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Original Article

Visual Comfort and Discomfort in Public Boarding Secondary Schools in Nairobi City County, Kenya

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ABSTRACT

Indoor light quality is the intensity and amount of illumination of interior spaces. Technological developments have led to the utilisation of artificial natural light. Illumination is crucial in the visibility of tasks. Quality of light can influence the visual comfort and ocular health of the students. Although Kenya lacks lighting standards for schools, ISO and CIE provide international guidelines on optimal illumination for various facilities. This study was conducted on public boarding secondary schools in Nairobi City County to assess the visual comfort or discomfort of students in classrooms. The study utilised a cross-sectional descriptive study design. Four hundred twenty-three students were randomly sampled from 8 schools. Illumination levels were measured in 38 classrooms using a calibrated Benetech GM1010 light metre and compared to levels recommended by ISO and CIE. A self-administered semi-structured questionnaire was used to collect data on students' visual comfort or discomfort. Data was analysed using SPSS version 23. Descriptive data were analysed using frequencies, while inferential data were analysed using chi-square. The study established that 15% of the respondents experience visual comfort during the day, 13.5% at night, and 12.7% both day and night. Fourteen classrooms achieved the recommended illumination level at 7:30, 20 at 13:00 hours, and 10 at 18:00 hours. Recorded levels ranged from 56.71 lux to 1289.93 lux. The study found a statistically significant association between visual comfort and factors such as existing eye problems, presence of blinds or curtains, number of windows, presence of whiteboards, classroom orientation and student sitting positions. The study recommends that public secondary schools need to ensure quality indoor illumination

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in their facilities to enhance the visual comfort of students in learning facilities.

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INTRODUCTION

The propagation of electric lighting has provided widespread access to light virtually anywhere at any time of day. The ability of light to increase the visibility of critical details of a task implies that lighting directly affects visual performance (Mujeebu, 2019). Artificial illumination is one of the most significant human technological advances. The prevalent utilisation of artificial light has adverse effects on humans, animals, and plant populations (U.S. Department of Energy, 2014). The European Committee for Standardisation (2011) defines visual comfort as a "subjective condition of visual well-being induced by the visual environment". Visual comfort refers to the conditions necessary for an ocular system to optimally perform its function. Consequently, it is essential to evaluate how we light architectural spaces.

The quality of light depends on six different characteristics that will make the environment ideal for the occupants of the space. These requirements are visual performance; post-visual performances such as reading, walking, and eating; communication and social interaction; mood and comfort; aesthetic judgements; and safety and health (Samani & Samani, 2012). School-going children need the correct balance of all of these aspects to enhance the learning process. The visual environment affects students' performance since it influences their ability to perceive optical stimuli and affects their mental health (Tureková et al., 2018). Educators, administrators, designers, and maintenance teams in educational institutions need to pay more attention to the illumination of interior spaces in schools depending on the functions of the room.

Learners spend the better part of their days in school. The school environment should cater to the children's physical, mental, and social needs. Environmental factors such as lighting play a significant role in the learning outcomes of the students. About 83% of learning occurs using the sense of sight during the learning process (Gilavand et al., 2016). Therefore, inadequate or excessive lighting in schools may affect the visual

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performance and mental health of the students. A study in elementary schools in Iran established that school lighting should create an atmosphere that ensures visual perception is undertaken with minimum discomfort and effort (Gilavand et al., 2016). Adequate illumination is vital in ensuring that both the staff and students focus on education instead of dealing with health challenges.

The Sustainable Development Goals aim to provide quality education for everyone. Unfortunately, this is yet to be achieved, particularly in developing countries. According to the United Nations Educational, Social, and Cultural Organization (UNESCO, 2013), educational institutions should be safe and intellectually stimulating. Kenya aims at fulfilling the Standard Development Goals (SDGs) through the provision of education for all. Vision 2030, through the social pillar, aims at providing internationally competitive education and training (Aloyo, 2015). The illumination of the learning environment influences the attentiveness and performance of visual tasks such as reading and writing by students. The achievement of these objectives may be achieved by maintaining a good quality of light in all learning institutions, including secondary schools.

There are recommendations for best practices for illumination in schools. However, classroom lighting is continually changing due to technological advancements (Tureková et al., 2018). The development of LED bulbs and the introduction of data projectors and whiteboards to schools call for the assessment of their influence on the quality of indoor illumination in learning institutions. The quality and quantity of light in the interior spaces of secondary schools are essential in guaranteeing the visual comfort of the students.

Problem Statement

Illumination has been found to have a direct effect on the visual comfort, productivity, mood, and overall health of human beings (Ram & Bhardwaj, 2018). Environmental factors have a 15-2-% impact as a parameter influencing public health. This aspect is only secondary to the population lifestyle that has a 50% impact on human health. Inadequate and excessive lighting can result in various physiological and psychological effects including lethargy, anxiety, headaches, eyestrain, nausea, backaches, neck aches, shoulder pain, lack of mental alertness, and daytime sleepiness (Ram & Bhardwaj, 2018).

The quality of illumination in the learning environment is influenced by technological developments such as the invention of LED bulbs and the introduction of whiteboards in schools (Negiloni et al., 2018). Students in boarding schools spend all their time within the school environment whenever the school term is in session. Consequently, schools should ensure that every architectural space meets the appropriate lighting standards to guarantee the safety and health of both the students and staff (Tureková et al., 2018). There are international standards that provide guidelines on the optimal amount of light required per room depending on the activities carried out in the school facility. Unfortunately, there is minimal regard for the influence of light on visual comfort and ocular health in Africa and particularly in Kenya.

Currently, Kenya lacks lighting standards for schools. The schools in Nairobi City County are located in regions with varying social classes. The Government of Kenya introduced the 100% transition from primary to secondary school policy hence increasing the number of students in secondary schools. Assessing the quality of light in schools is crucial due to the increasing student population that is exposed. The study focused on public schools since student enrolment is higher than that of private schools. Additionally, public schools have learners from diverse socioeconomic backgrounds hence providing a study population that has a broader demographic variation than private schools. Public schools tend to have high

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student populations, which may result in a better representation of the target population.

Moreover, the study focused on boarding schools since these students spend the majority of the year within the learning facility both during the day and night whenever the school is in session. The study was conducted in Starehe and Westlands Sub-Counties in Nairobi City County since they have the highest concentration of public boarding secondary schools in the county. There is a paucity of studies on illumination and visual comfort in secondary schools hence creating the need to evaluate the visual comfort of the students of public boarding secondary schools. This study, therefore, assessed visual comfort or discomfort in public boarding secondary schools in Nairobi City County, Kenya.

MATERIALS AND METHODS

The study utilised a cross-sectional descriptive study design. The study population was public boarding secondary school students in Starehe and Westlands Sub-counties in Nairobi City County. There are 7 boys' and 8 girls' schools bringing the total number of public boarding schools in the two sub-counties to 15 (County Director of Education Nairobi City, 2019). The study population is 17,170 students: 7219 boys and 9951 girls. The study focused on the indoor light quality of classrooms, science and computer laboratories, art rooms and libraries.

The approximation of sample size was facilitated by the use of Fisher *et al.* formulae (1993) as follows:

Since the study population is more than 10,000, the following equation applies:

$$n = \frac{z^2 xpq}{d^2}$$

Where n = sample size, z = standard normal probability for the confidence level., The confidence level used is 95% (0.95) and therefore the value of z is 1.96, p= probability of study population with desired characteristics, which is 50% (0.5), q = 1 – p = 1 – 0.5 = 0.5, d = level of significance

$$n = \frac{1.96^2 x\ 0.5\ x\ 0.5}{0.5^2} = 384\ respondents$$

To take care of attrition:

n = 384 X 110% = 423 Respondents

A sample size of 423 students was randomly selected from 8 schools. An observational checklist was used to make a record of the type of light source used; the position of light switches; the presence or absence of blinds or curtains; the kind of board used; whether all the luminaires were working; the total number and positioning of the doors, windows, and luminaires; and the general maintenance of the lighting equipment. Illuminance was measured using the Benetech GM1010 Split Light Meter. The source of light, whether natural or artificial, was noted before the illumination levels were measured. The measurement recorded was the light the students were exposed to at the time without any modification. To enable representative sampling across the room, it was then divided into six or eight sections depending on the size and arrangement of the student's desks. Measurements were taken from each section by positioning the light metre horizontally on students' desks. The illumination levels were measured thrice in a single day: between 7:00-800; between 13:00-14:00; and between 17:30-18:30 (Negiloni, Ramani, & Sudhir, 2019). *Plate 1* shows the Benetech GM1010 Split Light Meter.

