Winter 12-1-2021

The Impact of Light Intensity on the Subjective Complaints of Librarians and Users: an Investigation of an Academic Library

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Abstract
The objective of this study is to analyze the impact of light intensity on the subjective complaints of librarians and visitiors at an academic library. This research applied both quantitative and qualitative techniques on 696 visitors and librarians. The result suggests that the effects of light intensity include eyestrain, reading difficulty, dizziness, shoulder and back pains, as well as impaired concentration. Also, the frequency of reading and working impacted the subjective complaints. Furthermore, the intensity as well as the frequency of reading and working greatly influenced the subjective complaints. Based on the qualitative analysis, the development of light concepts and room design significantly influenced the comfort level. Therefore, the negative impact of lighting is exacerbated by the increasing frequency of reading and working. However, library room designs greatly contributes to the comfort level of librarians and visitors.

Keywords: light intensity, subjective complaints, eye fatigue, reading difficulty, room design, academic library

Introduction
Lighting is considered as a component of office environmental design that is relatively dependent on workplace standards. This parameter plays a very essential role, according to the workers' perspectivs and welfare. Based on the International Labor Organization (ILO), a significant relationship exists between workplace lighting and safety, ranging from mild to severe injuries (ILO, 2019). In addition, over 3 million American employees suffer various light-related injuries and accidents on yearly basis, including slipping, tripping, falling, and equipment failure (Ramirez, 2018).

Poor illumination greatly influences sight and eye fatigue due to strain from extensive exposure. These conditions did not follow the specified standards and therefore, tend to interfere with work activities. Previous research on the garment industry showed that standard lighting conditions demonstrated a positive effect in the form of increased productivity by 10% and reduced work errors by 30% (ILO, 2019).

However, other studies reported a positive relationship of lighting intensity and productivity. The results confirmed a correlation coefficient (r) of 0.629, indicating a robust and positive ccontext. Evidently, high intensity triggers greater work productivity, and vice versa (Widjanarti, Setyawan, & Qadrijati, 2019).

America's standard of light intensity follows the OSHA (Occupational Safety and Health Administration) provisions of 500 lux for office and showroom, 750 lux for workshops, and 200 lux for waiting rooms (Aveta, 2020). Meanwhile, in Indonesia, the Decree of the Minister of Health No. 70 of 2016 standards for occupational health requirements and Regulation of

the Minister of Manpower Number 5 of 2018, are applied. As a consequence, administrative tasks, including writing, reading, working on archives and selecting correspondence, require 300 lux. Accounting, bookkeeping, shorthand jobs, typing, and office work (indoors) are specified at 500 lux (Permenaker, 2018; Permenakes, 2016). Furthermore, the library space is grouped into offices, with requirement ranging from 300–500 lux.

The variation in standards based on work type possibly prevented negative impacts, due to inappropriate lightings. These poor conditions are known to trigger eye fatigues, headaches, stress and work accidents (ILO, 2019). Employees with computers need adequate lighting to avert eye strains, in the form of sore eyes, itching and headaches. Furthermore, computer vision syndrome (CSV) is described as the negative impact from extensive computer use (Lurati, 2018). The symptoms are also determined by other factors, including workload, and eye-to-object distance. Therefore, the complaints tend to vary across individual workers (Nadhiva & Mulyono, 2020). A major role that involves the extensive use of computers is the librarian.

The library survey at the North Sumatra State Islamic University reported 20-96 daily visitors. Prior to the pandemic, the population was estimated at 300. Generally, libraries are known to limit the number of users, but continue to provide the regular services. The specified duration to borrow, read or return books is typically 2 hours. Interviews with three library visitors showed that certain rooms were uncomfortable. For instance, the literacy corner lacks a backrest, and after 1 hour, the shoulders, back, and neck begin to sore. Similarly, the America corner and the reading room were very bright, due to excessive lighting. This circumstance results in eyes strains or watery conditions.

In addition, reading desks were positioned directly under the transparent roof in certain user and staff rooms. This placement generates a glaring effect, although the hallway of the bookshelf appears relatively dark and visitors tend to search for books using cellphones. Also, the reading table in the America corner is close to the window without curtains, while the other space adjacent to the bookshelf is not adequately lit, compared to the librarian's chamber. Based on the light meter model measurement, LX-1102 in the reading room and the librarian workspace of 129.2–300 lux does not fulfill the standards. Librarians work 8 hours per day with computers to categorize book subjects, perform administrative duties, and process repositories. Under this condition, the research’s objective aimed at analyzing the impact of light intensity on subjective complaints as well as to determine the exposure in the workplace. This study contributes to redesigning the library space so that the library can play a social role and minimize fatigue due to lighting.

