JRH
www.jrh.ir

Level of exposure to X-Ray in security gates of Tehran's Imam Khomeini airport

Firouz Valipour[1], Hossein Kardan Yamchi[2], Gholamhossein Pourtaghi[1], Habibollah Dehghan[3], Mohammad Salem[1]

Journal of Research & Health
Social Development & Health Promotion Research Center
Vol. 7, No. 1, Jan & Feb 2017
Pages: 563- 571.
DOI: 10.18869/acadpub.jrh.7.1.563
Original Article

1. Department of Occupational Health, School of Health, Baqiyatallah University of Medical Sciences, Tehran, Iran
2. **Correspondence to:** Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran
Email: hkardan111@yahoo.com
3. Department of Occupational Health Engineering, Isfahan University of Medical Sciences, Isfahan, Iran

Received: 12 Mar 2014
Accepted: 17 Nov 2014

How to cite this article:Valipour F, Kardan Yamchi H, Pourtaghi Gh, Dehghan H, Salem M. Level of exposure to X-ray in security gates of Tehran's Imam Khomeini airport. *J Research & Health*2017; 7(1): 563- 571

Abstract
X-Ray is an ionizing electromagnetic radiation with a wide spectrum. A setting where this radiation is widely used is airport security units. This study was conducted to measure the level of momentary exposure to X-Ray in operators and personnel working in security gates of Imam Khomeini airport. In this cross-sectional study, the X-Ray machines used in security gates of Imam Khomeini airport are HEIMANN. The radiation was measured in both men's and women's inspection units, with curtain down and curtain up when passengers' luggage coming out of the machine, around the machine, operators' seat located half a meter and one meter from the machine. The X-Ray was measured using smartlon. The results were analyzed using t-test, and level of X-Ray was compared to occupational standard limit of American conference of governmental industrial hygienists, 25 μsvh^{-1}. Total mean of X-Ray measured in different positions of HEIMANN machine was 1.02 $\mu svh^{-1} \pm 0.9032$ μsvh^{-1}. The X-Ray measured in men's and women's inspection units was 1.3025 $\mu svh^{-1} \pm 0.985$ μsvh^{-1} and 1.06 $\mu svh^{-1} \pm 0.658$ μsvh^{-1}, respectively. The X-Ray measured in this study was compared to the occupational standard limit using t-test, which indicated a significant difference. Although level of X-Ray in all above cases was lower than the occupational standard limit, any contact with this ray even at low doses may cause complications in humans. Therefore, constant monitoring is essential for maintaining and improving health of airport security staff.

Keywords: Airport, Exposure, Gate, X-Ray

Introduction
Use of technology in developed countries and its importance in developing countries have exposed users to adverse effects of technology [1,2]. Humans have been exposed to natural ionizing and non-ionizing radiations from the beginning of creation. With the advancement of science and technology in various fields such as energy, medicine, industry, education, research, and even household appliances such as televisions, luminous watches and computers, radiomaterials or radiation generators are widely used, and this has

resulted in higher exposure to these radiations [3,4].
X-Ray comprises a part of electromagnetic radiation spectrum and ionizing radiation with a wavelength of 0.01-100 Å (Angstrom) and has been widely used since Wilhelm Conrad Röntgen discovered it in 1895 [5]. The most important distinguishing feature of X-Ray is its penetration ability and ionization in the environment. X-radiations can pass through solid and liquid environments and are thus used for imaging of different body organs [6-8].
X-Ray is also used for radiography of metals and removal of defective parts and fractures from metal pieces [5]. A significant use of X-Ray is the inspection of suitcases and packages such that their content can be well identified without damaging them [9].
Despite many uses of X-Ray, it can be a risk to workplaces and cause serious irreversible damages to people in contact with this ray [10]. The history of radiobiology reveals that the biological effect of rather high doses of radiation was known just after discovery of X-Ray and radioactivity, but the effect of lower doses on humans' health is still ambiguous and under various investigations [11].
The wide use of X-Ray in various jobs necessities special occupational care for personnel exposed to this radiation because excessive exposure may cause ionizing radiation damages. Varieties of cancer, chromosomal anomalies, skin lesions, cataract formation, musculoskeletal disorders, and adverse effects on the thyroid gland, nervous system and gonads are side effects of X-Rays in humans [12,13].
Chronic exposure to low-dose ionizing radiations may influence lymphocytes functioning, especially in secretion of cytokines, such as interleukin 2 [14]. Blood cell count can be used as a measure for assessing damages to the hematopoietic system by ionizing radiation and as a biomarker appropriate for examining radiation-induced damages [15].
Today, potential complications can be prevented using different safeguards in the path of production and radiation of X-Ray and performing various periodical examinations in personnel [16]. A highly important measure for prevention of radiation-induced complications is to constantly monitor and measure the radiation leakage in workplaces, and this should be controlled at the standard limit [17]. It is of special importance to pay attention to the health of people exposed to low-dose ionizing radiation for a long time for occupational reasons. Control and reduction of exposure to different radiations in personnel are undoubtedly subject to making proper decisions and legislating rules and standards for the protection and safety against radiation. In this respect, this study was performed to accomplish continuous monitoring of harmful factors in workplaces and measure the level of X-Ray in security gates of Imam Khomeini airport.