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Plate 1: Benetech GM1010 Split Light Meter

Additional primary data was collected using a questionnaire. The questionnaire sought to determine the influence of the quality of illumination on the physiological symptoms, perceptions of brightness, and task performance of the users. The questionnaire was based on the parameters used in SBTool to assess visual comfort. The questionnaire was semi-structured and self-administered by the respondents and comprised three sections. The first section involved questions on the respondents' sociodemographic factors such as sex, age, name of the school, and the desk position in the classroom. The subsequent section sought to assess the task performance of the respondents by evaluating the visibility of the blackboard or whiteboard, glare, and their level of comfort with the existing illumination levels. The last part of the questionnaire addressed questions about the possible symptoms of inadequate or excessive lighting in classrooms. The questionnaire was designed in English. The respondents received oral instructions in English and Swahili to ensure the questions were well understood prior to receiving the questionnaires from the researcher before class sessions began. The students then completed the questionnaire and returned it to the investigator during class breaks. Data were coded into categories and then analysed using Statistical Package for the Social Sciences (SPSS), version 23.0. Descriptive data were analysed using frequencies, while inferential data were analysed using chi-square. Students experienced visual comfort when they rated the amount of light at their desks as normal; we were able to perform all the reading and writing tasks with the lighting in their classroom; and experienced no symptoms of visual discomfort.

RESULTS

Response rate

A total of 401 dully filled and usable questionnaires out of 423 were obtained from respondents for the study. This represented a 94.8% response rate. According to Mugenda and Mugenda (2003), this return rate was sufficient for doing the analysis. The high response rate can be attributed to the data collection procedures. The researcher informed the participants of the intended survey prior to giving them the self-administered questionnaires. A total of 38 classrooms, 8 science laboratories, 6 computer laboratories, 6 libraries, and 4 art rooms were analysed.

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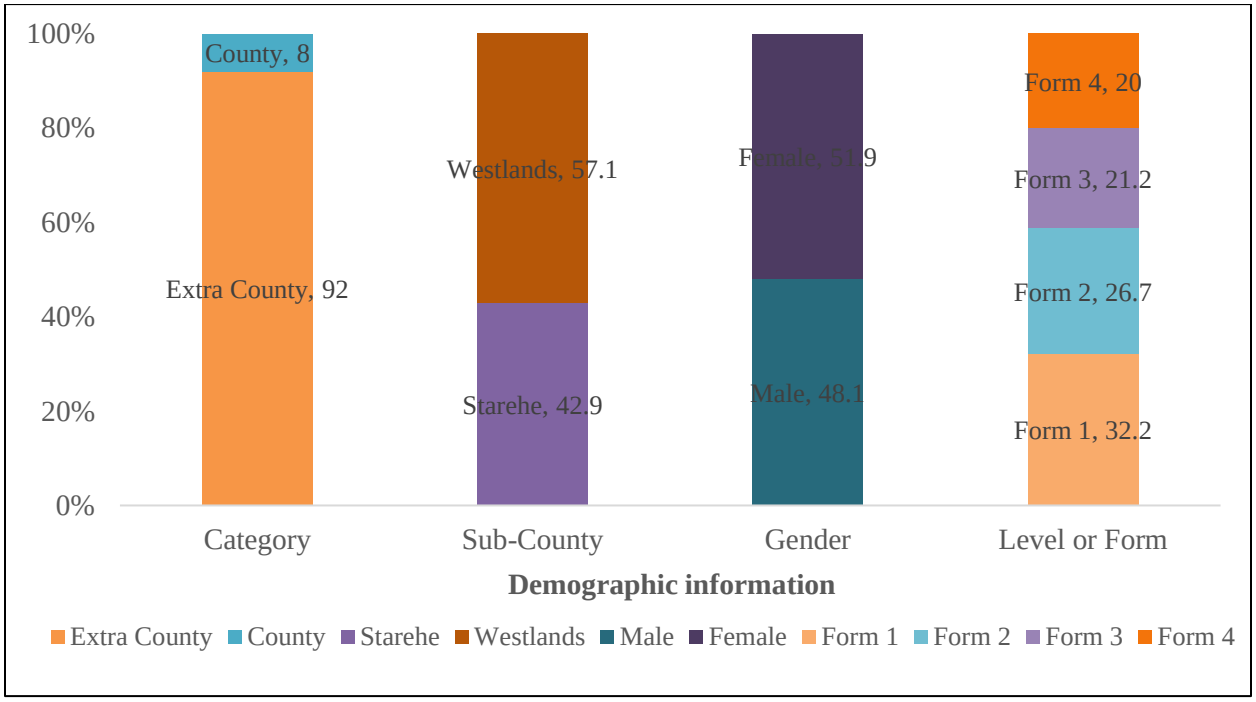
Sociodemographic Information

Category, Sub-County, and Gender of Respondents

Figure 1 presents the results on the demographic information of the respondents based on the category of school, the sub-county within which the school is located, and the gender of the respondents. The results indicate students from extra county schools were 369 while 32 were from county schools. This indicates that most of the schools in the area are extra county and hence usually receive higher financial allocation than lower-ranked schools. One hundred seventy-two respondents came from schools in Starehe Sub- County while 229 are from Westlands Sub-County. This distribution was based on the number of schools in each sub-county. This did not affect the visual comfort or discomfort of the respondents. There were 193 male students and 208 female students. This indicates that there was a gender balance in the distribution of the respondents. This did not affect the visual comfort or discomfort of the respondents. One hundred twenty-nine were in form one, 107 in form two, 85 in form three, and 80 in form four. The number of classroom streams tended to be progressively higher in form 1 than in form 4. This is an indication of an increase in enrolment in secondary schools due to the 100% transition from primary to secondary policy by the Kenyan Government.

Figure 1: Demographic information of respondents



Existing Eye Problem

The study sought to establish whether the respondents have any existing eye problem that has been addressed by an optician. The results indicate that 43.14% (173) of the students had visited a doctor. This shows that more than half of the respondents were yet to seek medical attention as a result of the effects of poor or excessive lighting, or they have not been majorly affected by the quality of illumination in schools. *Figure 2* presents results on the reasons respondents visited the optician. Results indicate that the most common eye problems were myopia (61.27%) and light sensitivity (30.64%).

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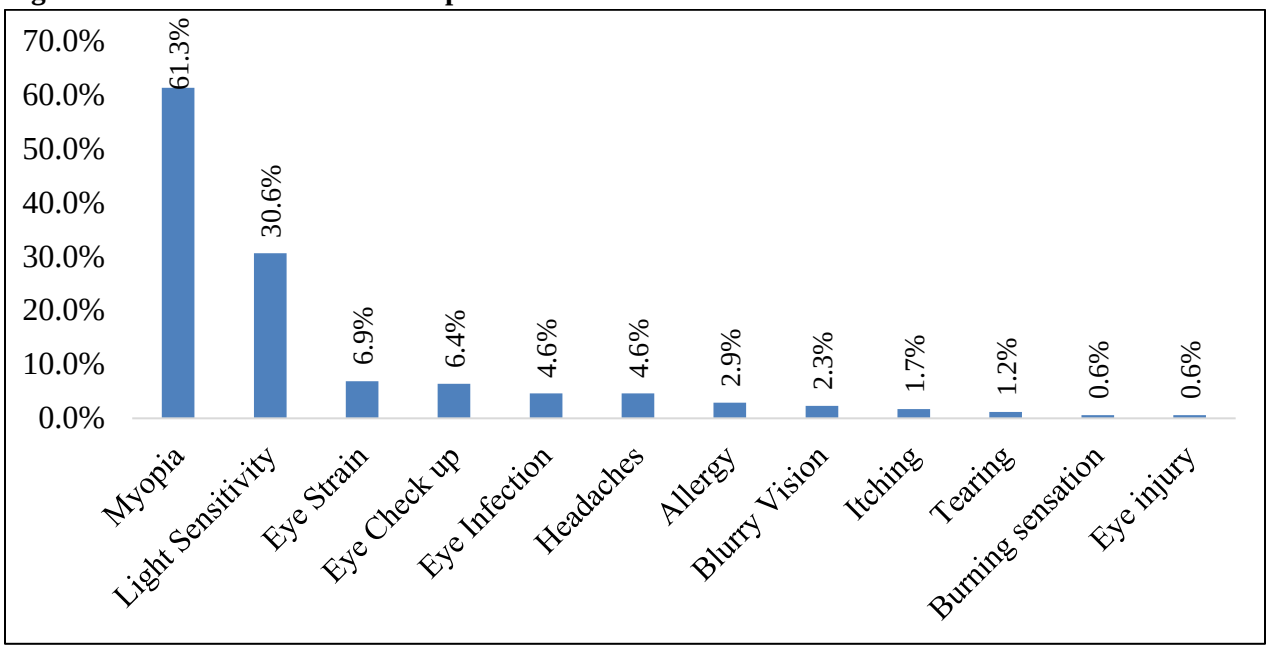
Figure 2: Reason for a visit to the optician



Duration of Exposure to Light in Learning Facilities

Figure 3 presents the proportion of students according to the number of hours they spend in each learning facility in a week. The results indicate that the length of one lesson, which is 40 minutes, is uniform across all schools in Kenya. Although some learning facilities are not used daily by students, they are used at varying degrees during the week based on the school timetable per the ministry of Education requirements. Consequently, the study sought to establish the number of lessons the respondents spent in the facilities in a week. Every school follows the regulations stipulated by the Ministry of Education. The students have nine 40-minute lessons and two-hour-long evening preps every weekday. This time adds up to 40 hours per week in learning facilities. All the respondents use classrooms daily. During school hours, classrooms are the default rooms that students use when they are not in science laboratories, computer laboratories, libraries, or art rooms. 100% of the respondents use classrooms and science laboratories. One hundred thirty-six students use the computer laboratories, 144 use the libraries, and only 80 respondents use the art rooms. Of the 8 schools, all of them had science laboratories, 6 had computer laboratories, 6 had libraries, and 4 had art rooms.

