Exposure to Solar Ultra Violet among Taxi Drivers in Damghan Area in 2016: A Cross-Sectional Study

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ABSTRACT
Ultraviolet emission from sun considered as a hazardous parts of optical waves. This study aimed at determining exposure to ultraviolet radiation among taxi drivers in Damghan. A cross-sectional survey was conducted on a sample of taxi drivers. Individual exposure to solar ultraviolet-A was assessed during day light working hours. Exposure was determined on the basis of radiation intensity and biologically cumulated standard erythema dose. Our findings showed that exposure was varied in terms of time and geographical sites. The exposure intensity ranged from 0.01 to 15.36W/m^2 and from 1.42 to 28.7W/m^2 inside and outside the vehicles, respectively. Drivers had the highest exposure from June till August (17.54W/m^2). Results showed lower exposure in April, May, and September (12.34W/m^2). Cumulative exposure based on erythema dose showed the highest value (41.0 SED) inside vehicle at 9-10 am intervals. Taxi drivers are exposed to significant ultraviolet radiation. Geographical situation and time caused variations in exposure. Future studies should focus on the health effects so that determine the risk of exposure more accurately.

Key words: Solar Ultraviolet, Occupational Exposure, Drivers

INTRODUCTION
UV (ultra violet A) is classified in the non-ionizing and optical radiations [1, 2]. The UVA, a part of the electromagnetic spectrum, emits naturally from the sun [2, 3]. The wavelength ranges 100-400nm. UV radiation includes UVA (320-400nm), UVB (290-320nm), and UVC (200-290 nm). Approximately, 100% of UVC and 90% of UVB are absorbed by the ozone layer, humidity, oxygen, and carbon dioxide in the atmosphere [4, 5]. Therefore, exposure to UVC reaching from sun to earth is negligible comparing to other types of this radiation [3]. Contrarily, about 95% of UVA solar emission reaches to the earth surface [6]. This type of radiation is applied in medical treatment. Review of studies indicated that environmental exposure ranges from 290 to 400nm [3]. Biological effects mainly depend on the type, exposure, and the intensity of UVA radiation [1]. Among the various components of solar radiation received in the atmosphere UVA radiation has the most adverse effect on the human body [7]. UVA radiation has been considered as an environmental risk factor [8]. Exposure assessment indicated that extreme outdoor exposure to UVA may result in visible skin-color changes among skiers [9].
UVA radiation can lead to different exposure conditions in the latitude, season, time, weather, and ozone layer [10]. Moreover, the factors such as weather conditions, altitude, radiation angle, location, and season could affect the amount of UVA exposure [11]. The exposure to UVA radiation has considered as the main cause of skin cancer [12]. Despite the positive and negative uses of solar radiation, the incidence of skin cancer has been reported more frequently among the male population in the occupational exposures [13]. Previous report indicated that workers engaged in outdoor activities may receive excessive exposure [4]. Research reported that working population engaged in construction, transportation and agriculture sectors may receive UVA excessively [14]. Despite attempts were made in everyday life to avoid excessive exposure to UVA radiation, but occupational exposure to outdoor UVA radiation may lead to an excessive health risk [14] and mainly increase the risk of skin cancer [13].
A study in Australia reported solar UV exposure as a carcinogen to road transport workers [15, 16]. A previous exposure assessment study concluded that

the increasing use of artificial sources of solar energy has caused exposure to UVA wavelength particularly in beauty and skin discoloration salons [3]. In addition, increased air pollution in the high-traffic urban and industrial environments has intensified a possibility of exposure to UV radiations [4].