Previous studies have examined the lighting intensity on eye fatigue. This paper, however, offers various observations, including the frequency of reading and working as well as the lighting intensity as potential factors significantly influencing the subjective complaints, termed eye fatigue, dizziness, shoulder and backaches, reading difficulty as well as impaired concentration. Converserly, the present research not only proves the contributing factors of subjective complaints but also intends to uncover other objections. Furthermore, the concept of exposure to lighting intensity is developed, using a qualitative approach. This method tends to expand the data on subjective complaints including comfort, and workspace design.

Method

Research Design

This research was conducted between May 2020 – June 2021 using a combination of quantitative and qualitative techniques. The quantitative approach employed a cross-sectional design to validate the impact of lighting intensity, characteristics and reading frequency on subjective complaints. The participants encompassed 16 librarians and 696 visitors between January – April 2020. In addition, 270 persons were employed to evaluated the sample size with the Slovin formula. The selection involved 2 methods: 1) a total of 16 librarians, 2) 254

library visitors choosen randomly. This aggregated to 270 samples. Furthermore, the quantitative data collection commenced between May – November 2020.

The second approach employed the qualitative data between January – June 2021, in order to expand on other subjective complaints. A focused interview design was used to support the research results of the first phase. Also, the key informants were determined by purposive sampling, comprising 3 librarians and visitors, while the supporting group were 2 library heads, where one is from Medan State University. Overall, 8 individuals served as the research informants.

Data Collection Technique

The questionnaires used in obtaining the quantitative data in the form of subjective complaints were adapted from the National Eye Institute Visual Function Questionnaire-25 (NEI-VFQ25) (Kurniawati, Mardji, & Kurniawan, 2018; Lin, Su, Chen, & Chu, 2019; Real, Hwang, & Bunya, 2020). These data comprised of 5 indicators, including eye strain, reading difficulty, dizziness, shoulder and back pain, as well as impaired concentration. Also, the Likert scale showed 4 options, termed very often (4), often (3), sometimes (2), and never (1). The questions consisted of 3 unfavorable and 11 favorable items. Furthermore, validity test was conducted on 30 students that visited the library in April 2020.

Lighting intensity data were acquired during the day by measuring the workspace and library reading room, using the LX-1102 model light meter. The evaluation areas were point A reading room 1, point B reading room 2, point C administration room 1, as well as point D processing and procurement room. However, the positions were determined by considering the most visited segment, and the librarian's corner.

The qualitative data collection encompassed the entire informants in the focus group discussion, after the quantitative analysis. The purpose was to gather the relevant information from the total informants, followed by creating a discussion on the examined topics. This included other complaints related to the poor lighting and maintenance conditions.

Data Analysis

Based on the analysis of quantitative data represented in a frequency distribution, the subjective complaints of eye fatigue and reading difficulties were categorized as mild, moderate, and severe, with scores ranging from 4–8, 9–11 and 12–16, respectively. Dizziness, shoulder and back pains, as well as impaired concentration were grouped into no complaints (2–4) and complaints (5-8). Subsequently, a path analysis of the respondent's characteristics, lighting intensity, as well as frequency of reading and working on subjective complaints were conducted, using Smart PLS software version 3.3.2. This application is capable of testing the validity and reliability of the questionnaire on the latent variables that become the variable constructs. The result of outer loading (>0.7) indicated a valid questionnaire, followed by a bootstrapping process to ascertain the hypothesis of the light intensity impact on subjective complaints of librarians and visitors. Also, the significance of the latent variable assessment is based on the T-statistic value, where (>1.97) indicated an acceptable alternative hypothesis. Furthermore, the contribution of the variable x to y is determined on the basis of the R-square value.

The qualitative data processing on the theme involving the analysis of the informants' statements was performed using the ATLAS.ti9 software. Meanwhile, the data was validated by triangulating the data sources, including the information obtained from 1) FGD, 2) documentation and 3) references. These results are presented in the form of theme diagrams and conclusions.

