of the cars in the same conditions. The results of Tehran air quality control revealed that all of the areas located in the area of Tehran Sar and the surrounding area (District 9) are exposed to excessive sound pollution. However, the highest air pollutants are available between 8 am and 10 pm at airports and surrounding areas. Based on studies conducted by Tehran air quality control company, the results of such various pollutants as carbon dioxide, nitrogen oxides and hydrocarbons (HC) have shown that there is not there is not a marked difference between the production of pollutants in public days versus to closed days. An average of 1500 kilograms per day, 190 to 200 kilograms of HC, 1700 to 1800 kilograms of nitrogen oxide, and 45 kilograms of suspended particles are distributed at this airport. Most of these pollutants are released from 8 am to 22 pm at the airport.

MATERIALS AND METHODS

CASE STUDY

The study area was at Mehrabad Airport, as one of the most important and oldest airports of Iran. Mehrabad is located at district 9 of Tehran metropolitan. The total area of Mehrabad Airport is 58000 cube meter and it is 3962 feet above sea level. The airport was founded in 1328 and has a four-legged flight, a number of gangways for taxiing planes, six terminals for passenger and the ability to service domestic and international flights. Mehrabad Airport

plays a significant role in transportation, shipping economics, political and international affairs. Figure 1 shows the location of Mehrabad airport in district 9 of Tehran.

Figure 1 – The Location of Mehrabad Airport in the District 9 of Tehran

As shown in Figure 2, based on the methodology framework, at first, all airport activities and operations were recognized and jobs were analyzed by William Fine method based on HSE aspects as well as regulations and standards. In order to assess the risks with this method, it is necessary to clearly rank the severity, probability and risk exposure of each aspect of airport activities. This technique involves the use of risk. A risk score, R, is computed from the equation (1)

$$RPN = C \times E \times P \quad (1)$$

Where,
C is the consequence rating value,
E is the exposure value, and
P is the probability value.

The risks were classified into three ranges: low, medium and high. All activities were evaluated based on the magnitude and severity of risk (RPN)[1] in each section, and the risks that required corrective action, have been reviewed. It should be noted that using proposed framework, the activities with high risks were largely recognized and eliminated or minimized. Table 1 shows the PRN classes used in William Fine method.

Table 1 - the PRN classes used in William Fine method.

Risk level	Measures	Rank
High	Urgent reform is needed to control risk and it needs to stop the under consideration activity	61-120
Medium	Emergency condition or necessary measures must be undertaken as soon as possible	31 - 60
Low	Potential risk factor is under control and consideration	0-30

