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Evaluation of Light Intensity Level in Physical Learning Environment of Qazvin University of Medical Sciences, Qazvin, Iran

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Abstract

Background: A lack of enough light in educational-academic spaces causes a wide range of damages and, most importantly, a destructive effect on the learning of students and researchers.
Objectives: In this study, the intensity of light (in terms of lux) in the classrooms and laboratories of the faculties of health and paramedicine, medicine, nursing and midwifery, and dentistry of Qazvin University of Medical Sciences, Qazvin, Iran, was measured in 2020.
Methods: In this descriptive-cross-sectional study, the numbers of classes and laboratories were 35 and 23, respectively. Natural and artificial light measurements were carried out in the morning and evening. The average readings were compared to international and national standards. Data analysis was performed using R software (version 4.1.0).
Results: The classes of the Faculty of Dentistry and Faculty of Medicine had the highest and lowest average intensity of general and artificial lighting, respectively. Moreover, 78% and 82.4% of the general lighting intensity readings in the morning and evening were within the standard range, respectively. However, only 36.8% and 26% of the total readings of artificial light intensity in the morning and evening were outside the defined standard range, respectively. The classes with western and eastern windows had significantly higher general lighting intensity than the northern geographic windows ($P < 0.001$).
Conclusions: In the classrooms and laboratories of Qazvin University of Medical Sciences, the general and artificial lighting in the Faculty of Medicine classrooms and in the majority of laboratories need to be improved.

Keywords: Light Intensity, General Light, Artificial Light, Classroom, Laboratory

1. Background

Humans obtain their major information and findings from the environment through a sense of vision (1). One of the essential needs for humans affecting their physical, physiological, and psychological behaviors is lighting. In order to maintain health and well-being, a standard illumination level should be provided for visual functioning (2). Good vision depends on desirable lighting. Under- or over-illumination can lead to various discomforts, such as eye fatigue, headache, physical fatigue, visual impairment, and psychological effects. It has been observed that even when someone has healthy eyes, the unsuitability of the lighting system will bring about undesired physiological, neurological, and psychological effects in the person (3, 4).

de Kort and Smolders observed that the extent of lighting affects the psychological and biological processes, where those exposed to sufficient light showed greater awareness and energy than those exposed to poor lighting (5). The illumination provided inside buildings improves the limited sunlight in them, enabling individuals to be active at different times of the day (6). Learning occurs with 83% eyesight, where impaired vision causes reduced educational efficiency. Therefore, learning and educational settings should be such that the student's

energy is merely spent on the learning process, not on attempts to have desired vision (7).

Humans' concentration and attention span can become limited in a fatigued state in comparison to the normal state (8). Most visual activities can set the ground for eyestrain, especially when the eye has to work for a long time. For eyesight, the person strains the muscles of their vision system, which in turn induces fatigue and strain in these muscles, whereby symptoms, including discomfort, pain in the region above the eyes, and low accommodation power, emerge (9, 10). Studies have shown that in the classroom, poor lighting conditions have a direct relationship with students' performance, learning, and health both quantitatively and qualitatively (11, 12).

Lighting sources in working environments are supplied naturally (by sunlight) and artificially (from lighting sources). The important factors that affect harnessing daylight include latitude, solar position, season, day hours, climatic conditions, and window dimensions and its placement edge or side in terms of geographical direction, material, and glass properties plus internal surfaces. For example, in some studies, the presence of a window on the southern side, high window-to-room surface area ratio, and closeness to the ceiling have been reported as factors that improve the room's lighting (9, 13).

University classrooms and laboratories are places where individuals usually spend a large part of their time for educational and research purposes. The presence of suitable lighting and its optimal distribution in such environments can reduce the incidence of eyestrain and reduction of accuracy. If individuals are exposed to unsuitable lighting, the real information might be lost, and the risk of mistakes by human resources and students increases (11, 14).