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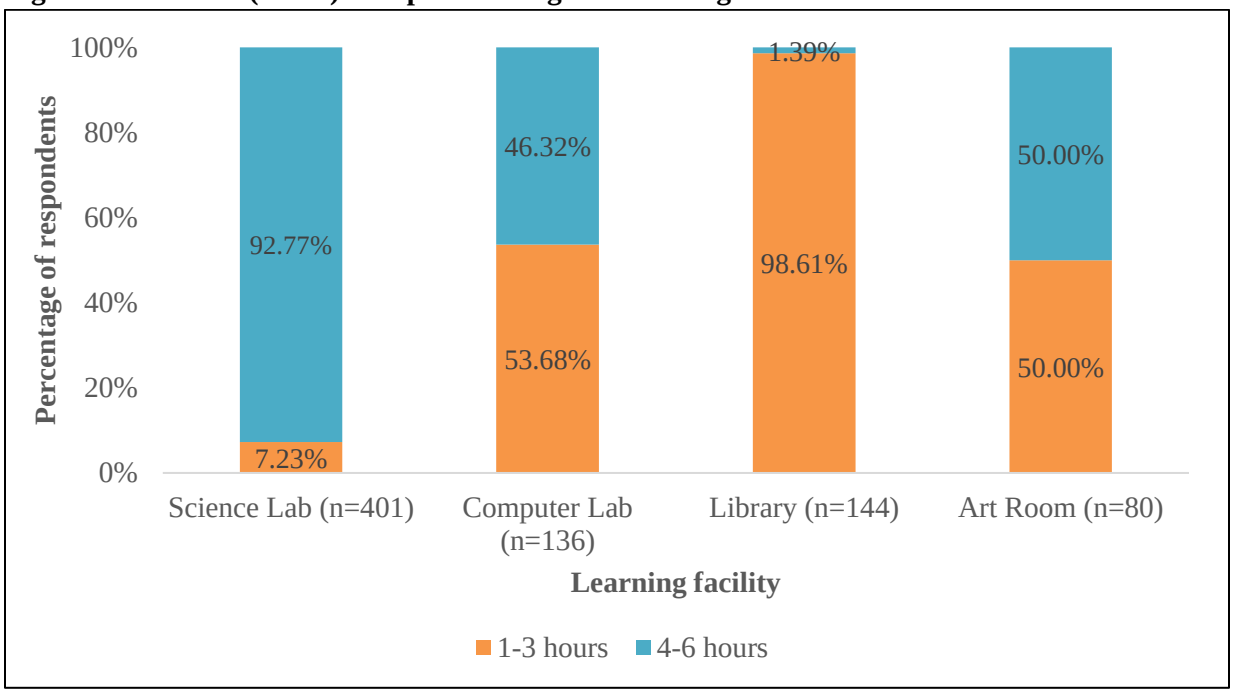
Figure 3: Duration (hours) of exposure to light in learning facilities

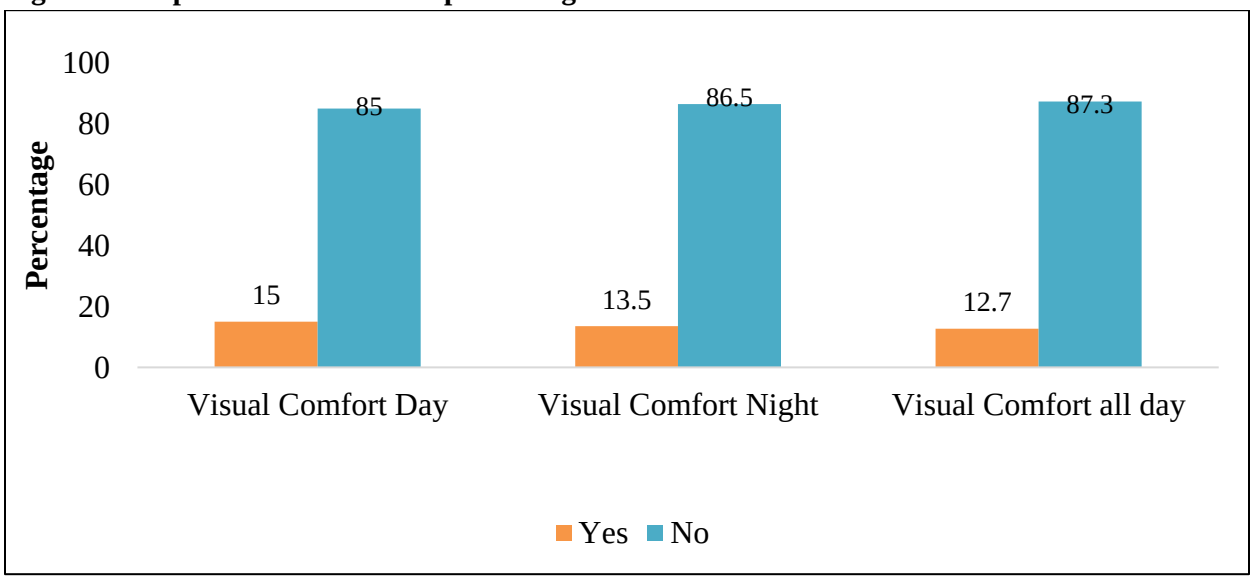


The Proportion of Students Reporting Visual Comfort

Students Reporting Visual Comfort

The study used three indices to determine whether the respondents experienced visual comfort or discomfort: Rating of light, task performance and symptoms of visual discomfort. *Figure 4* presents the results on the proportion of students experiencing visual comfort. The results indicate that 60 respondents experience visual comfort during the day, 54 at night, and 51 both day and night. A majority of the students experience visual discomfort in classrooms.

Figure 4: Proportion of students experiencing visual comfort



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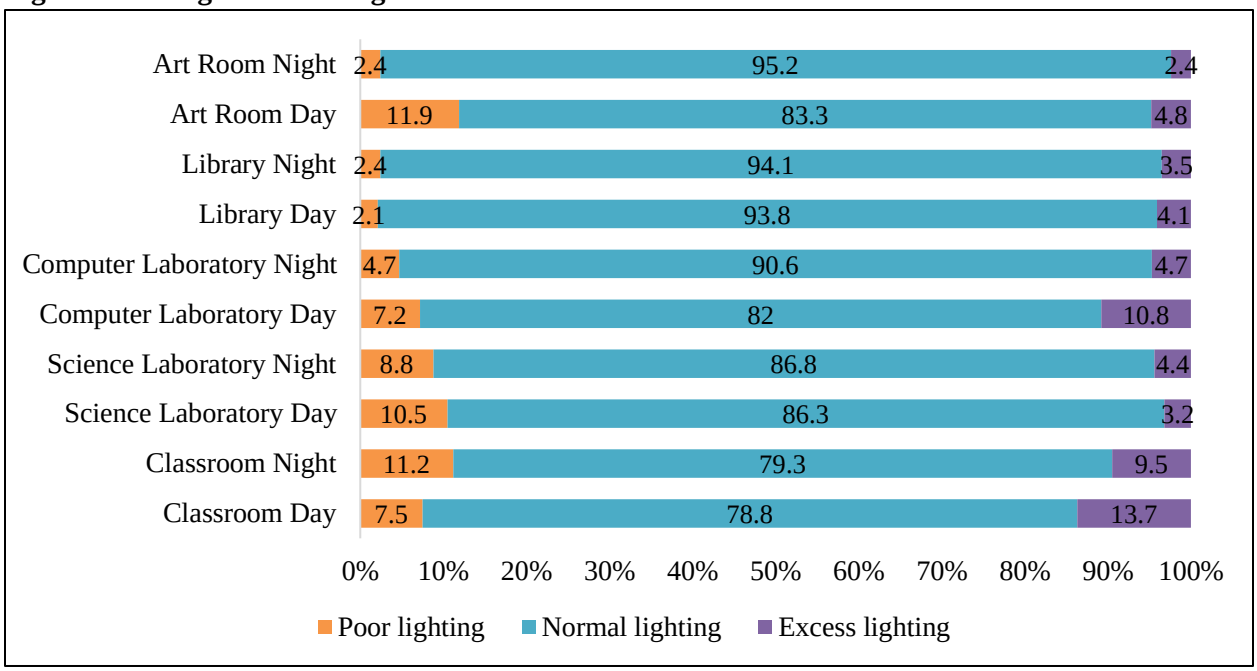
Rating Amount of Light at the Desk

Respondents were asked to rate the amount of light they received at their desks during the day and at night. This was intended to assess whether they were comfortable with the amount of light they were exposed to in various learning facilities. *Figure 5* presents results on the rating of the amount of light at the student's desk. Results indicate that at least 78% of the students stated that the light they receive at their desks is normal both during the day and at night. This means that the majority of the students claim to be comfortable with the amount of light they receive.