[1] Risk Priority Number

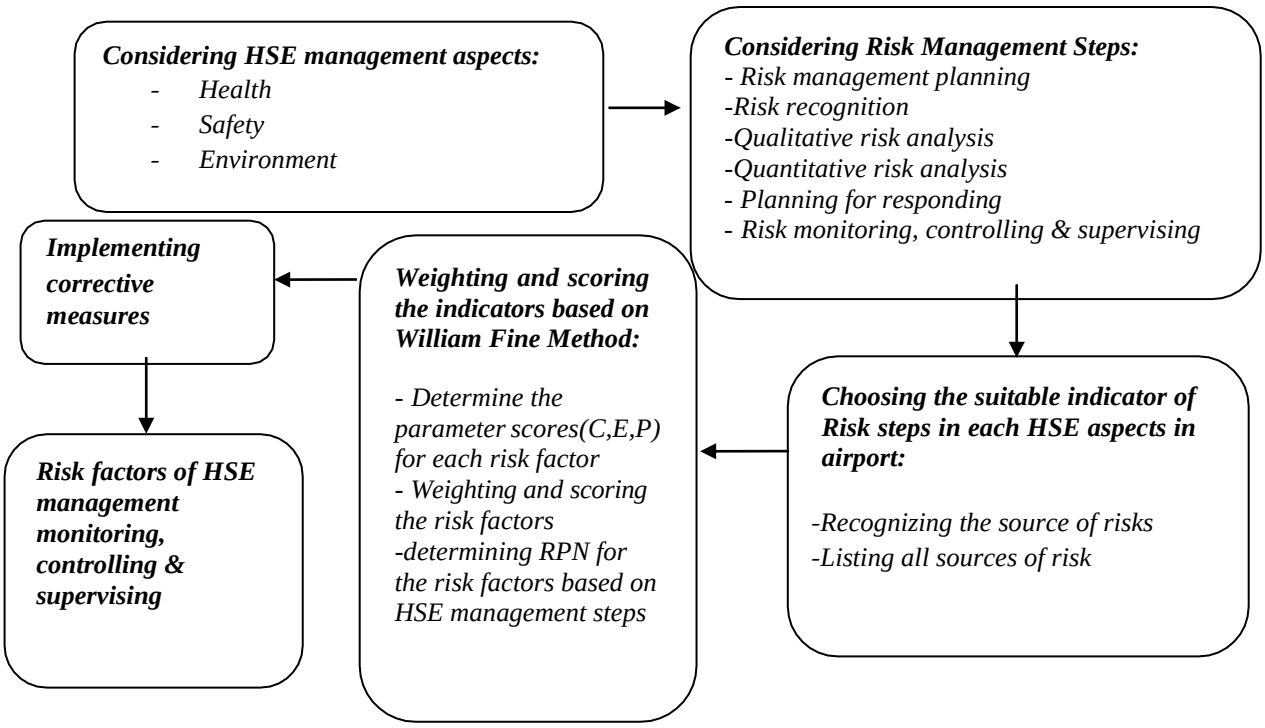

Figure 2 – Methodology Framework

The statistical population of this study included all officials and administrators of Mehrabad Airport. The desk research method has also been used to compile and collect the literature on the topic of research. The raw materials used in this research are checklists prepared by 12 experts and specialists. In this research, all airport activities are identified and analyzed in terms of safety and health regulations by using William Fine's method. After comparing the results with standards, in case of conflict, corrective measures should be considered to reduce RPN. In the next step, the data must be put in the matrix and segregated according to the components of the airport's instruction. Then, by introducing the occupations, the amount and type of exposure to the damaging factors, the application of the principles of risk management in the area of safety, health and environment have been determined, which led to the recognition of existing shortages.

RESEARCH FINDINGS:

The results of intended evaluations were put in sketched matrix based on William Fine procedure and were monitored and controlled. According to the findings, the air pollution resulting from exhaust gases produced by airplanes engines is deemed the greatest impact of the airport. It is noteworthy that air and land traffics resulting from the airport activities have increased air pollution. Also, it is noted that the traffic of heavy and light vehicles inside and around Mehrabad Airport, have given rise air pollution by CO and NOX respectively for 11.8 m/mg and 4 m/mg per vehicle**.** Table 2 shows the emissions produced by different airplane models.

Table 2 – The Emissions Produced by Different Airplane Models

Airplane Model	**Air Pollutants (Kg/Per Take-off & Landing)**		
	NOX	CO	HC
B747	57.6	76.1	36
Dc 10	41.6	68	34.3
L1011	41.5	115	70.3
B720B 707/DC8	14.7	92	97.7
A300	27.7	45.4	22.9
A310	22.2	14.8	3.3
B727	11.1	24.6	7.4
B737-300	7.8	12.5	0.7
B737-DC 9/S210	7.4	16.4	5
BAC1-11	11.7	39.7	22.6
FK28	4.6	34.1	34.3

First sound control stations are situated at the beginning of operational band of Mehrabad Airport. All airplanes taking off from Mehrabad airport, which are about 150 airplanes per day, start their take-off from this point. Also, this station is the first station of landing. Furthermore, airplanes landing in Mehrabad, which are about 152 airplanes per day, land adjacent to this station. Measuring is made in this station at different times of a day. Table 3 shows the results recorded by the first station of sound control from different airplane models.

Table 3 – Results Recorded by the First Station of Sound Control Station from Different Airplane Models

No.	**Airplane Type**	**SPL(dBA)**		**Remarks**
		Day	Night	
1	B747	5.105	108	Take-off
2	B727	5.103	107	Take-off
3	B737	5.100	103	Take-off
4	B720	104	106	Take-off
5	A300	87	90	Take-off
7	A310	92	6.94	Take-off
8	BAC1-11	7.89	5.92	Take-off
9	L1011	93	2.95	Take-off
10	FK28	9.95	98	Take-off
11	DC-10	8.79	83	Take-off
12	DC-10	2.75	5.78	Landing
13	B-727	87	8.89	Landing
14	B-747	3.89	3.90	Landing
15	B-737	6.87	3.90	Landing
16	B-720	2.88	4.91	Landing
17	A310	6.85	88	Landing
18	A300	5.83	85	Landing
19	FK-28	85	7.87	Landing
20	BAC1-11	3.88	6.85	Landing
21	L-1011	1.89	92	Landing
Average		538.90	92.468	

Second station of sound control is the final station of all taking-off or landing airplanes of Mehrabad airport. Measuring was made in this station during 24 hours per day and night. The distance between airplane and the station when its wheel takes off from the band surface is 500 meters. This distance at the time of leaving the band is 350 meters. Table 4 presents the results of the second station of sound control.