Result

Quantitative Data Analysis

The characteristics of the research sample were comprised of gender, age, and wearing of glasses. Subsequently, the univariate analysis was conducted and the results were displayed in the form of a frequency distribution table.

TABLE 1
Characteristics of the Research Sample

Characteristics	Frequency	Percentage
Gender		
Male	68	25.2
Female	202	74.8
Age		
19 – 32	231	85.6
33 – 45	24	8.9
46 – 54	15	5.6
Wearing of glasses		
Yes	80	29.6
No	190	70.4

Source: primary data, 2021

The characteristics of the research sample consisted majorly of 202 female (74.8%), 231 persons between 19– 32 years (85.6%) and 190 individuals without glasses (70.8%). Also, the univariate data of research variables, including light intensity, frequency of reading and working, subjective complaints are shown in the table below:

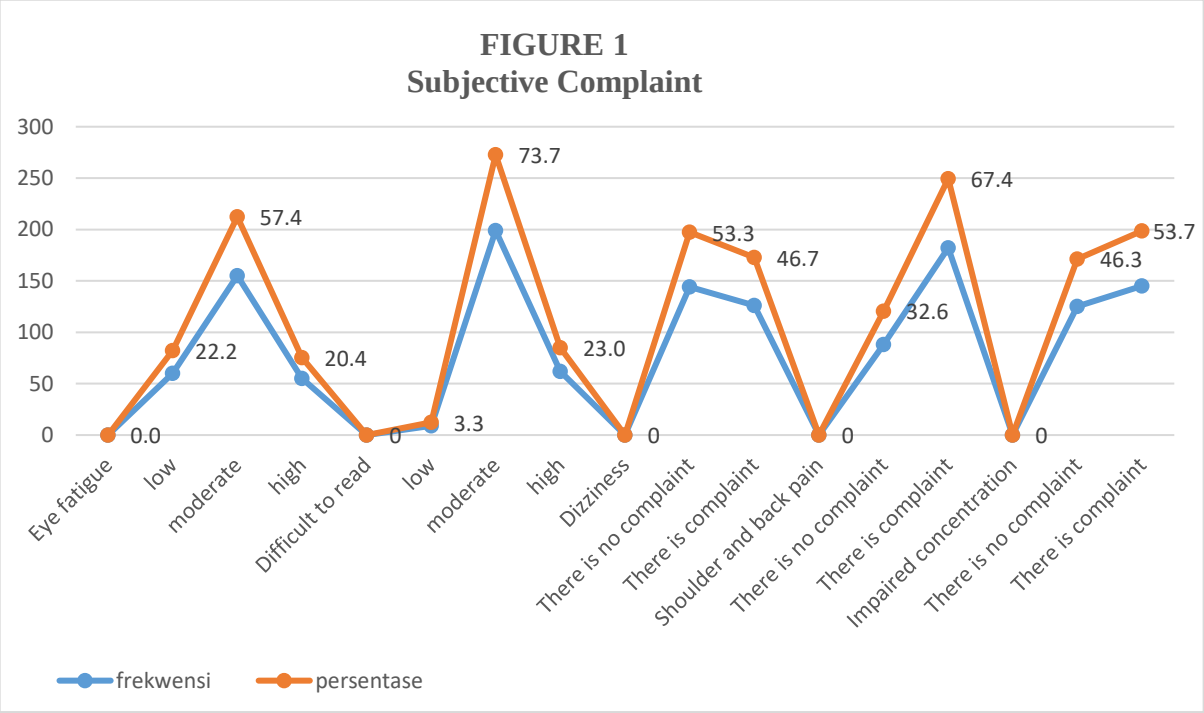
TABLE 2
Frequency Distribution of Lighting Intensity, Reading, and Working

Variable	Frequency	Percentage
Lighting intensity		
129.2 lux	107	39.6
210.5 lux	71	26.3
3.77 lux	30	11.1

380.0 lux	62	23.0
Frequency of reading and working		
Low	101	37.4
Moderate	132	48.9
High	37	13.7