Figure 5: Rating amount of light at the desk



Task Performance

Visibility of Blackboards and Whiteboards

Figure 6 presents results on the visibility of blackboards and whiteboards. Results indicate that classrooms had the lowest proportion of students (47.1% during the day and 51.6% at night) who were able to see everything written on the boards. The percentage of students reporting having the ability of the respondents are able to read everything written on boards increases at night in classrooms. This implies that there is adequate artificial lighting on the boards at night. Reduced ability to perform visual tasks lowers the visual comfort of the students.

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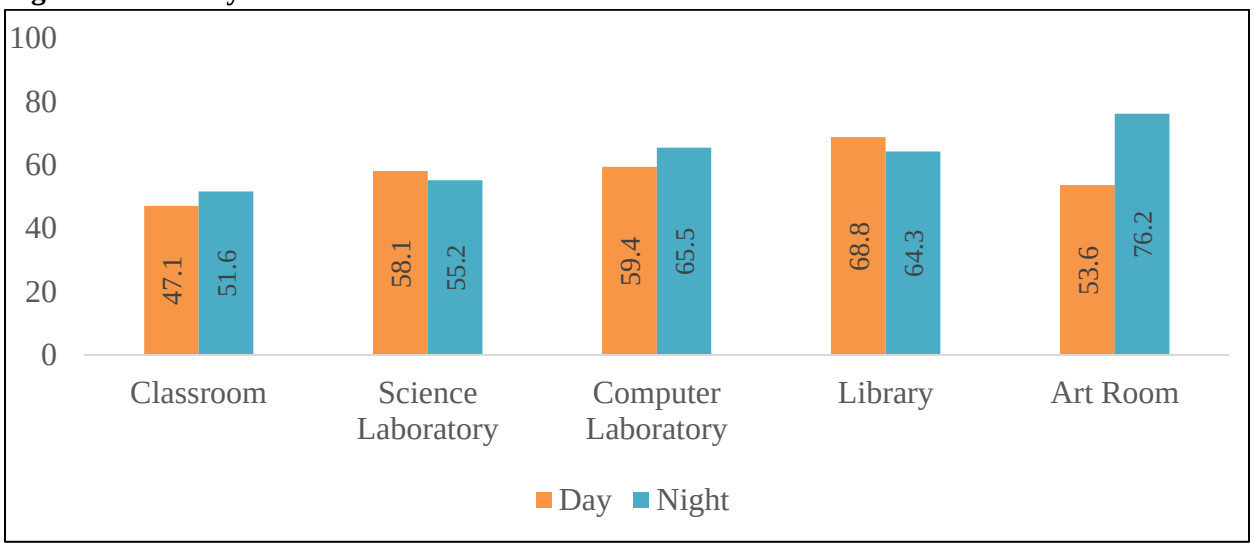
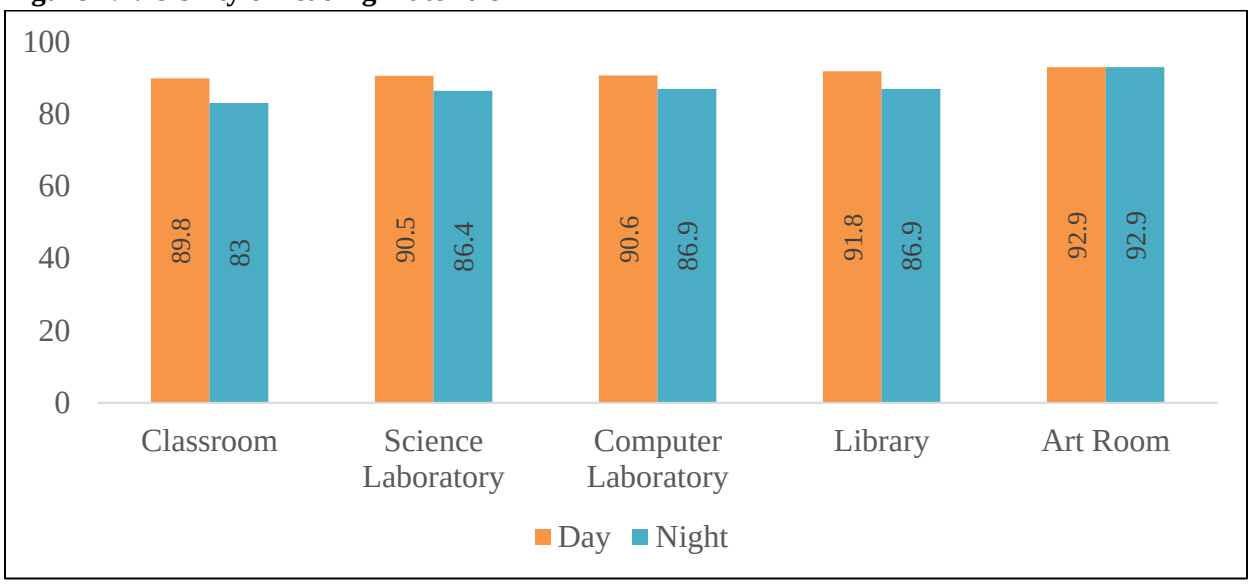
Figure 6: Visibility of boards



Visibility of Reading Materials on Learners' Desks

Figure 7 presents results on the visibility of reading materials on their desks. Results indicate that the majority of the students (89.8% during the day and 83% at night in classrooms) were able to see everything written on their reading materials on their desks. This implies that the ability of students to see reading materials on their desks reduces at night. This may indicate that the illumination levels at the students' desks are better than the illumination on the boards. Increased ability to perform visual tasks enhances the visual comfort of the students.

Figure 7: Visibility of reading materials



Visibility of the Computer

Results indicate that no school had computers located in any other room apart from the computer laboratory. 70.5% of the computer laboratory users during the day and 79.7% at night were able to see everything written on the computer. This implies that computer laboratories had adequate indoor illumination.

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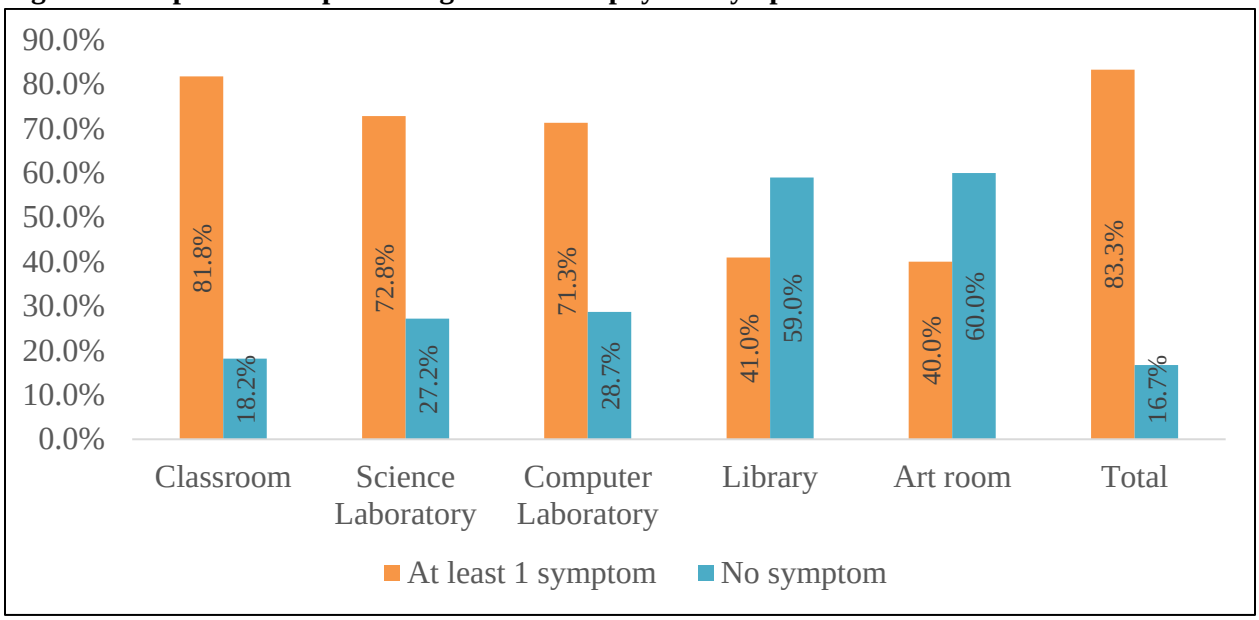
Symptoms of Visual Discomfort

