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Illuminance in Office Workstations and Related Health Risks in a Tertiary Institution within Edo State, Nigeria

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ABSTRACT: The extent of illumination within work places contributes to the productivity and wellbeing of the employees. Due to its relevance, health and safety organizations around the world have continued to instruct and enlighten employers on the necessity to place satisfactory lighting equipment's and mechanisms in place to guarantee the constant safety and wellbeing of their employees. This research is aimed at accessing the illuminance levels in office work stations in the Faculty of Life Sciences, University of Benin. Survey method was used to obtain primary data on the perception of the employees about illumination levels within their work environment and associated health risk. Illumination levels were measured within the work environment using a digital lux meter. The values obtained were compared with standards as set by the Occupational Safety Health and Administration (OSHA). The surveys conducted revealed that majority of the workers were unsatisfied with the lighting conditions. Illuminance readings taken shows that majority of the workstations had levels below (194.0-453.0Lux) the recommended standard of 500Lux, while others were above (524.4-666.9Lux). Health risks associated with bad illumination includes: eyestrain, stress, teary eyes and headaches. It is recommended that illumination levels be adjusted in areas where they are considered lower or higher than the set standards within the work stations. Workers should also be enlightened on the possible health risks associated with poor lightening conditions together with regular checking of illumination levels in all work stations of the institute.

Keywords: Illuminance, Lux meter, Office work stations, Occupational safety, Health risk.

Introduction

Illuminance can be defined as the intensity or amount of light that comes in contact with a surface area, like the work surface of a desk. According to an assessment carried out by Vischer and Wifi (2017), workplace elements such as spatial organization, ventilation, and lighting, as well as the degree of noise, have an impact on employee attitudes. Furthermore, several studies have demonstrated that aspects such as office design and workstation arrangement, ergonomics, indoor air quality, climatic condition, lighting, and noise have a significant relationship to employee productivity (Vimalanathan and Babu, 2013; Al horr *et al*., 2016; Kang *et al*., 2017; Labib *et al*., 2022).

Office workers invest a substantial amount of time in structures, and their convenience in the physical environment has an impact on their productivity and stimulates the production of a healthy workplace (Kang *et al*., 2017). The environment's illumination has an impact on work performance in addition to having an impact on human health and well-being (Dianat *et al*., 2013). Studies have demonstrated that improving a space's perceived brightness can significantly increase evaluation (Wang *et al*., 2022). The illumination of the walls and

ceiling is one of the main factors in a room's perceived brightness because brightness is mostly affected by what we see in our field of vision (de Vries *et al*., 2018; de Vries *et al*., 2021).

The likelihood of workplace injuries and accidents is reduced by good lighting (Omoifo-Irefo and Olamoju, 2021). The amount of light available to workers to complete their job safely and efficiently differs across jobs, while extremely low or the presence of excessive lighting in the workplace may have severe repercussions (Lamb *et al*., 2016). Pauley, 2004 and Kaushik *et al*. 2021, connected bad lighting to physical dysfunction, visual pain, daytime sleepiness, night-time sleeplessness, disorientation, seasonal sadness, gastrointestinal distress, irritability, an increased error rate, memory disturbance, and cognitive confusion. It has been found that psychological stress brought on by bad illumination can cause exhaustion, anxiety, eyestrain, migraines, and physical aches. A similar study by Juslen and Tenner (2005) also supports this conclusion suggesting that inadequate lighting conditions in the work environment can lead to psychological and mental discomfort and job dissatisfaction which ultimately will lead to a decrease in productivity and efficiency of workers and also have detrimental health effects (Lee *et al*., 2014; Katabaro and Yan, 2019; Chen *et al*., 2020). Consequently, there is a need for a holistic assessment to understand the office occupants' needs and predilections in workstations and the related health risks. It is against this background that this study seeks to examine the level of illuminance in office workstations and related health risks in the Faculty of Life Sciences, University of Benin, Nigeria. The objectives of the study were to:

- Measure the light intensity in office workstations in the Faculty of Life Sciences, University of Benin;
- Compare the measured light intensity with illumination standards for office work environments set by OSHA;
- Identify associated potential hazards and recommend corrective measures to protect the workforce;
- Evaluate workers awareness on illuminance levels and the health effects of poor lightening in work stations.