Table 4 – The Results of the Second Station of Sound Control

.	Airplane Type	SPL (dBA)		Remarks
		Day	Night	
1	B747	5.95	98	Take-off
2	B727	5.93	97	Take-off
3	B737	5.90	93	Take-off
4	B720	94	96	Take-off
5	A300	77	80	Take-off
6	A310	82	5.84	Take-off
7	BAC1-11	8.79	5.83	Take-off
8	L1011	73	3.85	Take-off
9	FK28	9.85	88	Take-off
10	DC-10	8.69	73	Take-off
11	DC-10	2.65	5.68	Landing
12	B-727	77	8.79	Landing
13	B-747	3.79	3.80	Landing
14	B-737	6.67	3.70	Landing
15	B-720	2.78	4.81	Landing
16	A310	6.75	78	Landing
17	A300	5.73	75	Landing
18	FK-28	75	7.77	Landing
19	BAC1-11	3.75	6.78	Landing
20	L-1011	1.79	81	Landing
Average		357.80	57.82	

Qualitative and Quantitative Analysis of Damaging Factors Risks before and After Corrective Measures (From Health Aspect):

For better evaluation and separation of risks and damaging factors, these factors were weighted and assessed based on quantitative criteria. Table 5 and 6 show the risks and damaging factors of quantitative analysis before and after the corrective measures, respectively (Health Aspect).

Table 5 – Risks and Damaging Factors Quantitative Analysis before Corrective Measures (Health Aspect):

Risks & Damaging Factors	Consequences of Risks & damaging factors	Repetition Coefficient	L*	M*	H*
All activities in all sections (office & operational)	Ergonomic factors	43	22	21	-
All airport jobs	Heating & cooling factors	47	22	19	6
Office jobs, the sounds of customers, technical jobs, sounds of routine activities	Sound pollution	51	28	19	4
All technical & office jobs	Air pollution	56	31	21	4
Sanitation staff & persons who take bath (more) – foodstuff contaminations (sometimes)	Biological factors	8	2	6	-
All personnel	Nutritional effects	43	43	-	-

* L= Low M= Medium H= High

Table 6 - Risks and Damaging Factors Quantitative Analysis after Corrective Measures (Health Aspect):

Risks & Damaging Factors	Consequences of Risks & damaging factors	Repetition Coefficient	L	M	H
All activities in all sections (office & operational)	Ergonomic factors	43	35	8	-
All airport jobs	Heating & cooling factors	47	32	15	0
Office jobs, the sounds of customers, technical jobs, sounds of routine activities	Sound pollution	51	40	11	0
All technical & office jobs	Air pollution	56	42	14	0
Sanitation staff & persons who take bath (more) – foodstuff contaminations (sometimes)	Biological factors	8	8	0	-

All personnel	Nutritional effects	43	43	-	-

Table 7 and 8 show the risks and damaging factors of qualitative analysis before and after the corrective measures respectively (Health Aspect):

Table 7 - Risks and Damaging Factors Qualitative Analysis before Corrective Measures (Health Aspect):

Risks & Damaging Factors	**Consequences of Risks & damaging factors**	**Repetition Coefficient**	**acceptable**	**undesirable**	**Unacceptable**
All activities in all sections (office & operational)	Ergonomic factors	43	22	21	-
All airport jobs	Heating & cooling factors	47	22	19	6
Office jobs, the sounds of customers, technical jobs, sounds of routine activities	Sound pollution	51	28	19	4
All technical & office jobs	Air pollution	56	31	21	4
Sanitation staff & persons who take bath (more) – foodstuff contaminations (sometimes)	Biological factors	8	2	6	-
All personnel	Nutritional effects	43	43	-	-

Table 8- Risks and Damaging Factors Qualitative Analysis after Corrective Measures (Health Aspect):