Source: primary data, 2021

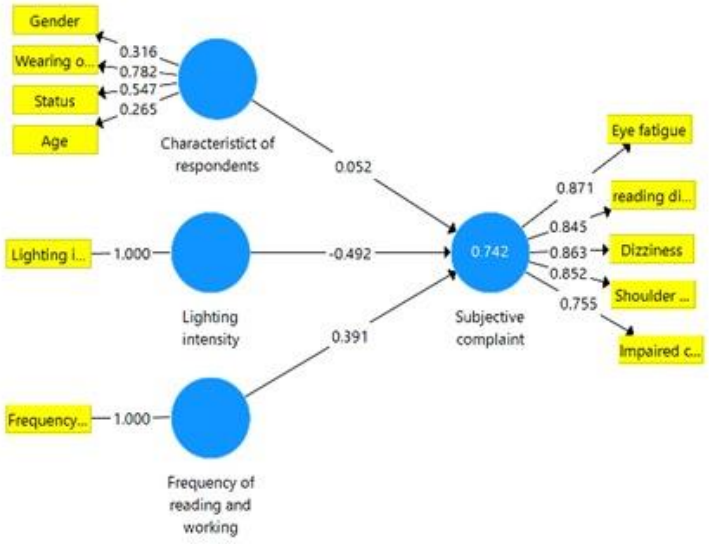
The lighting intensity was measured at four points commonly accessed by the librarians and visitors. Point A (reading room 1) was the most visited room, with a light intensity of 129.2 lux and is used by 107 persons (39.6%). The frequency of reading and working occurred in the medium category with 132 people (48.9%).



Furthermore, the subjective complaints encompassed eye strain in the moderate category with 155 persons (57.4%), reading difficulty in the moderate category of 199 individuals (73.7%), dizziness with 126 people (46.7%), shoulder and back pain with 182 respondents (67.4%), and concentration disturbances with 145 people (53.7%).

Figure 1 shows the validity and reliability tests of the questionnaire on latent variables using the PLS-SEM path analysis.

FIGURE 2
Analysis of the Outer Model



Based on the analysis results of the validity and reliability assessment, the outer value of the subjective complaint model comprised of eye fatigue (0.871), reading difficulty (0.845), dizziness (0.863), shoulder and back pains (0.852), as well as impaired concentration (0.755), with a total of >0.7. Cronbach's alpha value is 0.894 and the AVE value (0.703) appears greater than 0.5. Meanwhile, the composite reliability measuring the internal consistency of the questionnaire is 0.906. This estimate declared the questionnaire valid and reliable.

Furthermore, the relationships between the indicator and the variable construct (based on the previous theory) as well as the indicator and the new variable construct (frequency of reading and working) that is predictive, are analyzed on the basis of the T-statistic or p-value, as presented in the table below:

TABLE 3
Construct Relationship of Endogenous Latent Variables

Construct (variable)	Original sample	Sample mean	Standard deviation	T-statistic	p-value
Characteristics of respondents ➔ subjective complaint	0.052	0.057	0.030	1.728	0.085
Lighting intensity ➔ subjective complaint	-0.492	-0.493	-0.055	8.972	0.001*
Frequency of reading and working ➔ subjective complaint	0.391	0.389	0.058	6.790	0.001*

Source: primary data, 2021. (*significant = T-statistic >1.97 or p-value <0.05)

This table shows a significant influence of the variable constructs of lighting intensity, as well as the frequency of reading and working on subjective complaints with T-statistical values of 8.972 and 6,790, respectively. However, the respondents' characteristics showed no effect at 1.728.