Materials and methods

The materials used for this research are Digital Lux meter model: LUX1330B, A Global Positioning System (GPS model: ETREX 10), and a 1-2 Likert scale Questionnaire. Taro Yamane formula was used to determine the population size (Elaho and Odion, 2022).

Study area: The study was conducted at the Faculty of Life Sciences, University of Benin, main campus situated in Ugbowo, Egor Local Government Area of Edo State, Nigeria. The University is located in the humid tropical rainforest belt of Nigeria. The geographic location is at latitudes 6º 20' and 1.32"N, and longitudes 5º 36' and 0.53" E. The target sampling size was five (5) offices each from the various departments in Faculty of Life Sciences.

The departments included: Environmental Management and Toxicology (EMT), Biochemistry (BCH), Science Laboratory Technology (SLT), Plant Biology and Biotechnology (PBB), Animal and Environmental Biology (AEB).

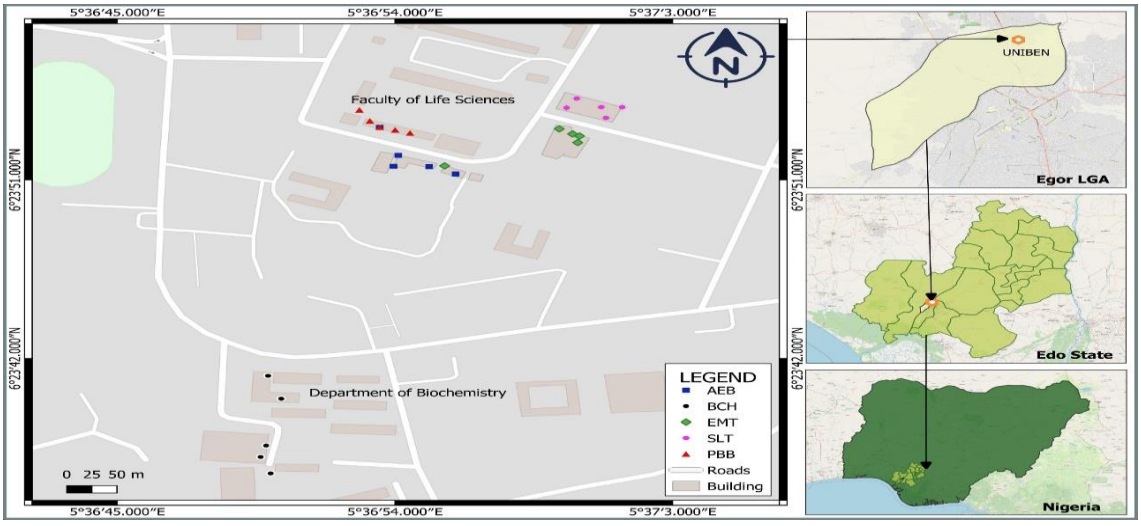

Figure 1: Map showing study area with sampling locations indicated

Sampling procedures: The sampling method was done according to a standardized method as described by (Mercy *et al*., 2021), with some modifications. The research covers twenty five (25) Offices within the Faculty Life Sciences in University of Benin. The study population covers one hundred and twenty five (125) employees in the faculty, who work for about eight (8) hours on a daily basis excluding weekends and are entitled to a one (1) hour break. A random-sampling (convenience-sampling) method was used. This research adopted survey method (questionnaires) to extract primary data on the perception of one hundred and twenty-five (125) employees (Academic and Non Academic staffs) about safety of workstations relating to illumination (lighting) level and to establish their rate of satisfaction, feelings about the lit environment and the existence of both visual and non-visual problems in their workplace and how these factors influence their health and work output within the faculty. Additionally, respondents were asked to self-report the prevalence of effects relating to musco-skeletal systems (Rodriguez *et al*., 2014), visual symptoms: dry eyes, teary eyes, eye strain, blurred vision, itching eyes, shoulder pain, neck pain, back pain, headache and stress. All variables covered in the questionnaire were designed and grouped under four (4) main questions:
(a) Do you experience uneasiness while working under the lighting condition in your office?
(b) To what extent do you think the lighting impacts on your work performance/productivity?
(c) Do you think the lighting condition has any effect on your health?
(d) What do you think can be done better to improve the lighting condition in your work station? The research retrieved questionnaires from ninety-five (95) participants. The locations of the offices were determined using a Global positioning system (GPS). Illumination levels (Lux) were measured using a Digital Lux meter, with readings taken in five (5) different departmental offices in Faculty of Life Sciences from 9:00am – 3:00pm, and all artificial lighting sources were switched on. Each office was divided into ten boxes and illuminance readings were taken at the centre point of these boxes, by placing the sensor of the lux meter horizontally on the surface, concentrating more on positions where tasks are usually carried out during working hours. The most stable value seen on the digital lux meter dashboard was recorded as the illuminance value. After repeating this process in all ten boxes, the mean of the recorded measurement was taken as the illuminance level recorded in that particular office. The recommendations by OSHA were regarded as an acceptable standard for evaluating office lighting levels due to its clarity (Mercy *et al*., 2021).
Data analysis: Deductions were made from the information obtained from the social survey and presented as percentages using pie chart. Other calculations and results were analyzed/ interpreted by statistical methods. Graph pad prism 5 and Microsoft Office Excel (Suite 2013) were the statistical tools employed. Data were presented as mean ± Standard deviation.