Method

This cross-sectional study was performed to measure the level of X-Ray in security gates of Imam Khomeini airport in summer 2013. The flight control and security unit in every airport is responsible for inspecting passengers and their luggage. Luggage is controlled with HEIMANN using X-Ray for detection in both men's and women's inspection units. There are three persons in each station; one person in position of line controller (in front of the outgoing rail of the machine), one person next to the luggage exit door (releasing the luggage stuck in the machine), and one person as a computer operator (monitoring luggage).
Both men's and women's inspection units in Imam Khomeini airport were examined in this study. Functioning positions of HEIMANN as shown in Figure 1. All measurements were performed using Smartlon device (Figure 2,3). Various positions device is described below:
A) Machine's curtain down: In this case, no luggage is passed through the machine, and protective curtains close the outlet valve of the machine completely (Positions 1, 4).
B) Machine's curtain up: In this case, the luggage comes out of the machine, and protective curtains are held aside in order

that the luggage can exit after being inspected (Positions 2, 6).

C) Around the machine: The top and both sides of the machine without any distance (Positions 3, 5).

D) Place of monitoring: It is the place where the operator is sitting and checking passengers' luggage through a monitor (Position 7).

This study was performed to measure the level of personnel's exposure to X-Ray at different positions of the machine in Imam Khomeini airport.