TABLE 4

R-Square Value

Variable	R-square	R-square Adjusted
Subjective Complaint	0.742	0.739

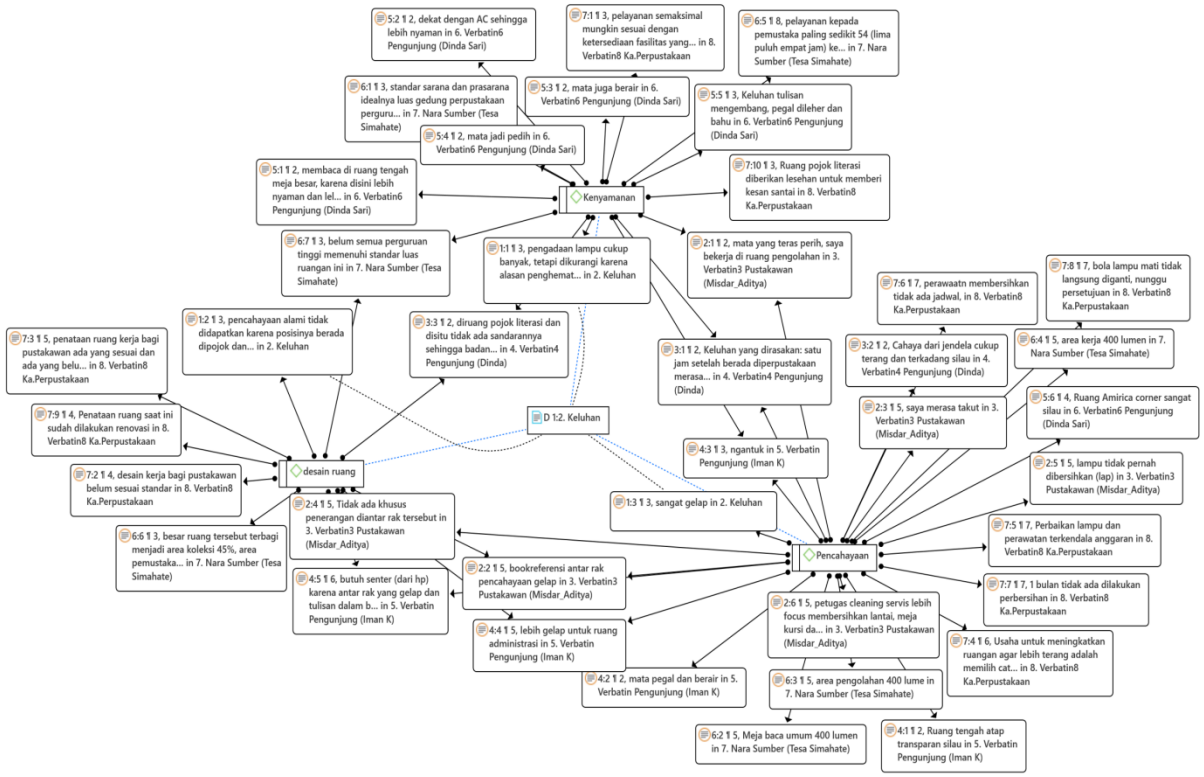
Source: primary data, 2021

The large R-square value (0.742) showed that a very robust model (74.2%) was formed by the endogenous latent variables. Also, the new variable construct of reading and working frequency in combination with lighting intensity, demonstrated a significant effect on subjective complaints of 74.2%.

Qualitative Data Analysis

The interviews and focus group discussion data were compiled in verbatim transcripts, and used to perform the analysis. This assessment begins with coding, transcript testing, and searching for statements that match the code, concepts, and relationships. The results are subsequently generated using the ATLAS.ti9 software as follows:

FIGURE 3
Qualitative Data Analysis Using ATLAS.ti9 software



Based on the ATLAS.ti9 analysis (Figure 2), the 8 informants obtained 3 (code) themes, including room design, comfort and lighting. The focus group interviews showed similar results of room design, comfort, and lighting, with 11, 15, and 23 quotes, respectively. Figure 2 indicates that the comfort and room design acquired 2 quotes, termed 3.3.1 and 6.7.3. Also, lighting and comfort acquired 3 values, including 2.1.2, 3.1.2 and 4.3.3L, while lighting and design attained 4 quotes, termed 2.2.5, 2.4.5, 4.4.5, and 4.5.6.

The advantage of qualitative data analysis using ATLAS.ti9 refers to the correlation coefficient between themes (code). Therefore, the qualitative approach showed similarities with the quantitative. The relationship patterns between the themes were determined by the cross-tabulation analysis of co-occurrence codes. Table 4 represents the results of the correlation coefficient between the themes (code).

TABLE 5
Co-occurrence Value

Theme (code)	**Room Design**		**Convenience**		**Lighting**	
	count	**coefficient**	**Count**	**coefficient**	**count**	**coefficient**
Room design	0	0.00	2	0.08	4	0.13*
Convenience	2	0.08	0	0.00	3	0.09
Lighting	4	0.13*	3	0.09	0	0.00

Source: primary data, 2021 (*strong code relationship)

The co-occurrence value occurred in the range of 0–1, where a stronger relationship is formed as the values approach 1. Table 4 shows that the frequency of quote occurrences simultaneously determined the strength of the theme (code) connection. The high co-occurrence value attained 0.13 in the cross table of the relationship between lighting and room design.