Results

The mean illuminance readings obtained for offices in the various departments are presented in the graphs shown in Figures 2-6. Light intensity readings in the different offices indicate that illumination levels were below the recommended OSHA standard in nineteen (19) office locations.

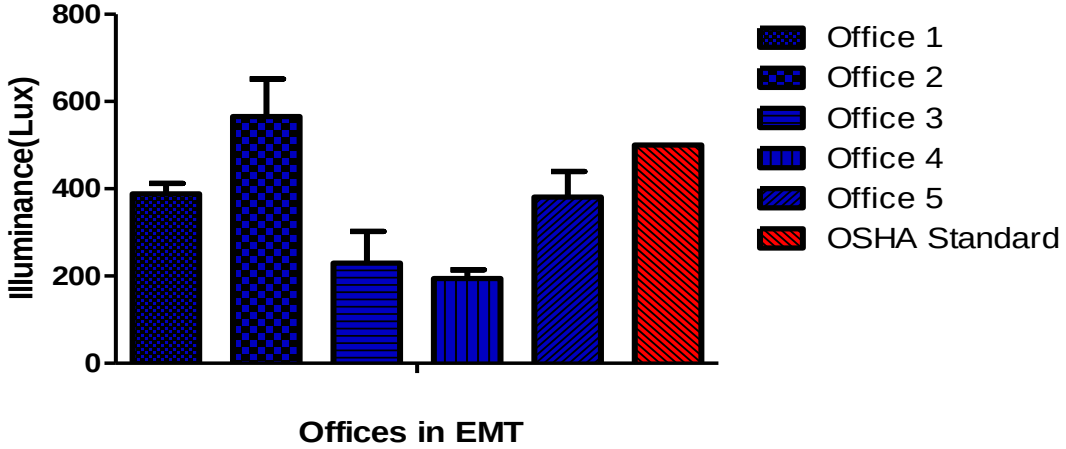

Figure 2: Mean illuminance readings from Offices in the Department of Environmental Management and Toxicology (EMT), University of Benin. (Values are mean±SD of ten (10) illuminance readings).