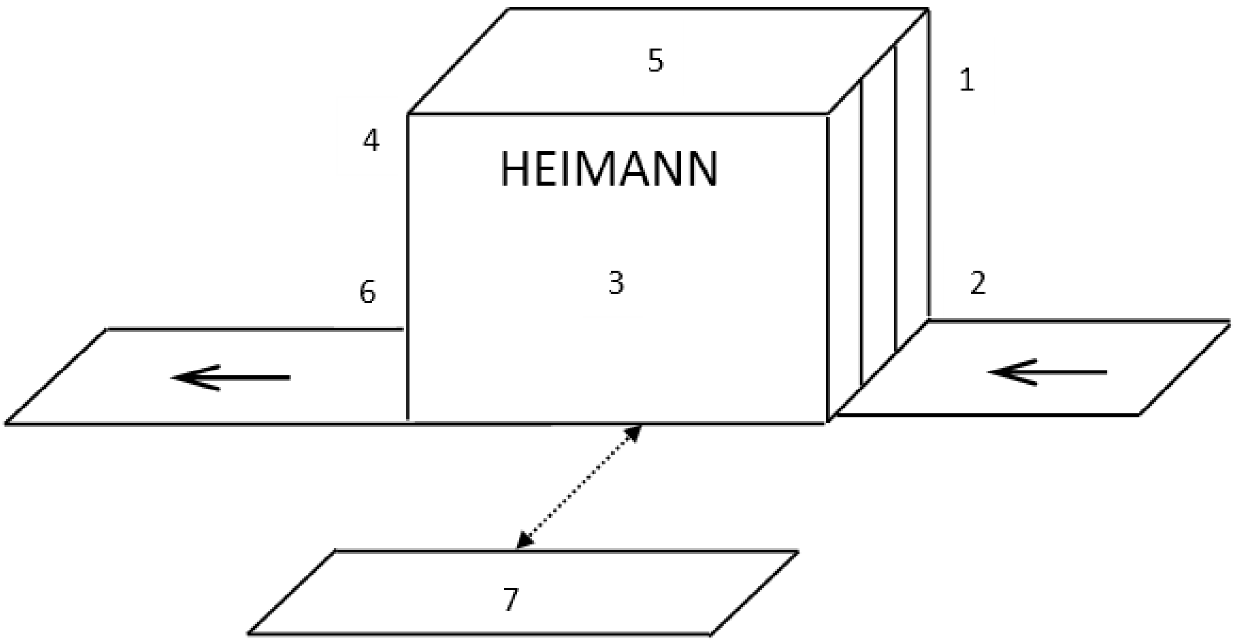

Figure 1 *Position of measurement points at baggage x-ray machines*

Figure 2 *Reading page of smartIon device*

Figure 3 *Measurement page of smartlon device*

The standard level of exposure to ionizing radiation for all personnel contacting with such radiation is 50 mSv per year according to American Conference of Governmental Industrial Hygienists (ACGIH-2012) [18]. Given that each year consists of 50 working weeks, standard dose of exposure per week is calculated as follows:

$$\frac{\text{Standard dose per year}}{\text{Number of working weeks per year}} = \frac{50000}{50}$$

=1000 standard dose per week (μsvh^{-1})

Furthermore, each week consists of 40 working hours, and standard dose of exposure per hour is calculated as follows:

$$\frac{\text{Standard dose per year}}{\text{Number of working hours per week}} = \frac{1000}{40}$$

= 25 standard dose per hour (μsvh^{-1})

Figure 4 *Inspection machine in the bottom of the screen*

The data were analyzed using descriptive statistics, including frequency, percent frequency, mean, graphs, analytical statistics, including t-test, and SPSS-19 in order to compare the level of X-Ray measured in this study with the occupational standard limit.

Results

The results showed that the X-Ray levels in all positions in those stations were lower than the occupational standard limit (25 μsvh^{-1}). The X-Ray measured in this study was compared to the occupational standard limit using t-test, and the results showed a significant difference in this regard ($p<0.05$). Maximum level of X-Ray was measured in the west wing of the airport, 2.ST station, in the men's inspection unit, when curtains were up (3.5 μsvh^{-1}), and minimum level of X-Ray was 0.4 μsvh^{-1} around the machine (3.ST of women's inspection unit & 5.ST of gates 1 & 2 of men's), when curtains were down (4.ST of women's inspection unit), and luggage monitoring at a distance of one meter to men's inspection unit (7.ST) (Table 1). Maximum level of X-Ray measured in the east wing of the airport (3 μsvh^{-1}) was related to Gate 2 of men's (2.ST) when curtains were up, and minimum level of X-Ray (0.4 μsvh^{-1}) was related to luggage monitoring (at a distance of half a meter to machine) of Gate 1 of men's inspection unit (3.ST). Tables 1 and 2 show the results of measurements about HEIMANN machine.

Table 1 *The results of X-rays in the western side Imam Khomeini international airport (μsvh^{-1})*

Row	Station Code	Position sensing	Ray rate			Allowable limite	Position
			Female	Male			
			Gate 1	Gate 1	Gate 2		
1	1.ST	Without distance from the lead screen (down screen)	1.4	1	1	25	Safe
2	2.ST	Without distance from the lead screen (top screen)	1.6	1.8	3.5	25	Safe
3	3.ST	Without distance from Generator (around the machine)	0.4	0.6	0.6	25	Safe
4	4.ST	Without distance from the lead screen (down screen)	0.4	0.6	1	25	Safe
5	5.ST	Without distance from generator (around the machin)	0.6	0.4	0.4	25	Safe
6	6.ST	Without distance from the lead screen (top screen)	1.2	1	2.2	25	Safe
7	7.ST	Location of tools monitoring (a distance of one meter from the device)	0.5	0.5	0.4	25	Safe

Table 2 *The results of X-Rays in the eastern side Imam Khomeini international airport (µsvh-1)*

Row	Station Code	Position sensing	Ray rate			Allowable limite	Position
			Female	Male			
			Gate 1	Gate 1	Gate 1		
1	1.ST	Without Distance from the lead screen (down screen)	1.2	2.1	1.2	25	Safe
2	2.ST	Without Distance from the lead screen (top screen)	2.8	0.8	3	25	Safe
3	3.ST	Location of Tools Monitoring (A distance of 0/5 meter from the device)	0.5	0.4	0.8	25	Safe
4	4.ST	Without Distance from the lead screen (down screen)	1	2	1.1	25	Safe
5	5.ST	Without Distance from Generator (Around the machin)	0.8	0.7	0.6	25	Safe
6	6.ST	Without Distance from the lead screen (top screen)	1.2	1.4	2.3	25	Safe

Mean X-Ray measured at different positions, including curtains up, curtains down, around the machine, and place of monitoring, was 3.8 ± 1.45 µsvh^{-1}, 2.67 ± 1.7 µsvh^{-1}, 1.13 ± 0.175 µsvh^{-1}, and 0.47 ± 0. 58 µsvh^{-1}, respectively. Figure 5 shows mean X-Ray at different positions of the airport security gates. As shown in Figure 5, maximum X-Ray was measured at ST.2 (curtains up at inlet valve) as 2.25 ± 1.01 µsvh^{-1}, and minimum X-Ray was measured at ST.7 (luggage monitoring at a distance of one meter) as 0.467 ± 0.0577 µsvh^{-1}.