The Illuminating Engineering Society of North America (IESNA) employs a proposed method called a network method for measuring illumination. The IESNA's suggestion for studying and writing is 500 lux illumination. In Iran, the minimum light intensity on desks and in classrooms is 300, and the desired value proposed for laboratories is 500 lux (15).

Any society's educational and academic system is the cornerstone of social, economic, political, and cultural development. Investigating the factors affecting the progress of societies indicates that countries can have powerful and efficient educational systems where this power has been contingent upon providing suitable conditions for their students, including the provision of physical and environmental conditions (13).

2. Objectives

The present study was performed to evaluate the illumination intensity of classrooms and laboratories of Qazvin University of Medical Sciences, Qazvin, Iran. Accordingly, the study results could be used to prevent complications arising from unsuitable lighting among students and researchers. Additionally, the results can contribute to enhancing their working efficiency. When these results reach relevant policymakers, they can take the necessary measures in future plans to make educational and laboratory spaces suitable in line with international and national standards.

3. Methods

This descriptive cross-sectional study, according to the accessibility of the statistical population, used the census sampling method to collect the data. The general and artificial light intensity in classrooms and laboratories of faculties of health and paramedicine, medicine, nursing and midwifery, and dentistry of Qazvin University of Medical Sciences in the morning and afternoon were investigated in 2020. The number of examined classrooms in this study was 35, and the number of laboratories was 23; out of the aforementioned numbers, 15 classrooms and 10 laboratories were located in the Faculty of Health and Paramedicine, 5 classrooms and 10 laboratories in the Faculty of Medicine, 10 classrooms and 2 laboratories in the Faculty of Nursing and Midwifery, and 5 classrooms and 1 laboratory in the Faculty of Dentistry.

This study explored the effect of several parameters on the extent of illumination, including sky status (i.e., cloudy and sunny days), the surface area of windows, the geographical position of windows (i.e., northern, southern, eastern, and western), the measurement time (i.e., morning and afternoon), and the presence of curtains. During measurement in each class and laboratory, in addition to the light intensity, the aforementioned factors were also recorded. The general light intensity referred to no curtain state under conditions when all lights were on, which included daylight (resulting from sunlight) plus the illumination of lamps. The artificial light intensity referred to the state with curtains and only included illumination from lamps. The measurements were performed during 9 - 12 a.m. for the morning measurement and during 1 - 4 p.m. for the afternoon measurement. The localized light intensity was measured only in the laboratory and under the hood.

In order to measure the light intensity, calibrated lux meter device (model: INS DX-200, INS Enterprise Co., Ltd., Taiwan) was used by a trained user (Figure 1). Using the

network method recommended by the IESNA, first, the surface area of the site of interest was divided into 3 × 3 squared stations. At the height of 75 cm above the ground level in the center of each station, the general and artificial light intensity in classrooms, general light intensity in laboratories, and localized light intensity were measured in the isolated illuminated parts of the laboratory, such as under the hood (16, 17). The measurements were replicated three times and then averaged. Subsequently, the relationship between the measured values with the geographical position, measurement time, surface area of the window, and standard surface area of illumination was examined.

Figure 1. Lux meter device model: INS DX-200

In addition to measuring the general light intensity in classrooms and laboratories, the average intensity of localized lighting was also explored across the area under laboratory hoods. For this purpose, the device was positioned such that while reading, the photocell surface of the device would be along the plane the user's eye interacts with during operation completely or most of the time. Overall, 281 stations were chosen for the general and artificial lighting of the classrooms, 387 stations for the general lighting of the studied laboratories, and 18 stations for localized lighting. Data analysis was carried out by R software (version 4.1.0).

4. Results

The present study was performed to measure the lighting intensity in the morning and afternoon periods in the classrooms and laboratories of Qazvin University of Medical Sciences. Table 1 shows the average general and artificial lighting intensity inside the classrooms. However, Table 2 shows the average general and artificial lighting intensity inside the laboratories. Considering the Faculty of Medicine classrooms, the lighting intensity values were lower than the recommended standard. Nevertheless, regarding the Faculty of Dentistry classrooms, the values of lighting intensity were above the recommended standard limits.