Risks & Damaging Factors	**Consequences of Risks & damaging factors**	**Repetition Coefficient**	**acceptable**	**undesirable**	**Unacceptable**
All activities in all sections (office & operational)	Ergonomic factors	43	35	8	-
All airport jobs	Heating & cooling factors	47	32	15	0
Office jobs, the sounds of customers, technical jobs, sounds of routine activities	Sound pollution	51	40	11	0
All technical & office jobs	Air pollution	56	42	14	0
Sanitation staff & persons who take bath (more) – foodstuff contaminations (sometimes)	Biological factors	8	8	0	-
All personnel	Nutritional effects	43	43	-	-

Quantitative and Qualitative Analysis of Risks and Damaging Factors Before and After Corrective Measures (From Safety Aspect):

Table 9 – Quantitative Analysis of Risks and Damaging Factors before Corrective Measures (Safety Aspect):

The scope of risks & Damaging Factors	**Consequences of Risks & Damaging Factors**	**Repetition Coefficient**	**L**	**M**	**H**
Presence or working in the places where accident or damage is probable	Breakage & injury	58	32	23	3
Presence or working in places exposed to respiratory damages	Pulmonary effects	24	14	6	4
Environmental activities in the places exposed to radiation & bad light (natural or artificial)	Eye effects	22	7	13	2
Working at the places contaminated by poisons or damaging factors	Dermal effects	17	8	9	-
Working at heat or exposure to fire	Burning by natural & artificial factors	17	13	0	4

The jobs exposed to nervous shocks by hot or cold factors	Nervous shock	16	5	7	4
Working with chemicals or being exposed to poisonous materials	Poisonous effects	13	7	4	2
Working at the places where electrical currency or static electricity exists	Electricity shock	9	7	2	-
Presence in security stations	Terrorism & security factors	2	2	-	-

Whereas, the RPN of some damaging factors of this section are high, those factors which seemed to need several corrective measures were reviewed once more and they were transferred to another group at the time of re-grouping.

Table 10– Quantitative Analysis of Risks and Damaging Factors after Corrective Measures (Safety Aspect):

The scope of risks & Damaging Factors	**Consequences of Risks & Damaging Factors**	**Repetition Coefficient**	**L**	**M**	**H**
Presence or working in the places where accident or damage is probable	Breakage & injury	58	45	13	0
Presence or working in places exposed to respiratory damages	Pulmonary effects	24	20	4	0
Environmental activities in the places exposed to radiation & bad light (natural or artificial)	Eye effects	22	16	6	0
Working at the places contaminated by poisons or damaging factors	Dermal effects	17	17	0	-
Working at heat or exposure to fire	Burning by natural & artificial factors	17	17	0	0
The jobs exposed to nervous shocks by hot or cold factors	Nervous shock	16	12	4	0
Working with chemicals or being exposed to poisonous materials	Poisonous effects	13	11	2	0
Working at the places where electrical currency or static electricity exists	Electricity shock	9	9	0	-
Presence in security stations	Terrorism & security factors	2	2	-	-

Table 11 and 12 reveal the risks and damaging factors qualitative analysis before and after the corrective measures respectively (Health aspect):

Table 11– Qualitative Analysis of Risks and Damaging Factors before Corrective Measures (Safety Aspect):

The scope of risks & Damaging Factors	**Consequences of Risks & Damaging Factors**	**Repetition Coefficient**	**acceptable**	**undesirable**	**unacceptable**
Presence or working in the places where accident or damage is probable	Breakage & injury	58	32	23	**3**
Presence or working in places exposed to respiratory damages	Pulmonary effects	24	14	6	**4**
Environmental activities in the places exposed to radiation & bad light (natural or artificial)	Eye effects	22	7	13	**2**
Working at the places contaminated by poisons or damaging factors	Dermal effects	17	8	9	-
Working at heat or exposure to fire	Burning by natural & artificial factors	17	13	0	**4**
The jobs exposed to nervous shocks by hot or cold factors	Nervous shock	16	5	7	**4**
Working with chemicals or	Poisonous effects	13	7	4	**2**

being exposed to poisonous materials					
Working at the places where electrical currency or static electricity exists	Electricity shock	9	7	2	-
Presence in security stations	Terrorism & security factors	2	2	-	-

Table 12– Qualitative Analysis of Risks and Damaging Factors after Corrective Measures (Safety Aspect):