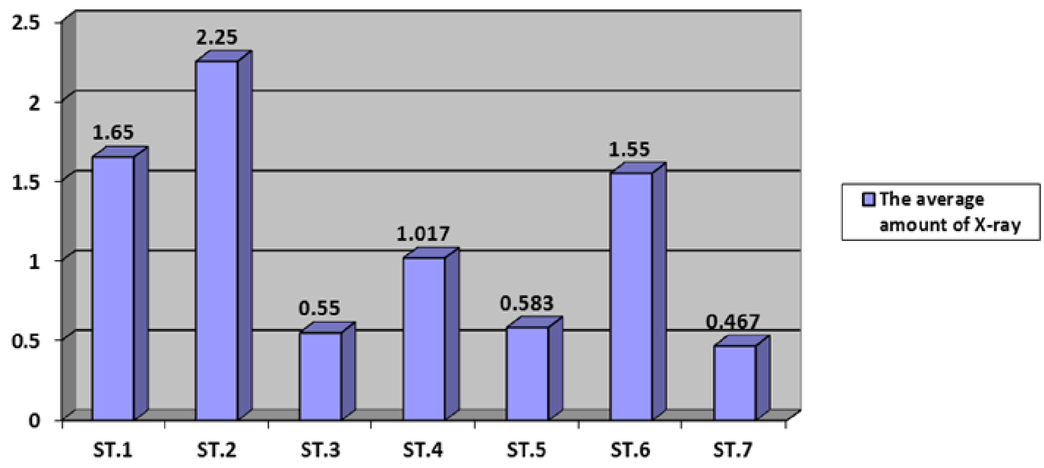

Figure 5 *The average amount of X-Ray in different situations of inspection gates*

Figure 6 shows the level of X-Ray in men's and women's inspection stations. Based on the results, mean X-Ray in men's stations was higher than that in women's stations and comprised 1.3025 ± 0.985 μsvh^{-1} and 1.06 ± 0.658 μsvh^{-1}, respectively. As shown in Figure 2 and 3, comparison of X-Ray in men's stations with that in women's stations revealed maximum level of X-Ray as 1.567 ± 1.366 μsvh^{-1} in Station 1 of men and minimum level of X-Ray as 0.843 ± 0.4826 μsvh^{-1} in Station 3 of men.