The purpose of this segment was to establish the number of respondents who experienced at least one physical symptom during learning sessions. *Figure 8* presents results on the proportion of respondents experiencing at least one physical symptom. Results indicate that 334 (83.3%) students reported experiencing at least one physical symptom in a school facility. Classrooms had the highest proportion of respondents who experienced at least one physical symptom at 81.8% in classrooms. This can be attributed to the fact that students spend considerably longer time in classrooms than in any other learning facility. An increase in the duration of exposure to inadequate or excessive light may lead to an increase in visual discomfort. Also, a higher percentage (92.8%) of the respondents use science laboratories for 4-6 hours a week. This affects the visual comfort or discomfort of the respondents. Computer laboratories have computers whose screens produce artificial light that increase the probability of visual discomfort.

Figure 8: Respondents experiencing at least one physical symptom



The results indicate that of the 228 students who have not visited an eye doctor, 169 (74.1%) of them have at least one symptom. This implies that although 56.9% of the respondents have not visited an eye doctor, many of them are still experiencing physical symptoms of visual discomfort. Some respondents may yet to seek medical attention for the effects of poor or excessive lighting, or they have not been majorly affected by the quality of illumination in the learning facilities.

Figure 9 presents the results on the proportion of students reporting symptoms of visual discomfort. The results indicate that the most common symptom in all learning facilities was eyestrain. That is 66.3% in classrooms, 58.6% in science laboratories, 62.5% in computer laboratories, 29.9% in libraries, and 26.3% in art rooms. Other common symptoms are headaches, glare, and tearing and desire to rub eyes. The least common symptom in all learning facilities is difficulty in discriminating between colours. That is 12.5% in classrooms, 13% in science laboratories, 16.2% in computer laboratories, 6.3% in libraries, and 11.3% in art rooms.

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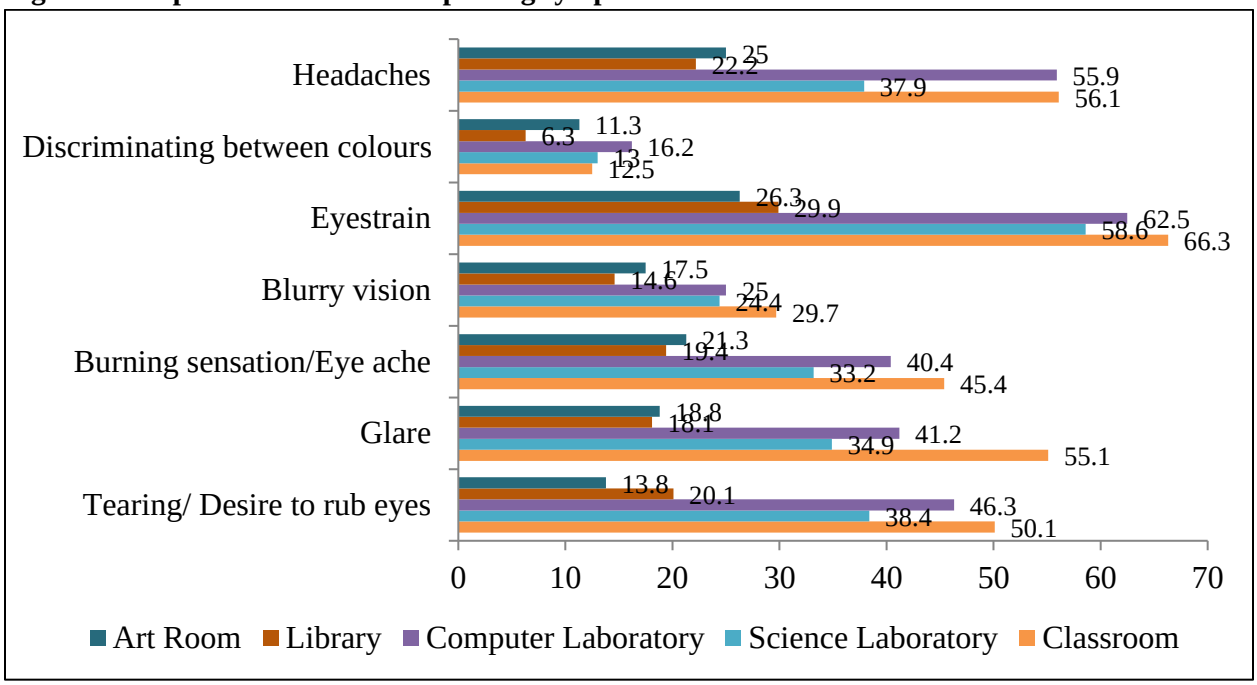
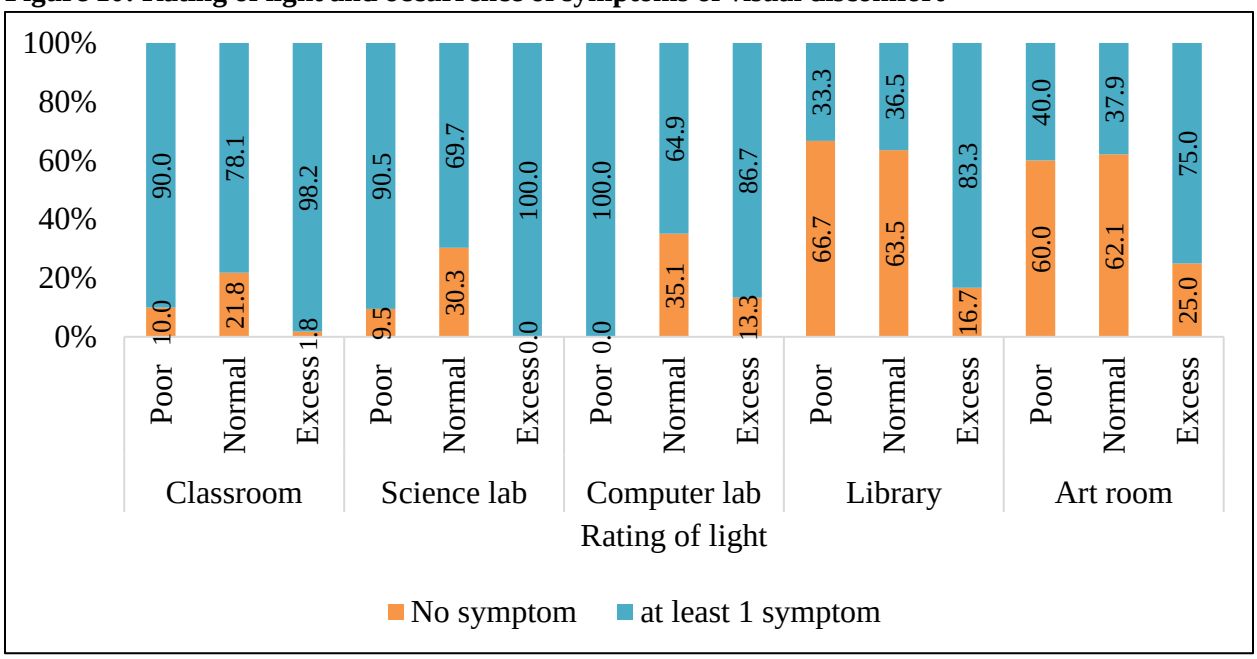
Figure 9: Proportion of students reporting symptoms of visual discomfort



The result from this section was compared to the user's general opinion of the visual comfort level to help verify whether physiological symptoms are associated with feelings of discomfort. *Figure 10* presents the results on the rating of light and the percentage of respondents reporting at least one symptom of visual discomfort. The results indicate that the highest percentage of respondents who reported experiencing no symptoms also rated the light as normal in every learning facility.