Overall, about 78% and 82.4% of readings of general lighting intensity in the morning and afternoon were within the standard range, respectively. However, only 36.8% and 26% of the total readings of artificial lighting intensity in the morning and afternoon were out of the standard range, respectively. This study also showed that there was a significant difference in the average lighting intensity between the two states of the presence of a curtain (i.e., artificial lighting) and the absence of a curtain (i.e., general lighting) on the windows ($P < 0.001$). The average general lighting intensity was higher than the artificial lighting intensity.

The difference in the values of general and artificial lighting intensity in different classrooms was because in each of the classrooms, depending on their location, the window of these classes has been along the daily sunlight radiation, thereby receiving more natural light. However, some of them are placed in the opposite direction of the dominant daylight; in this type of classroom, the major part of the measured light has been related to the artificial type. For this reason, in conducting this study, various geographical directions were considered for different classrooms and laboratories in both morning and afternoon for comprehensive investigations, and then the results were reported.

The average area of the windows of classrooms and laboratories was 6.27 and 6.40 m^2, respectively. The window surface area established a significant difference in the localized lighting intensity in the isolated parts of the laboratory ($P = 0.018$).

According to the results of Table 1, the Faculty of Dentistry classrooms had the highest average of general and localized lighting intensity. However, the Faculty of Medicine classrooms had the lowest average of general and artificial lighting intensity. Table 2 shows that the Faculty of Dentistry laboratories had the largest average general lighting intensity. Nevertheless, the Faculty of Health and Paramedicine laboratories had the minimum

Table 1. General and Artificial Light Intensity in Classrooms of Different Departments with the Percentage of Standard Readings

Department	Type	Light Intensity (lux)	Number of Classes	Standard Readings (%)
Health and Paramedicine	General	467.79 ± 141.38	15	91.9
	Artificial	384.67 ± 113.6		74.5
Medicine	General	211.46 ± 97.3	5	16.8
	Artificial	219.02 ± 157.48		26.9
Nursing and Midwifery	General	590.4 ± 270.12	10	99.4
	Artificial	386.71 ± 140.94		72.4
Dentistry	General	737.00 ± 314.35	5	100
	Artificial	449.00 ± 61.23		100

Table 2. General and Artificial Light Intensity in Laboratories of Different Departments with the Percentage of Standard Readings

Department	Type	Light Intensity (lux)	Number of Classes	Standard Readings (%)
Health and Paramedicine	General	342.08 ± 120.93	10	11.9
	Artificial	446.08 ± 78.88		33.3
Medicine	General	349.24 ± 148.24	10	17.4
	Artificial	359.68 ± 63.36		0
Nursing and Midwifery	General	432.43 ± 140.07	2	36.2
Dentistry	General	570.36 ± 86.18	1	83.3

average general lighting intensity. Finally, the results of Table 2 showed that the average artificial lighting intensity was higher in the Faculty of Health and Paramedicine laboratories than in the Faculty of Medicine laboratories.

The general lighting intensity of the classrooms with western windows showed a significant increase compared to the windows located on the northern side ($P < 0.001$). Furthermore, their artificial lighting intensity also had significantly higher values ($P < 0.045$). In addition, the classrooms with eastern windows showed a significant difference regarding general lighting intensity compared to the windows on the northern side of the classroom ($P = 0.019$); this value was significantly higher in them.

Considering classrooms' general and artificial lighting intensity, a significant difference was observed between morning and afternoon; in both cases, the intensity was significantly higher during the afternoon than in the morning ($P < 0.001$). Among the classrooms, the Faculty of Dentistry showed a significant difference, and the Faculty of Health and Paramedicine showed a significant difference regarding general lighting intensity ($P < 0.001$) and artificial lighting intensity ($P = 0.022$); in both states, the values were lower than the Faculty of Health and Paramedicine. On the other hand, in the Faculty of Dentistry classrooms, a significant increase was observed in general lighting intensity compared to the Faculty of Health and Paramedicine ($P = 0.004$).