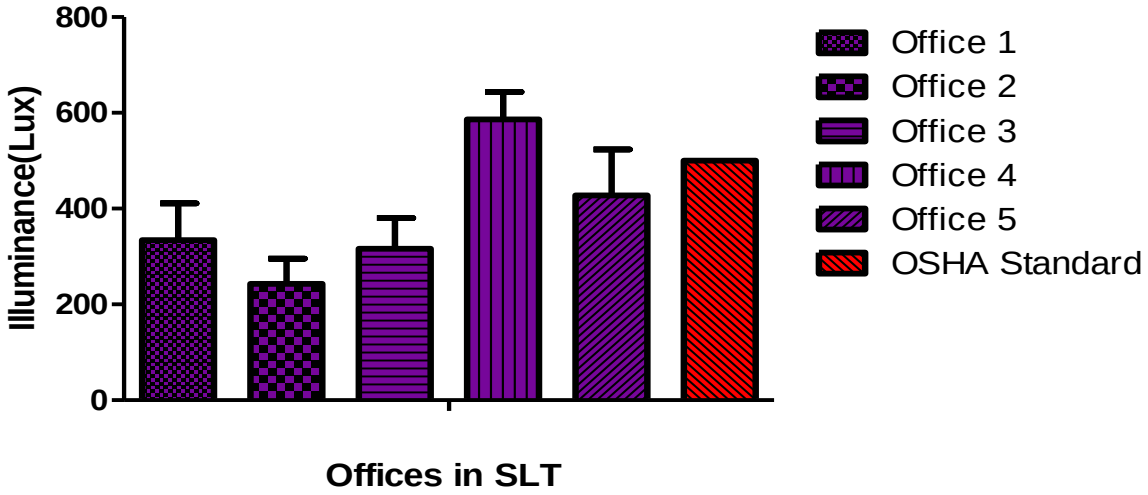

Figure 3: Mean illuminance readings from Offices in the department of Science Laboratory Technology (SLT), University of Benin. (Values are mean±SD of ten (10) illuminance readings).

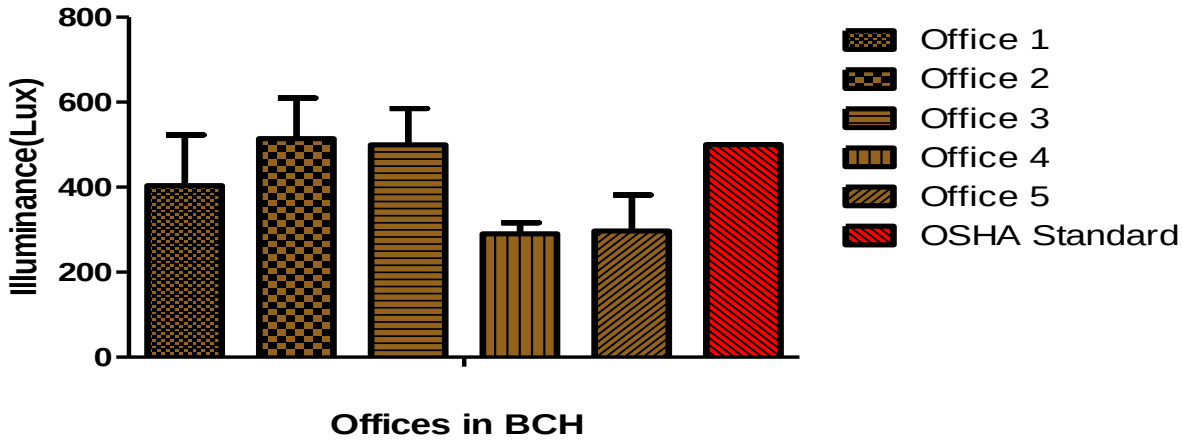

Figure 4: Mean illuminance readings from Offices in the department of Biochemistry (BCH), University of Benin.

(Values are mean±SD of ten (10) illuminance readings).

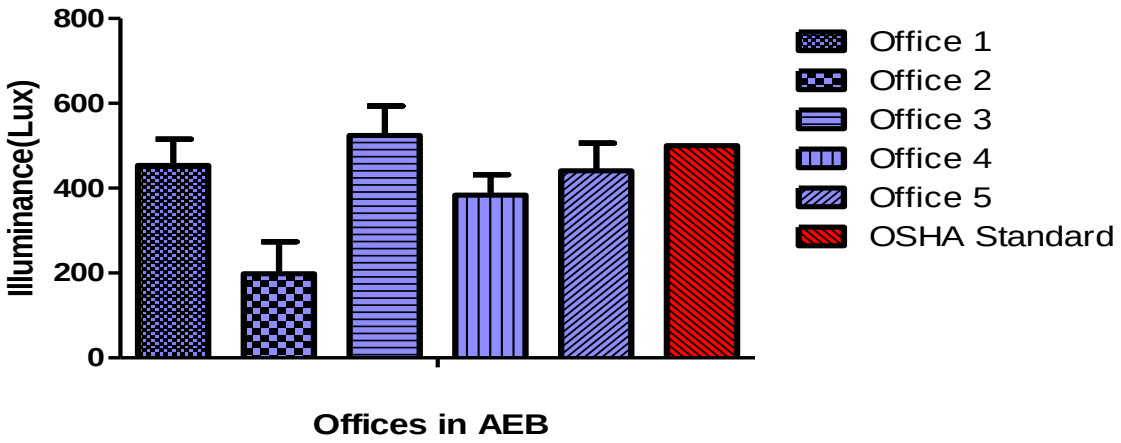

Figure 5: Mean illuminance Readings from Offices in the department of Animal and Environmental Biology (AEB), University of Benin. (Values are mean±SD of ten (10) illuminance readings).

