

# **Research Paper** Evaluation of Infrared Radiation and Occupational Cataracts in Bakeries in Qom Province, Iran

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# ABSTRACT

**Background & Aims of the Study:** Nowadays, ionizing and non-ionizing radiation seems to have a vital role in all aspects of human life. However, radiations such as infrared radiation (IR) adversely affect the human visual system. This study aimed to evaluate IR exposure and occupational cataracts in the selected traditional and automatic bakeries in Qom Province, Iran.

**Materials and Methods:** This cross-sectional study was conducted in traditional and modern bakeries with 306 workers. Demographic data were collected using a demographic questionnaire. IR measurement was done using the Hagner EC1-IR digital radiometer at the eye height and in the first and last hours of the workday. The obtained data were analyzed with statistical tests of the Chi-square, Fisher exact, 1-way ANOVA, and independent t test in SPSS software v. 20.

**Results:** According to the obtained results, 16.1% of the workstations had a high level of exposure to IR, and 20.3% of workers were suffering from cataracts. The results showed a significant correlation between the exposure level and jobs as well as tasks and working hours (P<0.05). Also, a significant correlation was observed between the risk of cataracts and the exposure level, workstation type, age, and experience (P<0.05). However, no significant difference was observed between the type of bakeries and the risk of cataracts (P=0.59).

**Conclusion:** Based on our findings, nearly one-sixth of the surveyed stations were higher than the standard limit in terms of IR measurement, and nearly one-fifth of workers were suffering from cataracts. The results indicated that due to the long-term exposure of bakery workers to IR, it is necessary to plan and implement effective control measures in bakeries.

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# 1. Introduction

umans in their life are exposed to many types of radiation, including ultraviolet radiation [1, 2], background radiation [3], microwaves [4, 5], and radon [6-8]. Nowadays, ionizing and non-ionizing radiation seems vital in all aspects of human

life, for example, in diagnostic and therapeutic activities [9]. However, besides its constructive role, radiations such as infrared radiation (IR) have significant adverse effects on the ecosystem and humans [10-12].

IR is a part of the non-ionizing radiations of the electromagnetic spectrum. It originates from any object with a temperature above absolute zero. This type of radiation is in the spectrum range between radio frequency and visible light, and its wavelengths are between 750 nm to 3 mm with 3 ranges, including A, B, and C [13]. Although IR has not been classified as dangerous radiation, prolonged exposure to this radiation can lead to adverse effects, especially on the visual system. Because the lens of the eye contains no blood vessels, it absorbs the heat resulting from the radiation and eventually leads to damage to the eye's lens and vision function [13, 14]. Researchers have documented adverse effects from exposure to IR on the human visual system, such as damage to the cornea and lens [13-18]. Previous studies on the effects of IR on the visual system have shown that visual damage is related to the dose of radiation exposure [15, 16], and cataracts usually occur after chronic exposure [16].

In addition to the sunlight as a natural IR source, workplaces, especially hot processes, are considered artificial IR sources [13]. Bakery is considered one of the hot processes. This job in Iran usually involves traditional organization and is associated with direct exposure to furnace fire and heat (Figures 1-3). Previous studies have examined the subjects such as the evaluation of heat stress in bakeries [19-22], the assessment of the thermal stress and strain caused by heat sources in various occupational environments [23], and the effects of heat on the reaction time and performance [24]. In addition, the literature had documented occupational visual system injuries and diseases resulting from work related to heat sources as well [17]. Similar clinical and epidemiological research among workers exposed to a high level of IR in industries such as glass making and foundry had confirmed significant health risks [25] and cataracts [26]. Workers exposed to high ambient temperatures have a 2.5% higher risk of losing 30% of their vision due to cataracts

than people in the same age group who are not exposed to high-temperature stress [27].

Occupational exposure of bakery workers to heat has been investigated in several studies. However, we cannot find much research on the evaluation of occupational exposure to IR, especially in developing countries such as Iran. About 72000 bakery units are working In Iran, and about 250000 persons are directly active in these units. Considering the dietary pattern of the Iranian society (high consumption of bread) and many people who are engaged in this job, it is vital to evaluate IR levels and related outcomes such as cataracts [28]. Because of the long-term exposure of the bakery workers to IR, its health risk, and the lack of sufficient literature about radiation exposure among bakery workers, it is essential to evaluate the exposure and its control.

The present study was designed to determine the exposure to IR and evaluate related outcomes such as cataracts in the selected bakeries of Qom Province, Iran.

# 2. Materials and Methods

This cross-sectional study was conducted in the traditional and automatic bakeries in Qom, Iran. At first, after inquiries to the Union of the bakery in Qom City, the number and location of all bakeries were determined based on the traditional and automatic structure (350 units for Sangak, 248 units for Lavash, 167 units for Barbary, and 36 units for white bread, totally about 2500 people). Then, 306 workers in 102 bakeries with different bread products, such as traditional thin bread (Taftoon, Lavash), traditional thick bread (Sangak, Barbary), and white or automatic bread, were selected randomly using multistage sampling and recruited in our study. Demographic data about the workers were collected using a demographic questionnaire. After that, the workers' exposure to IR was measured in different locations of the bakeries using a Hagner EC1-IR digital radiometer. Based on the measurement protocol, the device photocell was set in the direction of the radiation source (grill or ovens). To reduce the side effect of the sun's IR on measurement protocol, the measurement times were set during the night; otherwise, the early or late hours of the day.