Environmental UVA Exposure has been regarded a potential hazard to skin, leading to cancer [17, 18]. Human skin exposure to UVA may cause short-term and long-term sunburn reactions and photo aging consequences. UVA radiation and its effects on skin is a major issue, causing the skin aging, sunburn, precancerous, and cancerous lesions [5]. Further, UVA radiation may affect eyes and immune system [10]. Previous study revealed gradual and chronic effect of UVA radiation. This indicates cumulative nature of hazardous radiation in frequent exposures [3]. There has been an estimation of annually increasing solar UV in the atmosphere as reported by the World Health Organization [5]. The long wavelength of UVA radiation facilitates penetration by almost 50% exposing retinal layers of the eyes [3]. Previous studies extensively reviewed the impact of solar radiation on skin effects. However, research on accurate exposure estimations was rare in different occupational groups particularly among professional drivers. This study attempted to determine the extent of exposure to UVA among the taxi drivers. We also assessed the intensity of exposure and related work and environmental factors on UVA exposure among drivers. The information obtained from this study can be used to present the appropriate solutions to reduce the exposure and prevent the adverse effects of occupational exposure and also improve the working efficiency of people.

MATERIALS AND METHODS

Design and subjects

This is a descriptive cross-sectional study that was conducted in Damghan urban area from April to September in 2016. The climatic condition Damghan is desert climate with 1160 altitude and average temperature annually 15.4℃. The subjects were taxi drivers working within the urban area. The registered taxi drivers were 386 working in the urban area. Inclusion criteria in the present study were the agreement for cooperation to participate in the study and the drivers who have been normally worked during working hours 9 am – 3 pm. Taxi drivers were selected in three main various routes. Sampling and measuring locations were determined within 500 meter intervals of the driving routes with a cruise length of around 15 kilometer. Sampling and measurement were repeated five times per day and three days per month for every single location. Totally, 33 locations were chosen and 5940 samples were taken for assessing exposure assessment. Sampling and measurement were conducted inside and outside of the vehicle for each location. The studied dependent variable had been the exposure rate to UVA radiation that has been measured (W/m^2). The studied independent variables included the exposure time in different working shifts and months. The sampling and evaluation are performed during taxis activities and traffic in different routes of the city. Accordingly, the sampling and measurement of traffic in all parts of the city have been estimated.

Samples were collected during the solar UVA radiation in the environment. The exposure was measured according to the relevant biological effects [19]. Therefore, the Standard Erythema Dose (SED) exposure was determined [19, 20]. The effective exposure is equal to 100J/m^2, which is based on standard erythema dose [21].

Exposure measurement

Sampling and measurements have been conducted on a daily basis and exposure estimation in timespan of ٩ am- ٢ pm for taxi drivers. In order to measure exposure of drivers to UV radiation, the measuring device was placed inside and outside of the vehicle, and the exposure was recorded at various hours. The sampling and measurement of exposure to UV for drivers are measured with regard to the type of traffic in the whole city. According to preliminary study, each driver is exposed to UV radiation on an average of eight hours per day. The exposure of drivers to UVA radiation is performed by UV meter (EC-1 model) made by HAGNER in Switzerland. Before sampling, using the manufacturer's proposed method, the device is calibrated in terms of accuracy and precision.

All the measurements were taken during sunny and clear sky. Sampling and measurements in the car while the car windows are open and the device horizontally on the driver's shoulder have been done. And outside of the vehicle at a distance of 0.5 meters from the car was done. The previous study showed that 75% of the UV exposure is between 9-15 hours [2, 22]. Accordingly, In a preliminary study we determined the working hours of drivers and accordingly samples were taken at period intervals of 9-1٠, 1٠-11, 11-12, 12-13, and 13-14 (solar time, not local time).

Statistical Analysis

The radiation exposure is measured based on radiation intensity (W/m^2), and cumulative exposure is measured based on standard erythema dose (SED). In order to evaluate the exposure, the average measurements are calculated. The results are also compared with occupational exposure limits provided by the ACGIH. The acceptable exposure limit was proposed at 1.04w/m^2 by the Conference of States for exposure to UVA [4]. Data analysis was processed in a descriptive manner. The minimum, maximum, mean and standard deviations were determined to describe UVA environmental exposure.

Ethical consideration

Taxi driving organization was informed about the research purposes and their permission was obtained.