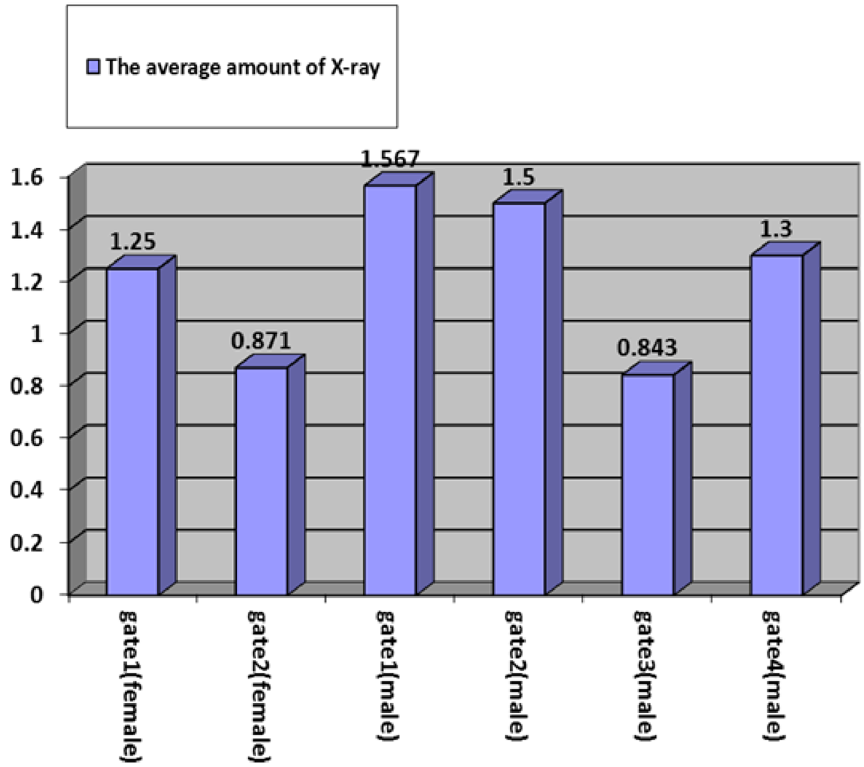

Figure 6 *The average amount of X-ray in male and female inspection gates*

Discussion

According to the results, total mean of X-ray was μsvh-1, and comparison of the total mean with the occupational standard limit (25 μsvh-1) using t-test showed a significant difference in this regard. In other words, the level of X-ray was lower than the standard limit. The results in different situations radiation detector device were significantly different from the standard limit . The results showed that the level of X-ray was lower than the standard limit. Mean X-ray measured in men's stations and women's stations respectively comprised μsvh-1 and 1.06 ± 0.658 μsvh-1, as the higher level of X-ray in men's stations might be due to the fact that men carry larger luggage, and thus, curtains should be wider, and more X-ray exits from the machine. Mean X-ray of all HEIMANN machines in the six security stations was μsvh-1, lower than the occupational standard limit. As seen in figures, maximum dose of X-ray was reported in men's security stations in the west wing of the airport when curtains were up as 3.5 μsvh-1, which was lower than the occupational standard limit (ACGIH-2012). According to J. England et al.'s study on similar machines, X-ray dispersion in the relevant centers was 0-1 μsv, and thus, no carcinogenic effect was observed in this regard [19].

Based on another similar study by NIOSH (National Institute for Occupational Safety and Health) on X-ray machines of L3–TEX–5500, CTX2500 model used in Cincindti, Baltimore, Boston, West Palm Beach, Providence and Miami, the level of X-ray was lower than the standard limit [9]. Zhumadilov et al. also found similar results in a Japanese airport, as their results agree with those of the present study [20]. A study conducted by Arnstein P, et al. on people exposed to constant radiation of X-ray in radiography needed for hand surgeries showed an increase in risk of complications caused by ionizing radiation in those people [21]. An assessment performed by NIOSH in 12 American airports reported that the level of X-ray in 90% of stations was higher than the standard limit, and the level of X-ray in 10% of stations was lower than the standard limit [22].

Conclusion

In general, X-Ray emission while working with X-Ray machines was partial and lower than the standard limit, but this result cannot prove safety of that level of X-Ray. The reason is that working hours of the personnel per day are not always the standard eight hours and sometimes may exceed 12 hours a day, and this can increase the risk of exposures in personnel. Therefore, it is necessary to keep the exposure lower than the daily occupational standard limit, control constantly, train those personnel exposed to rays properly, and formulate relevant instructions in order to maintain and improve health in personnel of security gates.

In this respect, measures, such as controlling and checking X-Ray machines continuously by relevant officers, avoiding entering hands into the machine's compartment, and turning off the machine while bringing out the luggage stuck in the machine, in order to maintain and improve health in personnel of security men's security stations. Moreover, doing examinations before employing personnel, doing periodical examinations (every 6 months), using personal dosimeters, such as film badge, not exposing each personnel to X-Ray more than 8 hours, and preventing pregnant women from working with X-Ray machines are effective in control and reduction of exposure to X-Ray. Use of warning signs and monitoring machines every 5 years also can contribute to prevention and reduction of risks of X-Ray. Future studies are recommended to examine the effects of X-Ray in several airports in Iran and compare the results as in retrospective studies.

Acknowledgements

We sincerely appreciate from Cooperation Imam Khomeini International airport (RA) and all relevant staff and also of Mr Ali Yazdi who needed cooperation and assistance with the aim of field measurements to carry out this study.

Contribution

Study design: VF, PGh, Dh

Data collection and analysis: SM, KYH

Manuscript preparation: KYH, VF, PGh, DH, SM

Conflict of Interest

"The authors declare that they have no competing interests."

Funding

The author (s) received no financial support for the research, authorship and/or publication of this article.

Refrences

1- Abdolmaleki A, Sanginabadi F, Rajabi A, Saberi R. The effect of electromagnetic waves exposure on blood parameters. *Int J Hematol Oncol Stem Cell Res*2012; 6(2): 12-4.