Regarding the general light intensity of laboratories, a significant difference was observed between morning and afternoon ($P < 0.001$) that was significantly higher than afternoon and morning readings. Among the laboratories, a significant difference was noticed between the Faculty of Dentistry and the Faculty of Health and Paramedicine regarding general light intensity ($P = 0.016$), which confirmed the higher value of this intensity. Table 3 shows the average general light intensity of the Faculty of Dentistry classrooms in cloudy/sunny states. Table 3 shows that in these classrooms, the cloudy state established a significant difference in general lighting intensity compared to the sunny state ($P < 0.001$). Statistically, the cloudy readings were lower than sunny conditions (Figure 2D).

Table 3. General Lighting Intensity of Faculty of Dentistry Classrooms in Cloudy/Sunny Conditions

Department	Condition	Light Intensity (lux)
Dentistry	Sunny	800.292 ± 439.820
	Cloudy	533.15 ± 149.76

Figure 2 depicts the comparison of general and artificial lighting intensity in the classrooms of various faculties to each other and to the standard values (300 lux). In part, A-C, in all cases except for some Faculty of Medicine classrooms in northern and southern positions in part

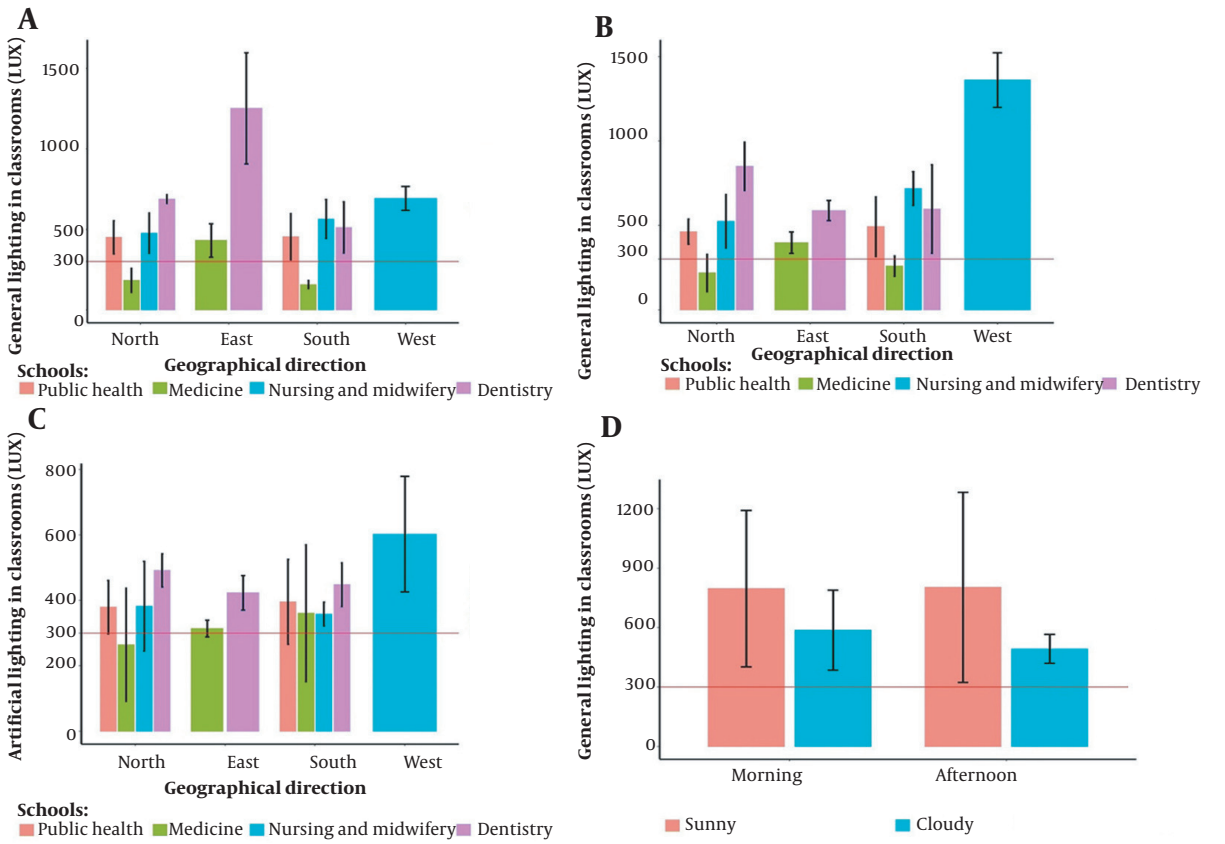

Figure 2. Comparison of general and artificial light intensity in classrooms of departments to each other and to standard values (lux); A, general light intensity in the morning according to geographical directions; B, general light intensity in the afternoon according to geographical directions; C, artificial light intensity in the afternoon according to geographical directions; D, general light intensity in faculty of dentistry according to cloudy/sunny weather