Figure 10: Rating of light and occurrence of symptoms of visual discomfort



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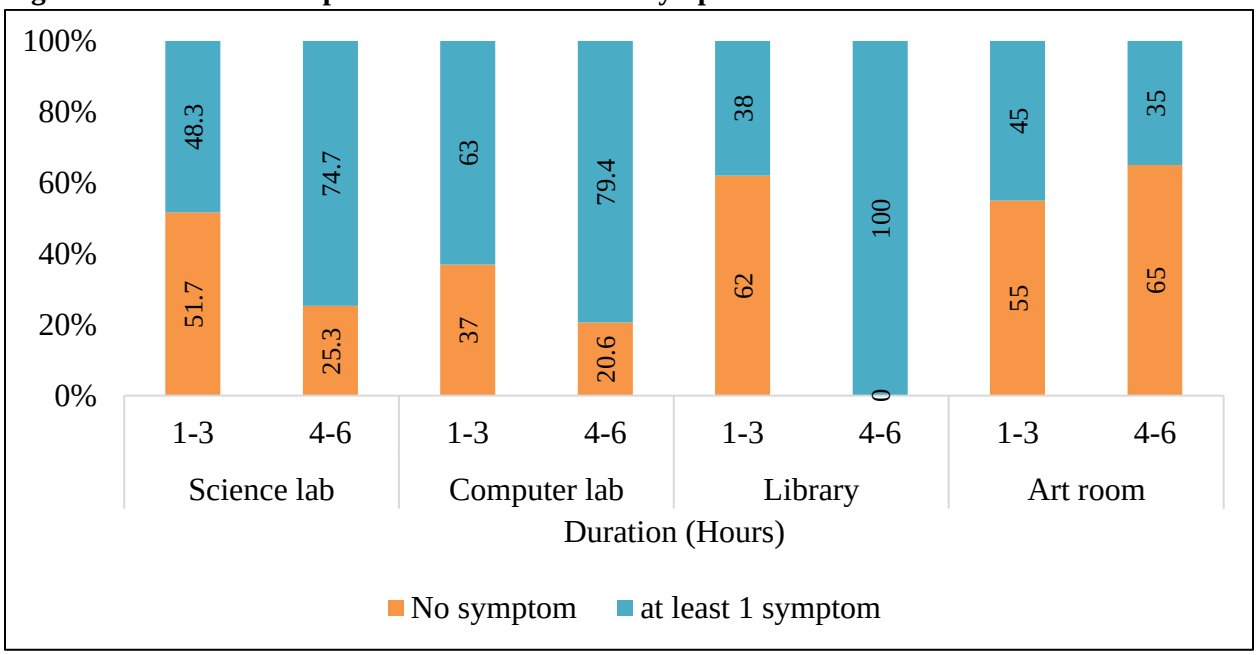
Duration of exposure was then compared to the occurrence of at least one symptom of visual discomfort to establish whether the duration of exposure to light influences the occurrence of symptoms of visual discomfort. *Figure 11* presents the results on the relationship between the duration of exposure and the occurrence of symptoms of visual discomfort. The results indicate that a higher number of students who spend 4-6 hours in science laboratories (74.7%) and computer laboratories (79.4%) experience at least one symptom of visual discomfort. This implies that spending more time in the learning facilities increases the probability of respondents experiencing at least one physical symptom of visual discomfort.

Figure 11: Duration of exposure and occurrence of symptoms of visual discomfort



Conformity of Indoor Illumination Levels to the ISO/CIE Standards

The levels of illumination in the facilities differed at different times of the day. The results were compared to the ISO and CIE standards. Since visual comfort can start to decrease when illuminance is over 1000lux, levels above 1000 were noted.

Light Levels in Classrooms

The recommended level for classrooms is 300 lux (ISO & CIE, 2002). *Table 1* presents results on the mean levels of illumination in the classrooms per school. Results indicate that only 2 schools recorded a mean of more than 300lux in the morning. In the afternoon, 6 schools recorded illumination levels above the recommended level. In the evening, only one school achieved the recommended illumination level. The mean illumination of 4 schools had achieved the recommended level. This implies that natural light in the afternoon contributes to the high number of schools that meet the recommended light levels. The lower levels of natural light in the morning and evening contributed to the high number of schools whose light is lower than the recommended levels.

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Table 1: Light levels in classrooms per school

School	Light level (Lux)			
	7:30	13:00	18:00	Mean
Jamhuri High	291.34	959.34	423.44	558.04
Dr. Ribeiro Parklands	278.31	557.34	128.44	321.36
Ngara Girls	232.63	335.12	217.74	261.83
Hospital Hill	219.04	263.69	173.29	218.68
Kangemi High	218.05	268.26	206.51	230.94
Parklands Arya	295.22	314.17	284.77	298.05
State House Girls	469	347.99	234.15	350.38
Nairobi Milimani	383.47	374.42	273.37	343.75
Mean	305.92	426.11	243.63	325.22

Table 1 presents results on the mean levels of illumination in the classrooms. Results indicate that of the 38 classrooms, 14 classrooms achieved the recommended illumination level at 7:30, 20 classrooms at 13:00, and 10 classrooms at 18:00. One classroom recorded more than 1000 lux at 7:30 and 4 at 13:00. The lowest levels recorded were 115.31 lux at 7:30, 66.91 lux at 13:00, and 56.71 at 18:00. The highest levels recorded were 1289.93 lux at 7:30, 1141.9 lux at 13:00, and 651.09 at 18:00. Nineteen classrooms had a mean that achieved the recommended levels.

Light Levels in Other School Facilities

The recommended level is 500 lux for science laboratories, 500 lux for computer laboratories, 500 lux for libraries, and 500-750 lux for art rooms (ISO & CIE, 2002). *Table 2* presents the results on the number of facilities whose illumination achieved the recommended levels. The results indicate that most of the learning facilities did not meet the recommended illumination levels. This is attributed to the lack of national standards for the illumination of educational facilities. Consequently, principals and other relevant authority lack guidelines on how to ensure adequate indoor illumination in the learning facilities.

Table 2: Number of facilities with the recommended light levels

Facility	Time			
	7:30	13:00	18:00	Mean for the day
Classrooms	14	20	10	19
Science Labs	1	0	0	0
Computer Labs	0	0	0	0
Libraries	1	1	0	0
Art Rooms	0	1	0	1

Environmental Factors Associated with Visual Comfort or Discomfort

Due to the small number of other learning facilities sampled, the study focused on classrooms to determine environmental factors associated with visual comfort. A chi-square analysis was conducted to establish the associations between the various environmental factors in classrooms.

Environmental Factors in Classrooms

Figure 12 presents results on the environmental factors in classrooms. Results indicate that out of 38

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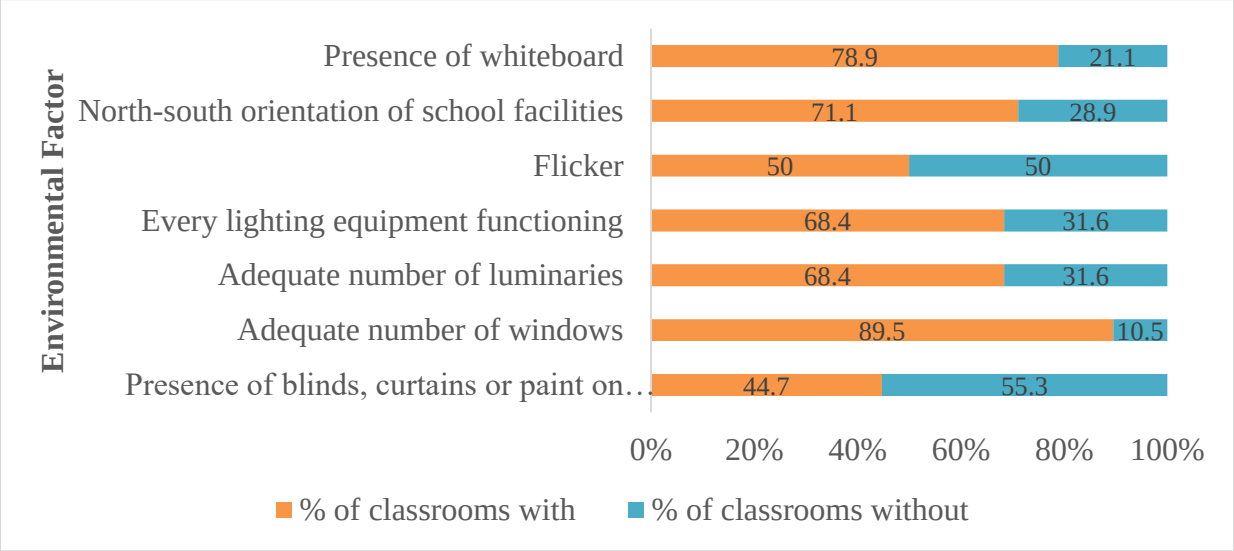
classrooms, 17 had blinds, curtains, or paints on windows. This enables the learners to control the amount of natural light entering the room. Consequently, the students can use the curtains to prevent experiencing glare. Thirty-four classrooms had an adequate number of windows. This increases the amount of natural light in the room hence reducing the reliance on artificial light. Twenty-six classrooms had an adequate number of luminaries. This enhanced the uniformity of light in the rooms. Every lighting equipment in 26 classrooms was functioning. This enhances the uniformity of light in the rooms. Nineteen classrooms had at least one light source that was flickering. Proper maintenance reduces the exposure to flickers since faulty bulbs are replaced on time. This enhances the uniformity of light in the rooms. Twenty-seven classrooms had a north-south orientation. School designs and buildings need to be oriented in the North-South direction to protect the occupants from the glare resulting from the 10:00 am and 4:00 pm sun. Thirty classrooms had whiteboards. The presence of whiteboards, which is a reflective surfaces, may increase the occurrence of glare. The type of light source influences the amount and quality of light received in a room. Although the observational checklist provided an exhaustive list of possible types of light, all the classrooms in every school relied on both natural light and fluorescent tubes. Every classroom had brightly painted walls. This enhances the brightness of the room.