2- Erdal N, Gurgual S, Celik A. Cytogenetic effects of extremely low frequency magnetic field on Wistar rat bone marrow. *Mutation Research*2007; 630(1-2): 69-77.

3- Mazdarani H, Saberi AH. Medical imaging techniques evolution of Roentgen's up to today. 1sted. Tehran: tarbiatmodarres university Publications;1991. PP: 1-4.

4- Ashrafossadat M. Ionizing radiation and their health. 1sted. Tehran: Tehran university publication;1997. PP: 149-50.

5- Harry W, Fischer Joel E, Gray William R, Hendee James G. Quality assurance for diagnostic imaging. National council for radiation protection & measurements report No.99. National council on radiation protection & measurements. Available atURL: http://www.ncrppublications.org/Reports/099.2006.

6- Mazdarani H. Practical protection Against radiation and applied radiobiology Tehran. Tarbiatmodarres university publications; 2004. PP: 33-41.

7- Thomas RH, Brackenbush LW, Dietze G. Conversion coefficients for use in radiological protection against external radiation. Adopted by the ICRP and ICRU in September 1995. *Ann ICRP*1996; 26(3-4): 1–205

8- Shapiro J. Protection of the patient in X-Ray diagnosis. Radiation protection: a guide for scientists, regulators, and physicians, fourth edition. Available atURL: http://www.icrp.org/publication.asp?id=ICRP%20 Publication%2016. ICRP Publication, 1999: 16.

9- Hupe O, Ankerhold U. Determination of ambient and personal dose equivalent for personnel and cargo security screening. *Radiat Prot Dosimetry*2006; 121(4): 429–37.

10- Bashore T. Fundamentals of X-reimaging and radiation safety. *Catheter Cardiovasc Interv*2001; 54(1): 126-35.

11- Shabestanimonfared A, Jalali F, Mozdarani F, Haji ahmadi M. The inhabitants health status in high and low natural background radiation areas in Ramsar, north of Iran . *Journal of Gorgan University Medical Science*2004; 6(1): 23-8 .

12- Gorson RO , Brent RL, Moseley RD, et al. Medical radiation exposure of pregnant and potentially pregnant women.1977. Report No: 054. Available at URL: http://www.ncrppublications.org/Reports/054

13- Committee on the biological effects of ionizing radiation (BEIR V), national research council. Health effects of exposure to low levels of ionizing radiation. Washington, D.C.: National academy press; 1980 .

14- Kalamzadeh A, Keihani A, Hajati J, et al. Total plasma level of antioxidant and immune system function in radiology and nuclear medicine staff. *Tehran University Medical Journal*2007; 65(9): 13-9.

15- Tavakkoli MR, Moradalizade M, Ananisarab GhR, Hosseini SM. Evaluation of blood cell count in the radiology staff of Birjand Hospitals in 2011. *Modern Care Journal*2012; 9(2): 80-6.

16- Gorson RO, Raventos A, Keasey D, Raymon Wu. Structural Shielding Design and Evaluation for Medical Use of X Rays and Gamma the Rays of Energies up to. Office of the federal register washingt. Available at URL: https://law.resource.org/pub/us/cfr/ibr/005/ncrp.49.1976.pdf. 10Mev.1976.

17- Périard MA, Chaloner P. Diagnostic X-Ray imaging quality assurance: an overview. *Can J Med Radiat Technol*1996; 27(4): 171-7.

18- Hsu FY, Lee WF, Tung CJ, et al. Ambient and personal dose assessment of a container inspection site using a mobile X-Ray system. *Appl Radiat Isot*2012; 70(3): 456–61.

19- England GCW, Keane M. The effect of X-radiation upon the quality and fertility of stallion semen. *Theriogenology*1996; 46(1): 173-80.

20- Zhumadilov K, Stepanenko V, Ivannikov A, et al. Measurement of absorbed doses from X-Ray baggage examinations to tooth enamel by means of ESR and glass dosimetry. *Radiat Environ Biophys*2008; 47(4): 541–5.

21- Arnstein PM, Richards AM, Putney R. The risk from radiation exposure during operative X-Ray screening in hand surgery. *J Hand Surg Eur*1994; 19(3): 393-6.

22- Achutan C, Mueller C. Health hazard evaluation report on evaluation of radiation exposure to TSA baggage screeners. Washington, DC: NIOSH, health hazard evaluation report; 2008.