According to the latest edition of occupational exposure limits in Iran (2021), to avoid damage to the cornea and lens, IR exposure in scorching environments and for a long time (1000 s and higher) is limited to 10 mW/cm<sup>2</sup>; hence, this limit was used to evaluate the exposure [13].



The relationship between occupational exposure to IR and cataracts was finally investigated, and based on our findings, control measures were recommended.

Obtained data were analyzed by the Chi-square, Fisher's exact, 1-way ANOVA, and independent t test using SPSS version 20 software. All subjects with previous diseases due to cataracts or any general visual disturbances were excluded from the study. Also, all people over 60 years old were excluded from the study.

## **3. Results**

The age range of the workers was between 16 and 58 years, with an average of  $35.47\pm10.41$  years. In the studied bakeries, 33.7% of workers were working as bread makers, and 32.4% and 33.7% were working at the whipping, and bread sticks stations, respectively. The average working hours per day were  $9.72\pm1.42$  h, and 77.1% of workers worked more than 8 hours during the day. The average work experience was  $8.2\pm5.77$  years. Table 1 presents a descriptive analysis of demographic variables in studied workers.

The obtained results about occupational exposure to IR revealed that the average exposure was 6.96±4.07 mW/ cm<sup>2</sup>, and the minimum and maximum of exposure were 0.2 mW/cm<sup>2</sup> related to whipping station in thin bread (Tafton/Lavash) and 22.5 mW/cm<sup>2</sup> related to the bread-sticking station in thick bread (Sangak), respectively. The survey showed that 16.7% of the workers were exposed to radiation higher than the allowable limit. Also, 45.1% of each bread-making and bread sticking station exceeded the allowable exposure limit. Also, 20.3% of the studied workers had experienced cataracts. Bakers with direct exposure to fire/heat or in the vicinity of grill/ oven had a higher rate of cataracts.

The results showed a significant difference between exposure to IR and bakery type (P<0.001). About 66.7% of stations with radiation levels higher than the allowable exposure limit were related to the traditional thick bread (Sangak) bakery. Then thin bread bakeries (Tafton/Lavash) with 25.5% of the total stations with radiation levels higher than the allowable exposure limit were in the second stage. A significant correlation (P=0.001) between the workstation and the exposure level to IR was observed. Also, 9.8% of the stations with radiation levels higher than the allowable exposure limit were related to whipping stations, and others related to bread makers and bread stickers, equal to (45.1%). White bread stations levels because of their modern equipment. However,

this type of bakery in developing countries such as Iran is rare. According to our study, a statistically significant correlation was observed between the level of IR with training courses in the field of occupational health (P=0.02). Training courses (on-site and off-site) have made employees aware of the dangers and changed their unsafe work behaviors. Also, the results showed that 68.6% of workers exposed to excessive allowable limits had no proper training courses (Table 2).

This study showed a statistical correlation between exposure to IR and the risk of occupational cataracts (P<0.001). According to the results, people with cataracts were exposed to IR at a rate of  $8.61\pm3.82$  mW/cm<sup>2</sup> on average. Also, a significant relationship was found between workstations and cataracts (P<0.001). In addition, no significant correlation was observed between the type of bakery and cataract risk (P=0.59) (Table 3).

The results showed that the relationship between exposure to IR and working hours was significant (P=0.01). Also, the results revealed that the average working hours for workers with exposure higher than the allowable limit was  $10.17\pm0.95$  hours. In addition, the difference between the risk of cataracts with age and work history was significant (P<0.001). Workers with cataract injuries, on average, had a work history equal to  $12.08\pm4.53$  years.

## 4. Discussion

Based on our findings, nearly one-sixth of the surveyed stations were higher than the standard limit in terms of IR measurement, and nearly one-fifth of workers were suffering from cataracts. In a study conducted by Hok-mabadi et al. in 2014 in Bakeries located in the north of Iran, the results indicated that the level of IR was lower than the limit [28], which is incompatible with the results of this study. This conflict seems to be caused by



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Figure 1. Traditional bread in Iran (Barabaray)





Figure 2. Traditional sread in Iran (Tafton/Lavash)

the type of user device, the distance of the device when measuring from the resources, and measurement methods. Based on the relationship between occupational exposure to IR and the type of bakery and workstations, it was revealed that the level of IR exposure was related to the type of bakery and workstations. Because of traditional styles of work as well as work station design and procedures, most of the workstations with IR levels higher than the allowable limit were related to thick bread bakeries (Sangak) and bread makers and bread stickers. Given that the bread makers and bread stickers were required to locate near to furnace or grills based



on their work demand, they were much more exposed to the heat and IR. Some of the research was similar to the present research. Majidi et al. conducted a study to assess exposure to IR in aluminum and iron castings industries in Zanjan City, Iran; their research showed that all occupational exposure of workers to IR was beyond the allowable limits [25]. However, due to the thermal effect of IR on the cornea and lens, exposure management such as increasing distance from the sources and personal protective equipment application should be considered. Also, research in two traditional glass factories in Italy similar to our findings indicated that ex-