High risk tasks	Consequences of Risks & Damaging Factors	Repetition Coefficient	acceptable	undesirable	unacceptable
Presence or working in the places where accident or damage is probable	Breakage & injury	58	45	13	**0**
Presence or working in places exposed to respiratory damages	Pulmonary effects	24	20	4	**0**
Environmental activities in the places exposed to radiation & bad light (natural or artificial)	Eye effects	22	16	6	**0**
Working at the places contaminated by poisons or damaging factors	Dermal effects	17	17	0	**-**
Working at heat or exposure to fire	Burning by natural & artificial factors	17	17	0	**0**
The jobs exposed to nervous shocks by hot or cold factors	Nervous shock	16	12	4	**0**
Working with chemicals or being exposed to poisonous materials	Poisonous effects	13	11	2	**0**
Working at the places where electrical currency or static electricity exists	Electricity shock	9	9	0	**-**
Presence in security stations	Terrorism & security factors	2	2	-	**-**

Whereas, RPN of risks in damaging factors was high in this section, some corrective measures were proposed and the implementation of such corrective measures and consequences arising from there, have been reflected in the given table according to the instructions of William Fine's method above mentioned high RPNs transferred to low-risk factors group.

Quantitative and Qualitative Analysis of Risks and Damaging Factors Before and After Corrective Measures (from Environment Aspect):

In this section, all factors holding potentials for damaging the environment were recognized. Among the factors, the sound and air pollutions produced by airplanes and the environment contaminations resulting from chemicals can be pointed out.

Table 13 and 14 show the risks and damaging factor's quantitative analysis before and after the corrective measures respectively (environment aspect):

Table 13 – Quantitative Analysis of the Risks and Damaging Factors before Corrective Measures (Environmental Aspect):

High Risk Tasks	Consequences of Damaging Factors	Repetition Coefficient	L	M	H
Working at the exposure of sound pollution	Sound pollution produced by airplanes	58	13	30	15
Working at the exposure of air pollution	Air pollution produced by airplanes	58	13	30	15
Working at the exposure of chemicals	Environmental contamination	10	5	5	-

Table 14– Quantitative Analysis of the Risks and Damaging Factors After Corrective Measures (Environmental Aspect):

High Risk Tasks	Consequences of Damaging Factors	Repetition Coefficient	L	M	H
Working at the exposure of sound pollution	Sound pollution produced by airplanes	58	41	17	0
Working at the exposure of air pollution	Air pollution produced by airplanes	58	33	25	0
Working at the exposure of chemicals	Environmental contamination	10	10	0	-

Table 15 and 16 show the results of the assessment of sound and air pollutions respectively, produced by aviation operations in residential places considering air flow resulting from pressure difference (wind) and air pollution scatters. Therefore, the scope considered for air pollution is wider than sound pollution.

Table 15 – The Assessment of Sound Pollutions Produced by Aviation Operations in Residential Places:

Assessment	Risks or Damaging Factors	Surrounding Places of The Airport (in meters)		
		L	M	**H**
Office & residential places around the airport	Sound pollution produced by aviation activities	30000	20000	10000

Table 16 – The Assessment of Air Pollutions Produced by Aviation Operations in Residential Places:

Assessment	Risks or Damaging Factors	Surrounding Places of The Airport (in meters)			
		P	L	M	**H**
Office & residential places around the airport	Air pollution produced by aviation activities	Total area	30000 & more	20000	10000

Table 17 and 18 show the risks and damaging factors of qualitative analysis before and after the corrective measures respectively (Environmental aspect):

Table 17 – Qualitative Analysis of Risks and Damaging Factors before Corrective Measures (Environmental Aspect):

High Risk Tasks	Consequences of Damaging Factors	Repetition Coefficient	Acceptable	Undesirable	Unacceptable
Working at the exposure of sound pollution	Sound pollution produced by airplanes	58	13	30	**15**
Working at the exposure of air pollution	Air pollution produced by airplanes	58	13	30	**15**
Working at the exposure of chemicals	Environmental contamination	10	5	5	-

Whereas, air and sound pollutions, as reflected in table 17**,** produced by airplanes and aviation operations are considered avoidable issues, the airport is not in a good status from a general viewpoint and this abnormality even affects residential neighborhood areas.