Discussion

Characteristics of the Respondents

The characteristics of research respondents observed more female librarians and visitors, due to the gender dominance at the State Islamic University of North Sumatra. This result is not in accordance with data from the Central Statistics Agency of North Sumatra Province. In the previous year, the male had a higher ratio of 50.2%, compared to the female (BPS, 2020).

The major age range occurred between 19–32, with 231 persons (85.6%) at undergraduate and master's degree programs. This data showed every library visitor as a student of the State Islamic University of North Sumatra, with regular visit the library to complete assignments, form discussions and read books necessary for the final project. The results matched an earlier research where the visitor population at the Airlangga University library was dominated by students, compared to lecturers. The highest use is ascribed to the Faculty of Law at 50.4% (Srirahayu, 2019). Previous descriptive studies on users'visits at the Tulungagung State Islamic Institute Library reported that the majority of visitors were highly-motivated students in search for references and materials in preparation for thesis as well as final assignments (Rafikasari & Rohman, 2018).

The majority of respondents in the non-glasses category were 190 (70.8%). This result matched the age characteristics in the young adult class with good visual acuity without the need for assistive devices (glasses). In contrast to previous research, the percentage of eye fatigue and double vision was higher in women with glasses (82.9%), as reported by Darmaliputra & Dharmadi (2019). This outcome was also based on the research on students using computers.

Quantitative Analysis on the Impact of Light Intensity

The light intensity showed a significant effect on subjective complaints as evidenced by path analysis of the relationship between endogenous latent variables. In addition, the T-statistic value observed a negative correlation pattern, indicating a lesser intensity impact on increasing subjective complaints. This result is supported by previous studies where inappropriate illumination negatively influenced workers. Furthermore, inappropriate intensity causes eye fatigue (Kurniawati et al., 2018). Also, a difference in eye fatigue due to decreased and increased intensity was also reported. Reading duration tends to weaken the vision power, otherwise called asthenopia, and the predominant symptoms include watery eyes, headache, blurred vision, red eyes, eye pain, heat, and double vision (Chandra & Kartadinata, 2018).

Lin (2019) measured the light intensity using 3 variables, termed work behavior, operational period, and short rest time. The results observed complaints of dry eyes and eye fatigue due to working close to a lighting source. Experienced workers have an extensive work period, and short rests tend to trigger eye fatigue. Therefore, adequate lighting and break duration appear very important to improving eye health.

This research indicated 5 significant subjective complaints due to lighting, including eye fatigue, reading difficulty, dizziness, shoulder and back pains, as well as impaired concentration. Previous studies did not analyzed these variables, despite using respondents' characteristics, lighting intensity, reading, and working frequency as causal factors (exposure).

Shoulder and back pains were mostly felt by the staff and visitors (67.4%). Lighting serves as a major factor in the work environment and also as an additional burden. This element exacerbates under unfulfilled and subsequently results in poor vision, stress eye muscles as well as inaccuracies of sighted objects, and also work errors.

Employees tend to observe objects in close proximity while working or reading, due to sight difficulties. Poor sitting posture or working hunched over an extensive period causes the misalignment of the back, leading to fatigue, aches, and pains. In accordance with previous research, workers with computers appear prone to computer visual syndrome with musculoskeletal complaints, including the neck, back, shoulder, wrist, finger discomfort, and eye muscle fatigue due to less static work postures (Lurati, 2018).

Based on World Health Organization data, eye fatigue (asthenopia) cases occurred between 40-90% (WHO, 2014). This risk was also experienced by home industry workers of written batik (Rachmah, Utami, Suwondo, & Jayanti, 2018). Age factor, eye refraction, eye distance with the work object, and light intensity are common causative factors. Therefore, the activity and work types in the room require appropriate illumination, particularly areas with accuracy, including production and design. Furthermore, the production workspace is expected to fulfill the precise standards, at least 300 lux.