RESULTS

The results of this study reported the intensity of radiation inside and outside the vehicles. Sampling and measurements were conducted according to the usual street traffic and working habits of professional taxi drivers in the urban area. Maximum, minimum, mean and standard deviation of the UVA intensities inside and outside vehicles during the spring and summer are given in Table 1. According to data, the average exposure to radiation in outdoor was 20 times more than the indoor.

Table 1: The intensity of radiation UVA (W/m^2) inside and outside the vehicle during the spring and summer (2016).

Sampling location	Intensity			
	Max.	Min.	Mean	Standard deviation
Inside vehicle	15.36	0.01	0.75	1.2
Outside vehicle	28.7	1.42	15.08	5.89

Average intensity of UVA in the spring and summer of the year is shown in Fig. 1. As indicated the maximum exposure to radiation outside the vehicle was in June and July. Findings showed high indoor exposures in April, May and September. The exposure rates remained steadily at lower levels in other months.

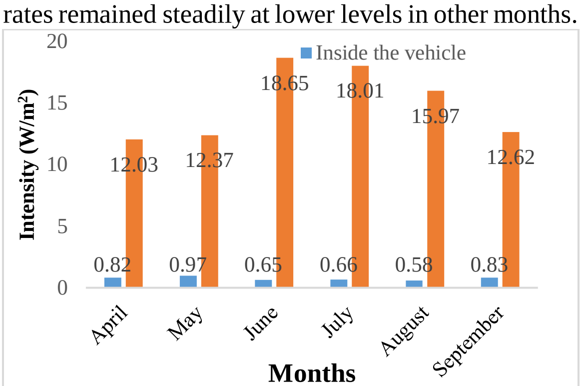

Fig. 1: The average intensity of UVA exposure during the spring and summer.

As shown in Figs. 2 and 3, higher rates of SED were determined at 9-10 hour interval. Furthermore, the maximum radiation intensity levels outside the vehicles were obtained at 12-13 hour interval. The higher exposure to radiation was measured inside the vehicle in spring. Our measurement indicated higher outdoor intensity of radiation in summer.

Our study determined a broad exposure range of UV radiation outside the vehicle from a minimum level of 2165.4 ± 691.2 SED to a maximum level of 3357 ± 1074.6 SED at maximum, and the total mean estimated at 2689.5 ± 380.04 SED.

In Fig. 4, the mean and standard deviation were measured inside and outside the vehicle, and the maximum standard deviation inside and outside the vehicle was in September and July, respectively. The minimum values inside and outside the vehicle were determined in August and April, respectively.

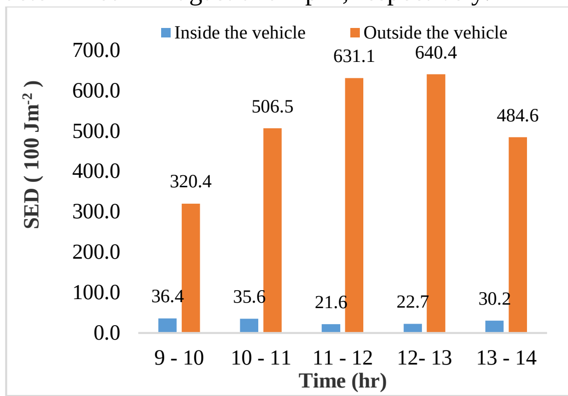

Fig. 2: The average exposure to UVA light intensity in SED among taxi drivers at different times of day in the spring.

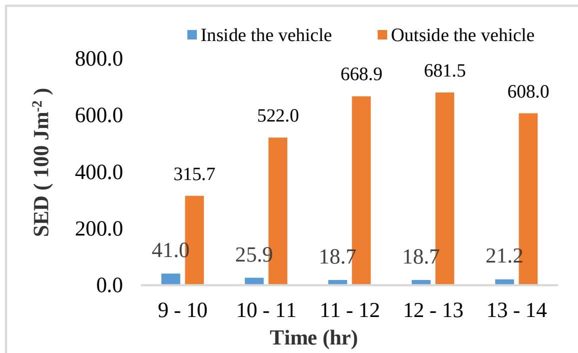

Fig. 3: The average exposure to UVA light intensity in SED among taxi drivers at different times of day in the summer.