Table 18 – Qualitative Analysis of Risks and Damaging Factors after Corrective Measures (Environmental Aspect):

High Risk Tasks	Consequences of Damaging Factors	Repetition Coefficient	Acceptable	Undesirable	Unacceptable
Working at the exposure of sound pollution	Sound pollution produced by airplanes	58	41	17	**0**
Working at the exposure of air pollution	Air pollution produced by	58	33	25	**0**

	airplanes				
Working at the exposure of chemicals	Environmental contamination	10	10	0	-

Considering the structure and tasks of airport, all concerning jobs are exposed to air and sound pollutions and none of these pollutions can be omitted. However, the quantity and duration of airport pollutions or contaminations can be reduced by some arrangements and corrective measures and shift their risks to a more acceptable range.

Table 19 – The Assessment of Air Pollutions Produced by Aviation Operations in Residential Areas (After Corrective Measures):

Assessment	**Risks or Damaging Factors**	**Surrounding Places of The Airport (in meters)**		
		Acceptable	Unacceptable	**Dangerous**
Office & residential places around the airport	Air pollution produced by aviation activities	40000	15000	5000

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Table 20 – The Assessment of Sound Pollutions Produced by Aviation Operations in Residential Areas (After Corrective Measures):

Assessment	**Risks or Damaging Factors**	**Surrounding Places of The Airport (in meters)**		
		Acceptable	Undesirable	**Unacceptable**
Office & residential places around the airport	Sound produced by aviation activities	40000	15000	5000

Table 19 and 20 show the results of the assessment of air and sound pollutions respectively, produced by aviation operations in residential places. Considering air flow resulting from pressure difference (wind) and air pollution scatters. Therefore, the scope considered for air pollution is wider than the scope considered for sound pollution. In order to control the sound and air pollutions and its negative impacts caused by aviation activities on residential neighborhood, actions such as using double pane windows, increasing green area, installation of noise barriers and air pollution absorbents were proposed and performed to some extents. As a result, by applying above-mentioned solutions residential areas around the airport became safer compared to the previous conditions

Results and Discussion. Mehrabad airport was designed to be constructed at the margin of the city, but the growth of Tehran situated the airport inside the city and has led to many problems. The experts find noise pollution as one of the critical problems of airports adjacent to residential areas. Noise pollution is too high in Tehransar and Mehrabad districts of Tehran. The Remarkable point is that Tehran is the most sound-polluted city of the country and the role of Mehrabad airport in this field is undeniable. In this research, all damaging factors of the airport activities were listed, the results of which have been indicated in diagram 1.

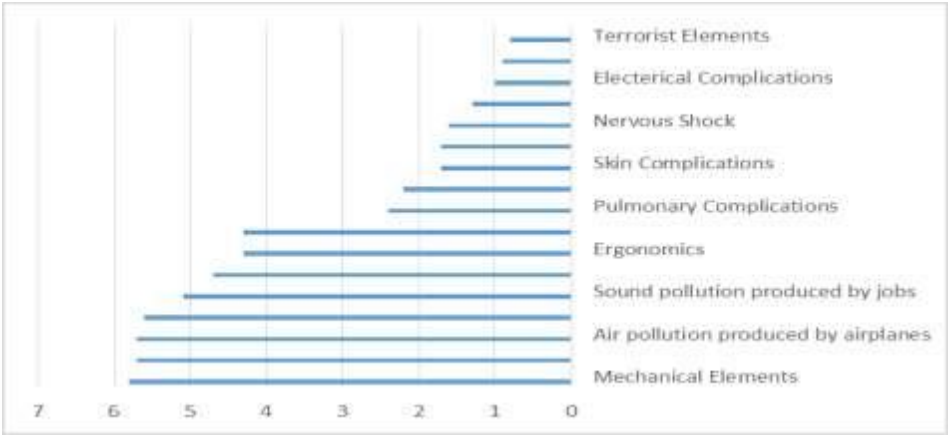

Diagram 1 – Risks and Damaging Factors

The above diagram is based on all data obtained in the research and the factor of recurrence of damaging factors in the airport complex.

In this study, 55 jobs and activities have been evaluated. During this assessment, 17 risk and injury factors were identified for each occupation or activity. Voice contamination, air pollution, mechanical factors, temperature effects, ergonomic factors, etc., can be identified as the risks identified in the airport. Mechanical factors with frequency rate of 58 are the highest and the terrorist factors with frequency rate of 2 are the lowest risks identified at the airport. It should be mentioned that the numerical index in the graph has a coefficient of 10 and is taken from the highest frequency rate factors among the occupants.