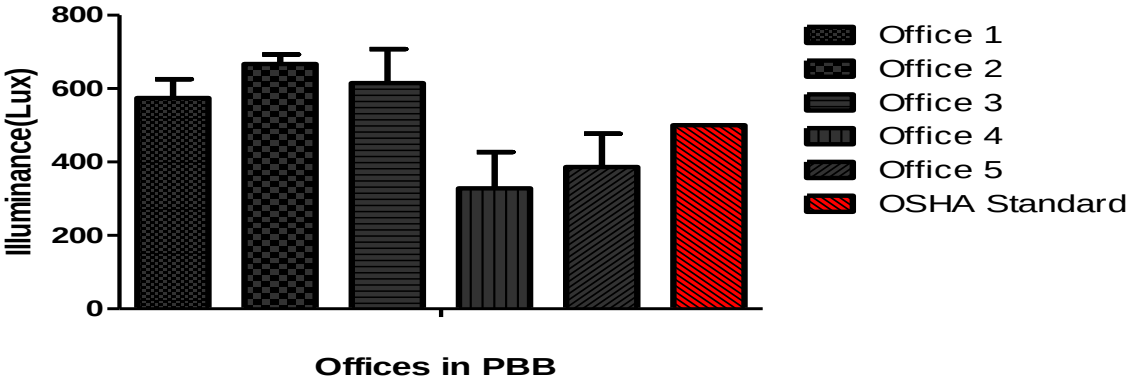

Figure 6: Mean illuminance Readings from Offices in the department of Plant Biology and Biotechnology (PBB), University of Benin. (Values are mean±SD of ten (10) illuminance readings).

Results of the social survey: A total of one hundred and twenty five (125) questionnaires were distributed to the workers and ninety-five (95) of the questionnaires were retrieved. Responses to options in each item of the questionnaire were analyzed using their percentage value as shown in Figures 7-9.

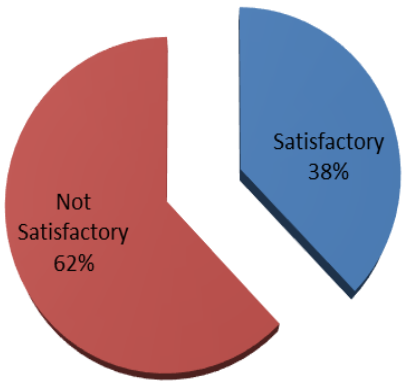

Figure 7: Lighting conditions in offices Data are represented as percentages of the participant's response to how they feel about the lighting condition in their work stations

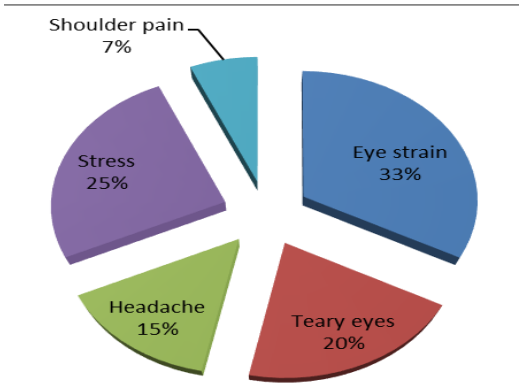

Figure 8: The Influence of lighting in work environment on occupant's health. Data are represented as percentages of the participant's response to occurrences of health related issues (Stress, headache, eye strain, shoulder pain, teary eyes).

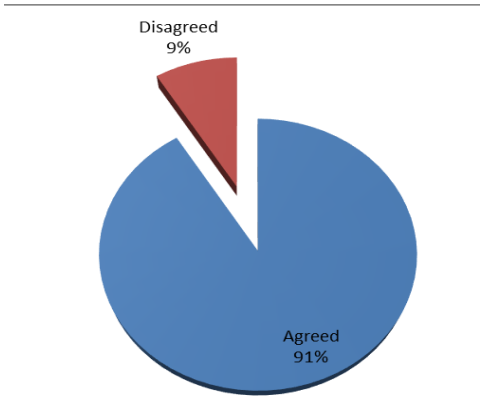

Figure 9: Influence of lighting condition in work stations on work efficiency. Data are represented as percentages of the participant's response to how they feel about the impact of lighting in their workstations and how it affects work efficiency.