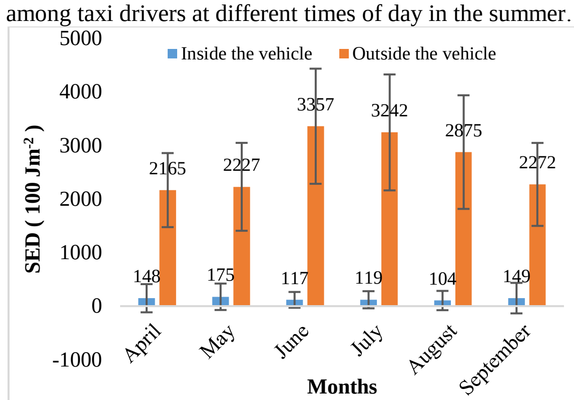

Fig. 4: The mean and standard deviation of exposure to UVA light intensity in SED from April to September.

In Fig. 5, the average radiation intensity levels outside and inside the vehicles are shown by white and black spots, respectively. Since the average radiation intensity levels inside the vehicle are insignificant compared to outside, the average intensity values inside the vehicle are magnified five-folded in scale.

UVA exposure measurements revealed variations in terms of various locations in the urban areas. The exposure trend revealed a gradual trend when moving from the East to the West part of the city.

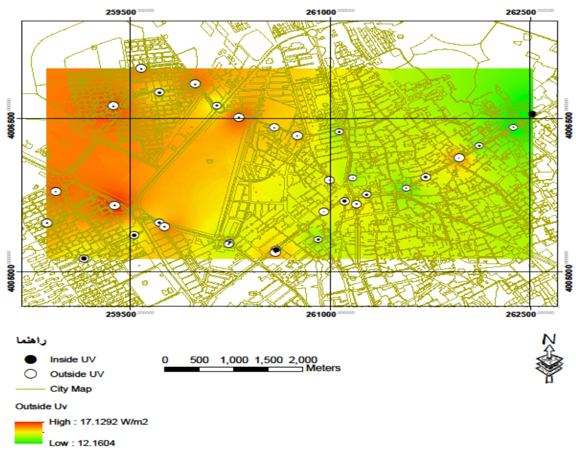

Fig. 5: Distribution, location and intensity of UVA rays in the spring and summer.

DISCUSSION

This study assessed exposure to environmental UVA radiations among taxi drivers. The key finding of the study was remarkable fluctuations in UVA exposure among taxi drivers which depends on the routes, seasonal location, and daily hours. Furthermore, in the present study Zenithal sun exposure had the highest measurement in June and July. This resulted in higher intensity outdoor solar UVA exposure [10]. However, the UVA intensity exposure was notably decreased inside the vehicle. Previous environmental assessment reported the highest daily exposure to UVA radiation in July, which is roughly in agreement with this study [23]. However, the intensity levels inside the vehicle at noon around 11-13 intervals were decreased compared to other daily hours. This could be contributed to the incident angle of sun light which is perpendicular to the vehicle's roof [4, 23].

ACGIH recommended the standard exposure limit for eight hours of exposure to UV radiation at 1.04W/m^2 level. Accumulated exposure limit was proposed as (1.04W/m^2 *(3600sec*5 hour)/ 100(j/m^2) /SED=187.2 SED [4]. The results of this study showed that the exposure of taxi drivers to UV is 104.4±180 SED at minimum and 174.6±246.6 SED at maximum, with the total average of 89.84±135.3 SED. [19]. In our study taxi drivers' exposure to UVA did not exceed the proposed SED exposure criterion. In the previous study UV exposure assessment in Valencia reported an average of 22.86 SED among lifeguards [24], and 32.24 SED among cyclists during the summer [19]. Our study revealed that average exposure of taxi drivers to UV radiation increased by 3.9 and 2.78 times as compared to lifeguards and cyclists, respectively. This variation might be attributed to different work practice patterns and regional meteorology. The findings of previous studies have estimated various exposures to UV. Different estimated exposure values might be attributed to radiation measurement method, and dosimeter position in terms of horizontal or vertical sampling and measurement.