A, general and artificial lighting intensity was within the national and international standard ranges. The Faculty of Dentistry and Faculty of Nursing and Midwifery were superior to other faculties.

Figure 3A illustrates that the average general lighting intensity across the laboratories of different faculties at the morning measurement was lower than the standard values (500 lux) except for the Faculty of Dentistry laboratories and Faculty of Medicine laboratories with southern windows. Furthermore, in the afternoon measurement, according to Figure 3B, in addition to the laboratories of the Faculty of Dentistry and Faculty of Medicine, which were mentioned earlier, the lighting intensity was within the standard range only in the laboratories of the Faculty of Nursing and Midwifery and Faculty of Health and Paramedicine which had southern windows. In other faculties, there was only increased average lighting intensity compared to the morning measurement; nevertheless, the average value of measurements was below the standard limit. Figure 3C depicts that the localized lighting intensity in the Faculty of Health and Paramedicine laboratories in both morning and afternoon matched the standard level and was acceptable. However, the localized lighting intensity in the Faculty of Medicine laboratories was read to be lower than the standard values.

5. Discussion

University is a place in which students, researchers, and professors spend most of their time learning science and knowledge. The environmental conditions of the laboratory and any other educational environment might affect individuals' health in some way and cause the development of different types of physical or psychological pressures, along with the consequences resulting from unsuitable body status. Since having clear eyesight requires proper lighting, and some parameters