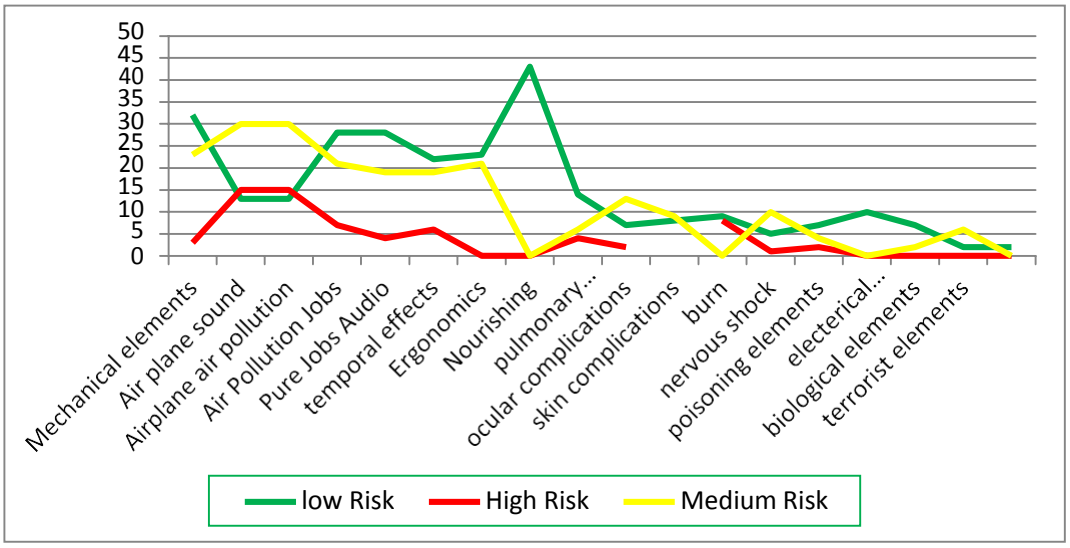

Diagram 2 –Frequency Rate of the Risks and Damaging Factors before Corrective Measures

The second diagram composed of three graphs with various numeric domains. Each graph represents a class of risks with a different numerical value. The data classification in this chart is based on the RPN obtained from the risk factors in the airport complex and in order to better understanding. the obtained RPN is according to the William Fin's methodology. Risks and damage factors were divided into three categories (low, medium and high risk). They are categorized according to the defined standards and initial tests, as well as expert opinions. Some of the risks and factors affecting the airport require corrective measures. The magnitude of the risk and damage factors need to be reduced and controlled by applying corrective measures the numerical risk scale in green is 0-30, in blue color from 31 to 60 and during the interval of 61-120 is at a high risk in red.

Among the identified risks, noise pollution, air pollution, mechanical factors and ergonomic factors are of more importance due to the amount of RPN obtained from the assessment and their repeatability coefficient. The other important issue is the effect of mentioned factors on airport residential areas. In fact, factors which have been referred here in this article cause several disorders such as neurological and cardio diseases, which is placed, in a dangerous category with high risks. Furthermore, they are the first priority in doing corrective measures as well. In the next step, factors such as respiratory, ocular, skin and burn injuries have been identified. Also Factors such as nervousness, poisoning, electrical, biological and terrorist problems are in good condition according to the analyses.

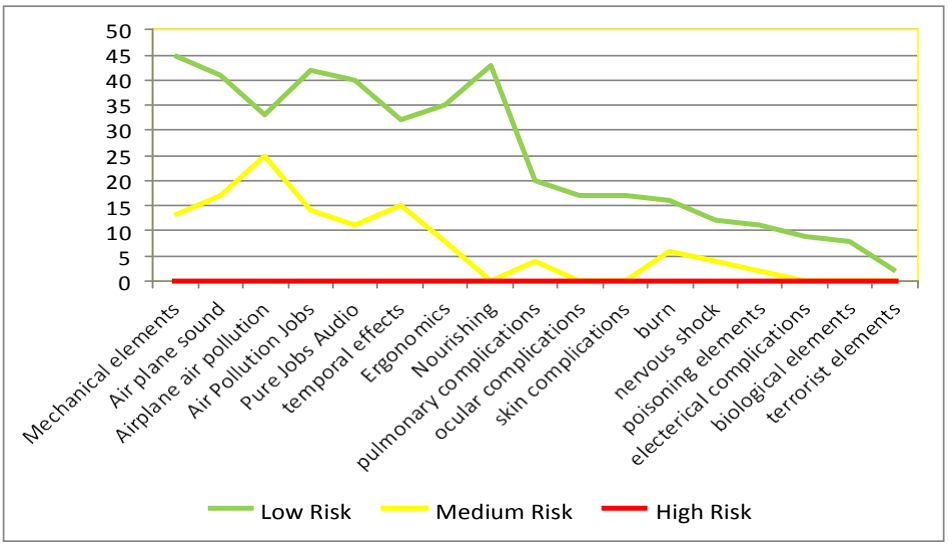

Diagram 3– Linear Diagram of the Risks and Damaging Factors after corrective measures

In the next step, after required corrections, following changes are announced. Table 21 shows the rate of risks after the corrective actions.