Discussion

Office workers invest a substantial amount of time in structures, and their convenience in the physical environment has an impact on their productivity (Kang *et al*., 2017). The environment's illumination has an impact on work performance in addition to having an impact on human health and well-being (Dianat *et al*., 2013). Making working environment parameters like lighting, noise, thermal stresses and so on, healthy and according to the standards is very vital for ensuring good health of workers and increasing their productivity and performance. Hence examining the level of illuminance in office workstations and related health risks is of the essence. The result from this study as presented in Figure 2 shows that four (4) out of the five (5) offices assessed for light intensity had illuminance readings of 388.1 Lux, 229.8 Lux, 194 Lux and 380.7 Lux in offices 1, 3, 4 and 5 respectively which were below the standard illumination level of 500 Lux. EMT Office 2 had illuminance reading of 565.4 Lux which was above the recommended illumination level. The low illuminance level seen in this study is consistent with the findings of Dianat *et al.* (2013) and Chen (2020).

The results obtained from the department of Science Laboratory Technology (SLT) as shown in Figure 3, revealed that the lightening conditions were inadequate in most of the offices. Office 1 (334 Lux), Office 2 (243.1 Lux), Office 3 (309.3 Lux) and Office 5 (434 Lux) had readings below 500 Lux. However, Office 4 (586.5 Lux) had a reading higher than the recommended illumination level. Inadequate lightening in office work stations may pose severe health risks such as mental and emotional discomfort which will eventually result to a decline in the efficiency and productivity of workers (Juslen and Tenner, 2005).

In the Department of Biochemistry, University of Benin, results obtained as shown in Figure 4, indicated that illuminance readings from Office 3 (499.4 Lux) fell slightly below the standard illumination level of 500 Lux, although this may not pose a major risk, adjustment of light intensity may be required in order to conform with the set standard. Office 1 (481.4 Lux), Office 2 (459.5 Lux), Office 4 (290.3 Lux) and Office 5 (297.2 Lux) on the other hand had illuminance readings below 500 Lux. It is important that the accurate level of illumination be met within workstations to mitigate signs of tiredness and enhance optical comprehension and avoid headaches and eye pains (Lee e*t al.,* 2014; Wessolowski *et al.,* 2014).

The result presented in figure 5 Shows that illuminance readings (453.7 Lux, 198.3 Lux, 524.4 Lux 383.4 Lux and 441.3 Lux) from offices in Animal and Environmental Biology (AEB), were not in conformity with the standard as recommended by OSHA. Illuminance levels maintained in line with OSHA's prescription, increase occupants' mood and alertness (reduce sleepiness) which are essential factors for increasing occupants' performance (Shamsul *et al*., 2013). Hence poor work performance may be due to contributions from these environmental factors.

The Department of Plant Biology and Biotechnology, had illumination levels that were significantly above the OSHA lighting recommendation of 500Lux with readings of 666.9 Lux for PBB Office 2, 595.2 Lux for Office 3, and 571.6 Lux for Office 1, as shown in figure 6. This may likely be due to the type of lighting in the offices in this department hence producing illumination levels higher than the 500 Lux, the study identified that most of these offices had glare. Studies have shown that the presence of these problems in the working environment significantly reduces visual sharpness; exert teary eyes, and causes visual fatigue (Rosenfield, 2011; Bellia *et al*., 2013, Wangsan *et al*., 2022). Some other literature affirms that the inadequately provided lighting environment also leads to mental and physical tiredness, affects the individual's possibility to concentrate on the task (Juslen and Tenner, 2005), reduces the workers' vitality, and induces sleepiness during work times.

The department of Plant Biology and Biotechnology (PBB) as shown in figure 6 had illumination readings that were significantly above the OSHA lightening recommendation of 500Lux with a reading of 666.9 Lux for PBB Office 2, 595.2Lux for Office 3, and 571.6 Lux for Office 1. This may likely be due to the type of lighting in the offices of this department exposing these offices to glare with resultant effects as discussed in figure 5.