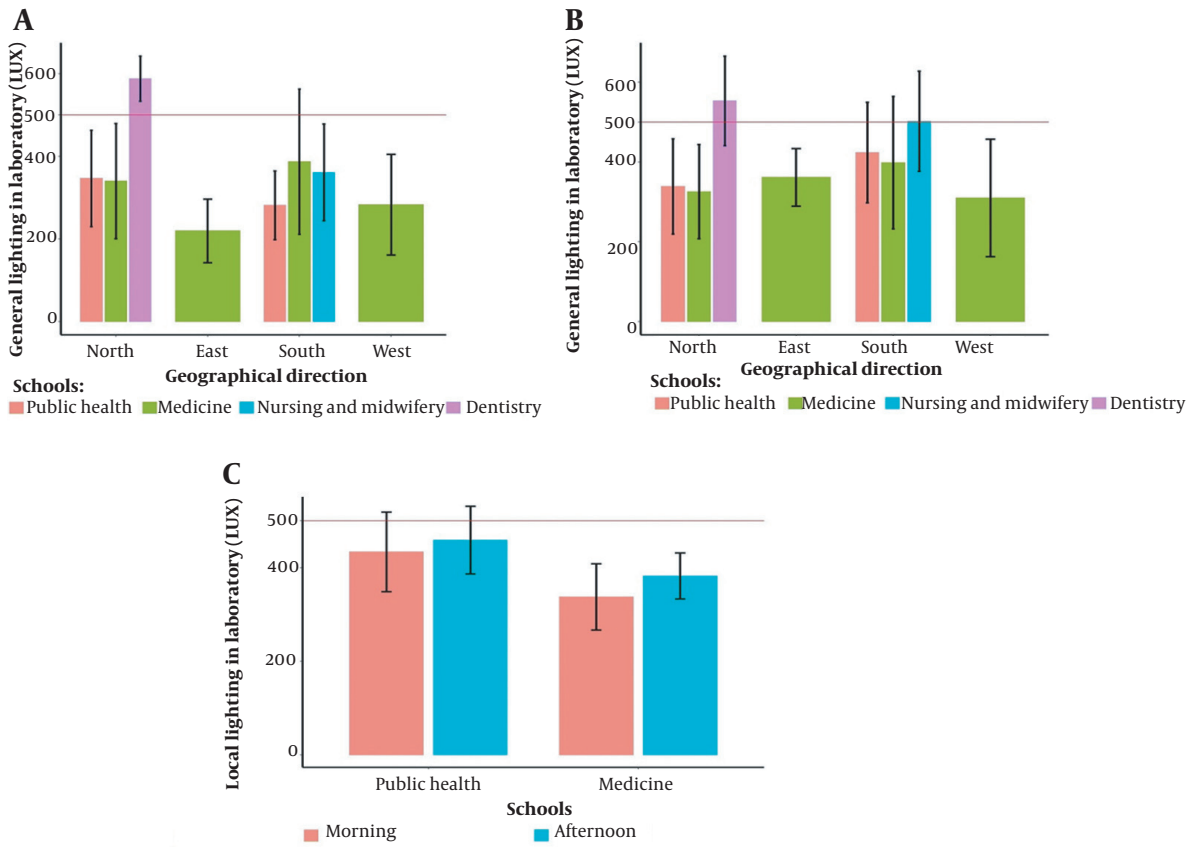

Figure 3. Comparison of the light intensity of general and localized lighting in the laboratories of different faculties and to standard values (lux); A, general light intensity in the morning according to geographical directions; B, general light intensity in the afternoon according to geographical directions; C, local light intensity in the morning and afternoon according to evaluated faculties

regarding lighting, such as intensity, form, and type of lighting source, directly affect the students' learning, lighting in educational environments is crucial. If this index is appropriate, the necessary balance between students' needs and their surrounding environments is established, thereby providing the ideal and suitable conditions for performing visual activities, such as studying and researching (3, 9, 11).

Based on the results of the present study, the average general lighting intensity and artificial lighting intensity in 88.6% and 82.9% of the classrooms were within the standard recommended range, respectively; overall, they have had a suitable status except for some classrooms. The results also indicated that only 13.1% and 33.3% of the examined laboratories had general and localized lighting within the standard range, respectively.

A study by Winterbottom and Wilkins in England indicated that in 88% of classrooms, lighting intensity has been above the standard limit (16). Furthermore, based on the results of Zare et al.'s study, regarding the halls of Hormozgan University of Medical Sciences, Hormozgan, Iran, the total illumination levels in all cases were higher than the standard value (17). According to the results of Hajibabaei et al.'s study (1) on examining the lighting intensity of laboratories with irregular geometric shapes in Zanjan, Iran, general and artificial lighting intensity was lower than the standard value in 51% and 99% of the studied libraries, respectively, and their illumination did not have suitable uniformity.

In a study performed on classrooms of primary schools in Nahavand, Iran, 60.3% of classrooms' lighting was within the standard range (18). According to a study conducted by Ghotbi Ravandi et al., it was found that the general and artificial lighting intensity in the libraries of Kerman University of Medical Sciences (Kerman, Iran) was below the IESNA standard level (300 lux) in 28.57% and 71.42% of the study halls, respectively (19). The results of Nadri et al.'s study also indicated that all the study halls

of Qazvin University of Medical Sciences' dormitories had illumination intensity lower than 300 lux (20). In a study by Golmohammadi et al. conducted in carpet weaving workshops of Bijar, Kurdistan, Iran, the results indicated that the artificial, general, and localized lighting intensity of the workshops was unsuitable due to insufficient sources of lighting (21).