Figure 3. The most famous traditional bakeries in Iran (Sangak)





Variables	Levels	No. (%)
	Lower diploma	191(65.41)
Level of education	Diploma	100(34.24)
	Higher than diploma	1(0.34)
Usuar of usual	8≥	65(21.2)
Hours of work	8<	236(77.1)
	Tafton/Lavash	137(44.8)
Decedence	Sangak	99(32.4)
Bread type	Barbary	65(21.2)
	White	4(1.3)
	Bread maker	103(33.7)
Job	Kneader	99(32.4)
	Bread sticker	103(33.7)
	Yes	62(20.3)
Eye disorder (Cataract)	No	240(78.4)
	Yes	139(45.4)
Iraining in the field of occupational health	No	165(53.9)
	Yes	172(56.2)
Awareness of the dangers of the Job	No	130(42.5)
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#### Table 1. Descriptive analysis of demographic variables in studied workers (n=306)

posure to IR was beyond the allowable limit in some workstations. The researcher expressed the requirement for eye protection in this study [29].

In the present study, a significant relationship was observed between exposure to IR and the risk of cataracts. In this regard, epidemiological studies suggest that longterm exposure to the human eye may cause damage to the visual system and the incidence of cataracts [16-18]. The results of studies conducted among welders and steel industry workers confirmed the results of this study. In addition, surveys among welders confirmed the relationship between exposure to radiation such as IR and the risk of eye diseases such as cataracts and corneal inflammation. The results of this study are consistent with their results [30, 31]. The study conducted by Sharon et al. also confirmed the results of this study and suggested that duration of exposure was identified as a critical risk factor for eye damage in bakers [17]. A significant relationship was observed between individual workstations, and cataract occurrence due to high exposure to IR in the bread-making workstation, justifying a higher rate of cataract occurrence than in other workstations. In addition, daily working hours and training in the field of occupational health were associated with exposure to IR. Also, inadequate training and lack of awareness about IR, as well as its harmful effects on the eyes and skin, contributed to exposure levels to IR in bakeries [32].

From the viewpoints of the effects caused by the IR absorption on the cornea and lens of the eye shown in epidemiological studies, it is essential to use personal protective equipment for eyes in jobs such as bakeries, especially traditional bakeries [33, 34]. Finally, according to the obtained data, occupational exposure to IR resulting from furnaces and ovens in the bakery job, similar to other major industries such as glass making



Table 2. Relationship between exposure to infrared radiation and bread-type production, workstation, and health education in (n=306)

Variables	Lovala	Percentage of Exposure		D
	Leveis –	≤10 mW/cm²	>10 mW/cm <sup>2</sup>	- P
Type of bread	Tafton/Lavash	49.8	25.5	
	Sangak	23.9	66.7	
	Barbary	24.7	7.8	<0.001
	White	1.6	0	
Workstation	Bread maker	31.2	45.1	
	Kneader	37.7	9.8	0.001
	Bread sticker	31.2	45.1	
Training in the field of occupational health	Yes	49.2	31.4	0.02
	No	50.8	68.6	0.02

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and foundry, should be highly considered, and more efficient control measures are crucial to reduce the exposure of workers [35, 36]. Applying control measures such as engineering, administrative controls, and finally, using appropriate personal protective equipment can reduce workers' exposure levels and the risk of diseases associated with radiation from the furnace or oven radiation, especially IR [37, 38]. Reducing the reflective surfaces in the workplace can effectively reduce the IR reflection, especially in the vicinity of furnaces and ovens for bread production [39, 40].

# **5.** Conclusion

Based on our findings, exposure time can be affected by radiation exposure, and most of the studied workers worked more than 8 hours per day, so reducing the working hours and work rotation plans can be effective in occupational IR exposure control. Training programs on IR and its effects on human health, exposure management, and medical examinations, as well as short courses for bakeries workers, are recommended. Finally, the use of IR shields and suitable/usable eye protection can have an effective role in reducing the exposure level and the risk of eye diseases among bakery workers.

Table 3. Relationship between occupational cataracts of the studied workers with workstation and the type of bakery (n=306)

Variables	Levels –	Cataracts		
		Yes	No	— P
Workstation	Bread maker	45.8	51.5	
	Kneader	0	100	<0.001
	Bread sticker	12.7	87.3	
Type of bread	Tafton/Lavash	46.8	44.8	0.59
	Sangak	27.4	33.5	
	Barbary	25.8	20.1	
	White	0	1.7	
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# **Ethical Considerations**

Compliance with ethical guidelines

This research was approved and registered at Qom University of Medical Sciences No. P/34/19953.

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This study was carried out and plan approved by the Deputy of Research and Technology of Qom University of Medical Sciences.

#### Authors' contributions

All authors equally contributed to preparing this article.

#### Conflict of interest

The authors declared no conflict of interests.

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