The results from this study are consistent with the findings of Mercy *et al.* (2021), whom had similar results from their study. Some other literatures affirm that inadequate lighting in the work environment could lead to mental and physical tiredness, affects the individual's ability to concentrate on the task reduces the workers' vitality, and induces sleepiness during work times (Steege *et al*., 2015; Mathews and Khann, 2016; Katabaro and Yan, 2019). Furthermore, the increased accidents rate, work dissatisfaction, and other forms of discomfort are also linked with insufficient lighting in the workplace (Konstantzos *et al*., 2020). To ensure conformity to set standards of the lighting conditions in work environments, an integrated lighting design method may be employed; this allows occupants the flexibility to control some aspects of their lighting environment hence improving occupants' satisfaction. User-centric lighting design is an ideal solution for improved occupants' health and sustained good performance at work stations (Jamrozik *et al.,* 2018). This has being described as an efficient method of improving work efficiency and creating a level of comfort in the work environment while ensuring work environment satisfaction for the occupants.

Findings from the social survey, indicated that a wide range of participants believe that the lighting conditions in their offices are not satisfactory (62%), while the remaining 38% considered the illumination levels in their offices sufficient (figure 7). This finding is similar to the findings of Katabaro and Yan (2019), who studied the

effect of lighting quality on working efficiency of workers in office building in Tanzania. Their results indicated that majority of the workers were less satisfied with the illumination levels in their work environment.

Data on how lighting in the work environment affects the health of occupants revealed that 33% of the respondents experienced eye-strain occasionally, 20% experienced teary eyes, 15% suffered headache during working hours, while 25% were stressed (figure 8). Furthermore, 7% of respondents recounted their experiences suffering from musculoskeletal symptoms such as shoulder pain when working in offices with poor lighting and this contributed to their stress levels. The amount of light available to workers to complete their job safely and efficiently differs across jobs, while extremely low and the presence of excessive lighting in the workplace may have severe repercussions (Kaushik *et al*., 2021). Additionally, Pauley (2004) also connected bad lighting to physical dysfunction, visual pain, daytime sleepiness, nighttime sleeplessness, disorientation, seasonal sadness, gastrointestinal distress, irritability, an increased error rate, memory disturbance, and cognitive confusion. It has been found that psychological stress brought on by bad illumination can cause exhaustion, anxiety, eyestrain, migraines, and physical aches. It is important that the exact level of illumination is made available within the office workspace to mitigate vital signs of fatigue and enhance pictorial comprehension and prevent headaches and eye pains (Lee *et al*., 2014; Wessolowski *et al*., 2014).

The assessment of the influence of lighting condition in work stations on work efficiency indicated that a well-lit environment promoted work alertness and that it significantly influenced work efficiency (Figure 9). In a similar study, Wang *et al*. (2021) looked into how indoor lighting affected people's ability to execute cognitive activities and interact with others. The study made by Steidle *et al*. (2013) backs up the argument made by Wang *et al*. (2021). Changing a space's (lit) ambiance can influence social behavior in both positive and bad ways. Zhong *et al*. (2010), in their study discovered that darkness promoted dishonesty and cheating whilst affecting the health of the workers. In order to achieve an effective lighting system in the faculty of Life Sciences, University of Benin, it is recommended that an ambient-task lighting method should be adopted because it offers the advantage of providing illumination where it is needed most, and it is more economical. Also, ambient-task lighting method allows the individual worker to adjust the appropriate illuminance for the task being performed according to their preferences. Furthermore, efforts should be made to provide windows to some offices wherever possible because access to daylight and views to the external environment is beneficial to occupants' health and wellbeing. Some existing literature affirms that occupants strongly prefer daylight to electric lighting (Katabaro and Yan, 2019). Day lighting is considered the best source of light with exceptional colour rendering and continuous spectrum, which offers the best light for human visual comfort and health (Al Horr *et al.,* 2016). Additionally, unswerving inspections be carried out on eyesight and health of employees whom are exposed to maximum or minimum illuminance levels in their workstations. Equally, recurrent inspection of illuminance levels in several locations in the university should be deliberately carried out. Lastly, the repairs of plug-in cords, connections, paddings and replacement of illumination equipment when bad should be regularly done. In all, the lighting in the work environment should be designed to provide not only the right visual conditions but also the conditions which promote occupant's health and wellbeing.

Conclusion

The results from this study revealed that most of the workstations in offices of the Faculty of Life Sciences, University of Benin, were poorly lit. Poor illuminance levels pose danger to the eyesight and general health of employees. It is therefore recommended that the illuminance level in office work stations, be improved to increase productivity and wellbeing.

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Competing interests

The authors declare that they have no competing interests.

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