In a study by Sepahi Zoeram et al., the results indicated that in 90% of the examined classrooms, total lighting intensity matched the IESNA standard values; nevertheless, in 10% of the cases, total lighting intensity in the classrooms did not match the standard value (3). In a study performed by Khoubi et al. on evaluating the lighting intensity of the libraries of faculties and educational hospitals of Kurdistan University of Medical Sciences in 2015, the average lighting intensity in the study halls of men and women was 460 and 382 lux, respectively, which was higher than the standard limit set by the IESNA. This finding has been primarily due to the adequacy of artificial lighting sources and suitably harnessing their natural lighting (22). The aforementioned studies' results are well in line with the present study's results. The mismatch of the studied sites with their use has caused the illumination to be lower than the standard limit in some cases due to neglecting the design of a suitable lighting system and benefiting from daylight in these sites.

A study by Javan et al. examined the light intensity of 24 study halls of the dormitories of Isfahan University of Medical Sciences, Isfahan, Iran. Javan et al. showed that the daylight of the study halls, with an average of 567 lux, was within the standard limit. However, the lighting at night, with an average of 229 lux, did not have a suitable status due to the elimination of natural sources and the use of artificial ones (10). In a study by Esmaeili et al. evaluating the lighting intensity of the libraries of Rafsanjan University of Medical Sciences, Kerman, Iran, in 2013, the average lighting intensity was lower than the national standard limit in half of the examined sites. Accordingly, considering the adverse effects of inadequate lighting on individuals' health and productivity, the lighting system in libraries should be corrected (23).

The measurement of lighting intensity of primary schools of Ahvaz, Khuzestan, Iran, in a study by Fouladi et al., confirms that the average general lighting intensity in 75% of classrooms and 62.5% of corridors was lower than the standard level. Furthermore, the measurement of local lighting on blackboards and desks indicated that only 12.5% of the classrooms had suitable status (11). The aforementioned findings are in line with the results of most previous studies. The aforementioned results are also in line with the present study's results regarding the findings of the part of laboratories and some classrooms; however, they did not match the general results of the classrooms in the current study.

The reasons for reduced general lighting intensity in the Faculty of Medicine classrooms can be the presence of dead lamps in classrooms 1, 3, and 4 and the few windows in this faculty. Considering general lighting intensity in this study, only the Faculty of Medicine classrooms were not within the standard range. On the other hand, only the Faculty of Dentistry laboratories were above the standard range regarding general lighting intensity. Nevertheless, lighting intensity fell within the standard range in other faculties. Based on the results, generally, the localized lighting intensity of the Faculty of Health and Paramedicine laboratories was not within the standard range.

5.1. Conclusions

Generally, based on the results and evaluations performed on the classrooms and laboratories of Qazvin University of Medical Sciences, the general and artificial lighting conditions in some classrooms, especially the Faculty of Medicine classrooms and in most laboratories, need to be improved. The significant solutions proposed for resolving the defects of lighting systems include the use of proper arrangement patterns of lighting sources (natural and artificial) for uniform distribution of lighting, the proper selection of sources of lighting, the establishment of a balance between the number of windows and the educational environment's needs for natural lighting, the installation of lamps at suitable heights, and timely maintenance, repair, and replacement of dead lamps considering the lifespan of lamps. Observing all these issues would lead to the standardization of classrooms and laboratories. It is also suggested that future studies explore and evaluate the lighting quality, type of lamps used, principles of proper design and balanced arrangement of lamps in classrooms, laboratories, and educational-academic environments, and energy productivity considering the electricity blackout in recent years.

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Footnotes

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