Figure 12: Environmental factors in classrooms



Environmental Factors associated with Visual Comfort During the Day

A chi-square analysis was conducted to establish the associations between the various environmental factors. *Table 3* presents the results of the chi-square analysis of the environmental factors associated with visual comfort during the day. Results indicate that there was a significant association between visual comfort during the day and the following environmental factors:

Presence of Blinds, Curtains or Paint on the Window

The null hypothesis was rejected, $X^2(1) = 3.982$, $p < .05$). The phi value > .10. There was a significant association between the presence of blinds, curtains, or paint on windows and visual comfort during the day. The association was moderate. The presence of blinds, curtains, or paint on windows provides the respondents with a level of control over the amount of natural light that they are exposed to through the

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windows, reducing the exposure to glare. Consequently, they may control their level of visual comfort in the classrooms.

Number of Windows

The null hypothesis was rejected, $X^2(1) = 6.986$, $p < .05$). The phi value > .10. There was a significant association between the number of windows and visual comfort during the day and visual comfort at night. The association was moderate. The size and number of windows affect the amount of natural light that the students are exposed to in the classroom during the day.

Number of Luminaries

The null hypothesis was accepted, $X^2(1) = 2.333$, $p > .05$). There is no association between the number of luminaries in the classroom and visual comfort during the day. This can be attributed to classrooms mainly depending on natural light as opposed to artificial light during the day.

Every Lighting Equipment Functioning

The null hypothesis was accepted, $X^2(1) = .045$, $p > .05$). There is no association between every lighting equipment functioning and visual comfort during the day. This can be attributed to classrooms mainly depending on natural light as opposed to artificial light during the day.

Presence of Flicker

The null hypothesis was accepted, $X^2(1) = .542$, $p > .05$). There was no statistically significant association between the presence of flicker in a classroom and the visual comfort of the students during the day. This can be attributed to classrooms mainly depending on natural light as opposed to artificial light during the day.

Presence of Whiteboard

The null hypothesis was rejected, $X^2(1) = 5.895$, $p < .05$). The phi value > .10. There was a significant association between the presence of a whiteboard and visual comfort during the day. The association was moderate. Whiteboards increase the area covered by reflective surfaces in classrooms which may result in glare, which is a symptom of visual discomfort.

Orientation of Classroom

The null hypothesis was rejected, $X^2(1) = 4.163$, $p < .05$). The phi value > .10. There was a statistically significant association between the orientation of the classroom and the visual comfort of the students during the day. The association was moderate. Rooms whose windows have the North-South orientation avoid the glare from the 10:00 and 15:00 sun hence enhancing the visual comfort of the room's occupants.

Sitting Positions of the Student

The null hypothesis was accepted, $X^2(1) = 13.450$, $p > .05$). There was no statistically significant association between the sitting position of the respondent and their visual comfort during the day.

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Table 3: Chi-square analysis of the environmental factors associated with visual comfort during the day

Environmental Factors			Visual Comfort during Day		X^2(df)	p	Phi
			No	Yes			
Presence of blinds, curtains, or paint on window	Yes	Count	184	24	3.982 (1)	.046	.100
		Expected Count	176.9	31.1			
	No	Count	157	36			
		Expected Count	164.1	28.9			
Adequate number of windows	Yes	Count	315	49	6.986 (1)	.008	.132
		Expected Count	309.5	54.5			
	No	Count	26	11			
		Expected Count	31.5	5.5			
Adequate positioning of light sources	Yes	Count	254	39	2.333 (1)	.127	
		Expected Count	249.2	43.8			
	No	Count	87	21			
		Expected Count	91.8	16.2			
Is every lighting equipment functioning	Yes	Count	234	42	.045 (1)	.832	
		Expected Count	234.7	41.3			
	No	Count	107	18			
		Expected Count	106.3	18.7			
Presence of flicker	Yes	Count	188	30	.542 (1)	.462	
		Expected Count	185.4	32.6			
	No	Count	153	30			
		Expected Count	155.6	27.4			
Presence of whiteboard	Yes	Count	301	46	5.895 (1)	.015	.121
		Expected Count	295.1	51.9			
	No	Count	40	14			
		Expected Count	45.9	8.1			
Orientation of school facilities	Yes	Count	215	46	4.163 (1)	.041	-.102
		Expected Count	221.9	39.1			
	No	Count	126	14			
		Expected Count	119.1	20.9			

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Environmental Factors			Visual Comfort during Day								X^2(df)	p	Phi
			No					Yes					
Sitting position of the respondent			1	2	3	4	5	6	7	8	13.450 (1)	.062	
	Yes	Count	57	63	47	53	54	55	6	6			
		Expected Count	57.0	57.0	54.4	54.4	53.6	54.4	5.1	5.1			
	No	Count	10	4	17	11	9	9	0	0			
		Expected Count	10.0	10.0	9.6	9.6	9.4	9.6	.9	.9			

Table 4: Chi-square analysis of the environmental factors associated with visual comfort at night

Environmental factors			Visual Comfort at Night		X^2(df)	p	Phi
			No	Yes			
Presence of blinds, curtains, or paint on window	Yes	Count	187	21	4.212 (1)	.040	.102
		Expected Count	180.0	28.0			
	No	Count	160	33			
		Expected Count	167.0	26.0			
Adequate number of windows	Yes	Count	317	47	1.040 (1)	.308	
		Expected Count	315.0	49.0			
	No	Count	30	7			
		Expected Count	32.0	5.0			
Adequate positioning of light sources	Yes	Count	259	34	3.238 (1)	.072	
		Expected Count	253.5	39.5			
	No	Count	88	20			
		Expected Count	93.5	14.5			
Is every lighting equipment functioning	Yes	Count	241	35	.468 (1)	.494	
		Expected Count	238.8	37.2			
	No	Count	106	19			
		Expected Count	108.2	16.8			
Presence of flicker	Yes	Count	190	28	.159 (1)	.690	
		Expected Count	188.6	29.4			
	No	Count	157	26			
		Expected Count	158.4	24.6			
Presence of whiteboard	Yes	Count	308	39	10.968 (1)	.001	.165
		Expected Count	300.3	46.7			
	No	Count	39	15			

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		Expected Count	46.7				7.3					
Orientation of school facilities	Yes	Count	220				41				3.226 (1)	.072
		Expected Count	225.9				35.1					
	No	Count	127				13					
		Expected Count	121.1				18.9					
Sitting position of the respondent			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	17.404 (1)	.015	.208
	Yes	Count	59	63	46	55	56	56	6	6			
		Expected Count	58.0	58.0	55.4	55.4	54.5	55.4	5.2	5.2			
	No	Count	8	4	18	9	7	8	0	0			
		Expected Count	9.0	9.0	8.6	8.6	8.5	8.6	.8	.8			

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Environmental Factors Associated with Visual Comfort at Night

Table 4 presents results on the environmental factors associated with visual comfort at night. Results indicate the following for each of the environmental factors:

Presence of Blinds, Curtains or Paint on the Window

The null hypothesis was rejected, $X^2(1) = 4.212$, $p < .05$). The phi value > .10. There was a significant association between the presence of blinds, curtains, or paint on windows and visual comfort at night. The association was moderate.

Number of Windows

The null hypothesis was accepted, $X^2(1) = 1.040$, $p > .05$). There was no association between the number of windows and visual comfort at night. There is very little natural night at night. Consequently, the number of windows has no effect on visual comfort at night.

Presence of Whiteboard

The null hypothesis was rejected, $X^2(1) = 10.968$, $p < .05$). The phi value > .15. There was a statistically significant association between the presence of a whiteboard in a classroom and the visual comfort of the students at night. The association was strong. Whiteboards increase the area covered by reflective surfaces in classrooms which may result in glare, which is a symptom of visual discomfort.