Epidemiological and case-control studies have documented causal relationship between solar radiation and skin cancers. There was a link between continuous exposure to sunlight and skin disorders. However, interrupted exposure was not related to solar skin symptoms [2]. This study indicated remaining inside the vehicle could reasonably decline UVA and therefore could lead to remarkable lowered skin risk.

Measurement radiation UVA in Valencia reported 87.93 SED in the summer, which is significantly lower than the average SED result in our study. This variation might be due to the different geographical altitude of Damghan and Valencia as the altitude was 1160 and 60m, and latitude was 36.1 and 39.28, respectively [19].

Urban traffic and resulted air pollution has been considered a factor that may increase UVA exposure. This might be related to depletion of ozone layer in the atmosphere [4].

Previous researches reported the lowest intensity environmental exposure levels during spring and summer in Ahvaz and Hamadan. These results were in agreement with our finding which determined the minimum exposure levels in spring and summer. The highest intensity levels of environmental exposure were reported in Ahvaz and Hamadan in June and September, respectively [11, 25]. Similarly, in our study the highest level was measured in June. Compare to our study, the higher intensity levels in above-mentioned cities might be attributed to latitude variations and sampling position. The latitude of Ahvaz is located 5 north degrees lower than Damghan, and the position of detecting sensor was directly toward sun in Hamedan study that might result in data variations. This study revealed an increasing trend of environmental UVA exposure while moving from the eastern to the western part of the urban area. This could be justified by the canopy of trees acted as a barrier to excessive radiation.

Effect of UV radiation on skin burns or corneal inflammation depends on wavelength of the light. The threshold limits value of UV exposure proposed by American Conference of Industrial Hygienists (ACGIH) approved by International Commission on Radiation Protection (ICRP). In occupational exposure protecting the lens and retina from excessive UVA radiations, the non-weighted exposure rate in daily exposure of 17 minutes should not be less than

1J/cm^2 or 104J/m^2. Exceeding daily exposure from 17 minutes, the intensity of UVA should be limited to 10 W/m2 [26]. The results of this study showed that the exposure inside the vehicle is not up to the point to cause the potential risk for retina and lens damage. However, outside vehicle exposure exceeded the safe limit and thus may be considered a potential danger to health.

According to the previous study UV exposure would be decreased in autumn and winter and we also predicted a lower and moderate exposure levels for taxi drivers in these seasons. This study did not investigate in autumn and winter of the year, since the exposure conditions of taxi driver are different, moreover, based on the calculation, the evaluation and analysis of the spatial distribution of UV in autumn and winter was moderate for Damghan, indicating the safe seasons in terms of UV exposure [27]. The current assessment study was limited to UV exposure risk determination in terms of environmental factors. In the future studies, it is suggested to investigate the health effect of solar radiation among workers in open environments.

CONCLUSION

The solar UV intensities measured inside and outside vehicle were lower and higher the recommended level, respectively. Frequent and long duration of work in outdoor environment may lead to excessive exposure. The high level of exposure among the drivers outside the vehicle means the possibility of increased risk for skin cancers. Protective measures should be taken to reduce the exposure. Previous studies emphasized on skin protective behaviors and practices and promote the knowledge of outdoor workers about the risk of UV exposure. Educational and training programs should focus on approaches and safe work procedures to minimize the unnecessary exposure to sunlight during working period.

ETHICAL ISSUES

This research was implemented according to the ethical codes instructed by Semnan University of Medical Sciences. All participants were clearly informed concerning the purpose of the study.

CONFLICT OF INTEREST

Authors of the manuscript did not have conflict of interest.

AUTHORS' CONTRIBUTION

The overall implementations of this study were the results of efforts by corresponding author. All authors have made contribution into the review and finalization of this manuscript. All authors read and approved the final manuscript

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