Table 21- the Rate of Risks after the Corrective Measures

NO.	Factors	Rate of Risk (after corrective measures)		
		L	M	**H**

1	Mechanical factors	45	13	0
2	Noise pollution(air plane)	41	17	0
3	Air pollution (air plane)	33	25	0
4	Air pollution (other activities)	42	14	0
5	Noise pollution (other activities)	40	11	0
6	Temporal effects	32	15	0
7	Ergonomic factors	35	8	0
8	Factors of nutrition	43	0	0
9	Respiratory complications	20	4	0
10	Ocular complications	17	0	0
11	Skin complications	17	0	0
12	Burn factors	16	6	0
13	Neuropsychiatric factors	12	4	0
14	Poisoning factors	11	2	0
15	Electrical shock	9	0	0
16	Biological factors	8	0	0
17	Terrorist factors	2	0	0

Training is the best and most effective measure for controlling, reducing and eliminating risk, since staff can become aware of their jobs, activities and prevent accidents. In the next step, the damaging parameters were eliminated with the help of experts in each sector as well as the utilization of various technologies or maintenance system. Finally, the use of protective equipment and training on how to use these tools have been taught to airport personnel. It should be noted that the necessary controls were initially carried out for occupations with a higher percentage of incidents, followed by occupations that had a second and third priority. Therefore, the high risks were eliminated or reduced by doing corrective measures as well as medium risks to some extent in a case that the RPN number of each risk is less than the defined range for that class. As seen in diagram 3, the corrective measures have been implemented, high risks have been removed, some of medium risks have been transferred to low risks group and RPNs of the remaining reveal a reduction in their risk percentage.

According to the findings of this research, the problems of Mehrabad airport are not limited to noise pollutions and it also comprises air pollutions. About 170 flights are carried out from Mehrabad airport per day, while each landing or take-off ends in environmental contaminations equal to thousands of automobiles. Time limits of flights are one of the factors that can help the residential neighborhood. Henceforth, the closing time of flights can be declared at 11:00, excluding emergency cases and their opening time is 6:00 AM. Another suggestion is to transfer the airport to another place that requires a long-term schedule. Among all quick arrangements for reducing the airport noise pollution, we can benefit from the tools such as acoustic walls, establishing green spaces, and double-glass acoustic windows.

Also, for removing interior problems of the airport, we can hire well-experienced experts in relating section and informing the personnel about damaging factors of the same section. Moreover, a suitable plan could be designed for acculturation and using engineering tools suitable for the personnel physics. Finally, safety equipment could be used in each section when necessary.

As a result, in those sections which are exposed to chemicals, we face fewer problems if the instructions for maintaining and using chemicals are implemented entirely. But, paying no attention to the regulations or unsuitable use of the regulations mostly causes some problems. For preventing from such problems, it is suggested that the personnel should be firstly trained, especially those who have been hired in these sections beforehand and they should be informed about all necessary cases. Another suggestion is to change the materials which are overused in order to minimize environmental impacts.

Conclusion. This research, aimed at identify and evaluate all activities that may cause danger or have a high risk probability at Mehrabad airport and introduce a suitable framework for its HSE management.

By obtaining expert opinions, all activities were evaluated by William Fine method. Based on the results and compliance with existing standards, the most important risks include the risk of air pollution, noise pollution, ergonomic complications of fall from height which were identified and ranked. In the second phase, by integrating the components of the environmental risk management process with safety management, step by step, their shared areas have been identified. Then, four tools of avoiding, reducing, transferring and accepting were introduced and proposed to reduce damaging factors. Finally, by integrating the expert opinion obtained from standards and William Fine method, an HSE management framework was developed for Mehrabad Airport. The introduced framework can be applied to other airports of Iran.

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CONFLICT OF INTEREST

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

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