Sitting Positions of the Student

The null hypothesis was rejected, $X^2(1) = 17.404$, $p < .05$). The phi value was > .15. There was a statistically significant association between the sitting position of the respondent and their visual comfort at night. The association was strong. The illumination of the rooms may not be uniform for every sitting position. Students who are seated directly below a luminaire may be exposed to higher levels of illumination than those who are not. Students who sit directly under luminaires that are flickering or not functioning may also increase the probability of experiencing discomfort.

DISCUSSION

The Proportion of Students Reporting Visual Comfort

The findings revealed that only 15% of the respondents experience visual comfort during the day, 13.5% at night, and 12.7% both day and night. This was indicated by the proportion of respondents that reported having the ability to perform all visual tasks, rated the light at their desks as normal, and did not experience any symptom of visual discomfort.

The findings revealed that more than 78% of the students claim to be comfortable with the amount of illumination they received at their desks both during the day and at night. Additionally, most of the students who rated the light as poor or excessive reported experiencing at least one symptom of visual discomfort in all the learning facilities. Although most of the students reported being comfortable with the quality of illumination, a large percentage also reported experiencing at least one symptom of visual discomfort. This implies that the students adapted to the low light levels resulting in reported comfort by the majority.

With regards to task performance, the findings revealed that the proportion of students reporting having the ability of respondents is able to read everything written on boards increases at night in classrooms. Also, the ability of students to see reading materials on their desks is reduced at night. Computer laboratories had adequate indoor illumination. This was indicated by having more than 70% of students both during the day and night. The findings support the study done in modern university classrooms in Taiwan, where tasks on students' desk surfaces also had the highest scores (Chiou et al., 2020).

Also, the study findings established that 83.3% of the respondents experienced at least one physical

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symptom while using the school facilities. A higher percentage of students (74.7% in science laboratories and 79.4% in computer laboratories) with longer durations of exposure reported experiencing at least one symptom of visual discomfort. Additionally, the most common symptoms in all the learning facilities were eyestrain, headaches, and glare. These findings were highly agreeable with a study conducted in university classrooms in Taiwan (Chiou et al., 2020) that found a high percentage of respondents had vision-relative physical symptoms.

Indoor Illumination Levels and Visual Comfort or Discomfort

The study findings established that schools recorded higher illumination levels at 13:00 than at 7:30 and 18:00 due to sunlight. Results indicate that 36.8% of the classrooms achieved the recommended illumination level at 7:30, 52.6% at 13:00, and 26.3% at 18:00.

The majority of the schools did not achieve the recommended light levels. In science laboratories, only one school met the recommended level in the morning and none in the afternoon and evening. In computer laboratories, no school met the recommended levels at any time of day. In libraries, only one school had illumination levels above the recommended standards in the morning and afternoon and none in the evening. In art rooms, only one school had illumination levels within the recommended standards in the afternoon and none in the morning and evening. The findings were compared to a study conducted in secondary schools in the United Kingdom that recorded 64% of the classrooms had minimum illuminance of above 300 lux (Winterbottom & Wilkins, 2009).

Environmental Factors Associated with Visual Comfort

The study findings established that various environmental factors are associated with visual comfort or discomfort in schools. Every school in the study relied on natural light and fluorescent tubes in all the learning facilities. Fluorescent bulbs are more prone to flickering than any other bulb type. Flickering may cause visual discomfort symptoms such as headaches and eye strain.

The study findings established that there was a moderately significant association between visual comfort during the day and the presence of blinds, curtains, or paint on windows; orientation of the classrooms; the presence of whiteboard; and the number of windows. These findings are consistent with a study conducted in secondary schools in the United Kingdom that found a weak but significant association between illuminance and total window area (Winterbottom & Wilkins, 2009).

Also, the study established that there was a moderately significant association between visual comfort at night and the presence of blinds, curtains, or paint on windows. There was a strong significant association between visual comfort at night and the presence of a whiteboard, and the sitting position of the respondents.

Conversely, there was no significant association between visual comfort during the day and the number of luminaries; every lighting equipment functioning; the presence of flickers; and the sitting position of the respondents. There was no significant association between visual comfort at night and the number of windows; the number of luminaries; every lighting equipment functioning; the presence of flicker; and the orientation of the classrooms.

CONCLUSIONS

From the findings, the study interprets that students in public secondary schools in Nairobi City County experience visual discomfort. The majority of the classrooms recorded illumination levels that were lower than the recommended lux in the morning and evenings. Most classrooms achieved the recommended lighting in the afternoon. Although most of the students (more than 78%) reported being comfortable with the quality of illumination, a large percentage also reported experiencing at least one symptom of visual discomfort. This implies that the students adapted to the low light levels resulting in

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reported visual comfort by the majority. Additionally, students who spent longer durations in a learning facility had a higher probability of experiencing at least one symptom of visual discomfort. According to the findings, the most common symptoms in all the learning facilities were eyestrain, headaches, and glare. There is a significant association between visual comfort during the day and the presence of blinds, curtains, or paint on windows; the number of windows; the orientation of the classrooms; the presence of a whiteboard; and the sitting position of the respondents.

Recommendations

Recommendations from the Study

This study makes recommendations to the Ministry of Education and relevant authorities in schools. The following recommendations aim at reducing visual discomfort in public secondary schools in Kenya:

- The indoor illumination levels should be altered to achieve the standard guidelines recommended by ISO and CIE.
- Improve the learning environment by changing factors such as installing blinds, curtains, or paint on windows; building learning facilities in a north-south orientation; and installing LED bulbs instead of fluorescent tubes to enhance visual comfort.

Recommendations for Further Research

The current study focuses on assessing visual comfort in public boarding secondary schools in Nairobi City County, Kenya. Consequently, future research can be conducted in other regions in Kenya due to the varying climatic and socioeconomic conditions in the country. These researchers can compare their results with current results.

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REFERENCES

Aloyo, P. (2015). The Relationship Between Physical Environment and Academic Achievement in Public Secondary Schools in Nairobi City, Kenya. PhD. Kenyatta University.

Chiou, Y.-S., Saputro, S., & Sari, D. P. (2020, May 11). Visual Comfort in Modern University Classrooms. *Sustainability, 12*. doi:10.3390/su12093930

European Committee for Standardisation. (2011). *Light and lighting - Lighting of workplaces - Part 1: Indoor workplaces.* Brussels: European Committee for Standardisation.

Gilavand, A., Gilavand, M., & Gilavand, S. (2016). Investigating the Impact of Lighting Educational Spaces on Learning and Academic Achievement of Elementary Students. *International Journal of Pediatrics, 4*(5), 1819-1828. doi:10.22038/ijp.2016.6768

ISO & CIE. (2002, May 15). Lighting of indoor workplaces. *International Standards*. ISO & CIE. Retrieved from https://www.academia.edu/38216388/ISO_CIE_8995_1_2002_E_Character_PDF_document?auto=download

Mugenda, O., & Mugenda, A. (2003). *Research Methods: Quantitative and Qualitative Approaches.* Nairobi: Act Press.

Mujeebu, M. A. (2019). Introductory Chapter: Indoor Environmental Quality. *IntechOpen*. doi:10.5772/intechopen.83612

Negiloni, K., Ramani, K. K., & Sudhir, R. R. (2019). Environmental Factors in School Classrooms: How They Influence Visual Task Demand on Children. *PLoS ONE, 14*(1). Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=134061518&site=eds-live

Article DOI: https://doi.org/10.37284/eajhs.6.1.1123

Ram, M. S., & Bhardwaj, R. (2018). Effect of Different Illumination Sources on Reading and Visual Performance. *Journal of Ophthalmic and Vision Research, 13*(1), 44-49. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edsgao&AN=edsgcl.523649591&site=eds-live

Samani, S. A., & Samani, S. A. (2012). The Impact of Indoor Lighting on Students' Learning Performance in Learning Environments: A Knowledge Internalisation Perspective. *International Journal of Business and Social Science, 3*(24), 127-136. Retrieved from http://www.ijbssnet.com/journals/Vol_3_No_24_Special_Issue_December_2012/14.pdf

Tureková, I., Lukáčová, D., & Bánesz, G. (2018, November). Quality Assessment of the University Classroom Lighting - A Case Study. *TEM Journal, 7*(4), 829-836. doi:10.18421/TEM74-21

U.S. Department of Energy. (2014, 05 01). *Lighting for Health: LEDs in the New Age of Illumination*. Retrieved from Office of Scientific and Technical Information: https://www.osti.gov/biblio/1221107-lighting-health-leds-new-age-illumination

UNESCO. (2013, June). *Education For All National EFA 2015 Review Guidelines.* Retrieved from UNESCO Digital Library: https://unesdoc.unesco.org/ark:/48223/pf0000222445

Winterbottom, M., & Wilkins, A. (2009). Lighting and discomfort in the classroom. *Journal of Environmental Psychology*, 63–75.