Workers view the object continuously and the eyes tend to accommodate these elements at the similar intervals. However, with poor illumination, the accommodation appears greater, with the occurrence of painful muscle contractions over an extensive duration. The intensity measurement at 2 points of the library reading room is below 300 lux. Evidently, the librarian's and administrative room, as well as the procurement and processing workspace did not fulfill the standard of atleast 500 lux. Ideally, the library room light intensity is specified between 300-500 lux. Previous research reported an 8% increase in productivity due to improvements in workplace illumination from 300 to 500 lux. A high light condition provides an alert effect, concentration, and a minimal work error (Preto & Gomes, 2019).

The additional factor of frequency in terms of combined reading and working was proven to influence eye fatigue, reading difficult, dizziness, shoulder and back pains, as well as

impaired concentration, based on path analysis. These two variablea are known to significantly contribute to subjective complaints (74.2%). Previous research did not provide a comprehensive assessment. Another study reported that fatigue and eye strain due to the use of digital eye strain (DES) equipment occurred optimally among respondents working in front of screens beyond 5 hours per day (Mohan, Sen, Shah, Jain, & Jain, 2017).

This research observed a weakness of not analyzing the visitor's duration. However, a 2 hour interval was imposed due to the COVID-19 pandemic. Based on these considerations, the exposure factor to subjective complaints appeared very appropriate, including the frequency of reading and working. The duration refers to the time span, while frequency corresponds to the rate or amount. Therefore, higher frequency causes more respondents to read and work in the library.

The combined lighting condition between artificial (lamp) and natural (sun) lights was measured in the research location from 09.00–12.00. Indoor spaces require artificial illumination as natural sunlight is not easily accessed, particularly during cloudy, afternoon or evening period. Previous research reported that daytime measurements at zone 3 reading room on the 21st floor of the National Library building with an intensity of 92 lux did not fulfill the Indonesian National Standard (Puni, Nurwidyaningrum, & Apriliansyah, 2020).

Qualitative Analysis Results

Three complaint themes from the librarians and visitors were observed, including room design, comfort, and lighting. Another novelty of this study is the concept development of exposure to lighting intensity using a qualitative method that has not been earlier conducted. For instance, previous researches proved that the intensity influences comfort, under quantitative method. Environmental conditions, termed light intensity, also contributes to eye fatigue in nurses (Azmoon, Dehghan, Akbari, & Souri, 2013). In contrast to this paper, the comfort level was not directly influenced, except in terms of room design, based on the co-occurrence correlation coefficient, as depicted in the scheme: lighting ➔ room design ➔ comfort.

Setting the lighting intensity involves workspace design structuring. The wall color arrangement also influences the dark and light atmosphere. In addition, the white color provides a bright impression, while displaying the reflective property of light. Therefore, the library room requires appropriate use of white wall paint. Based on the results of previous studies, the light emitted by the lamp is absorbed by the amateur, in a partly emitted downward and upward reflection. Ceilings, walls, and floors causes color reflection. As a consequence, 85% of the light is reflected by white paint (Guntur & Putro, 2017).

The data from the focus group discussion activities showed glare complaint by several informants as the reading table was directly under the transparent roof. Therefore, the arrangement of work equipment, including tables and chairs as well as windows and doors, is expected to consider natural sources, to avoid the effects of glare and eye fatigue common to artificial light intensity (Rary, Souisa, & Talarima, 2019).

Light placement and direction need to be adjusted to consider an appropriate space for reading tables and chairs. Similarly, the use of digital devices for extensive work period risks the occurrence of negative complaints due to continuous eye accommodation. The DES prevalence increases with the continuous use of digital device (Sheppard & Wolffsohn, 2018). Also, related data reports that 90% of digital equipment users experience eye strain and discomfort due to continuous light exposure, close distance to the work object, and minimal material sizes (Coles-Brennan, Sulley, & Young, 2019). Therefore, proper planning appears very necessary in preventing eye strain and discomfort by restructuring the ergonomic work environment.

Libraries as a means of education, information, research, and recreation are expected to provide services that prioritize the needs, as well as comfort of users and librarians (Irfan & Fitriasi, 2018). The development of information technology improves library services as a means of scientific communication, facilitating the library function in disseminating information either in print or online. A major success indicator in terms of disseminating information and advancing science in universities is the increasing need for information services in libraries.

Furthermore, relevant with Lin's research (2019), the design modification as a means of providing information needs to keep pace with technological advancement, to accommodate learning needs and increase users' satisfaction. This change tends to significantly impact visitors' continuous use and motivation. Previous research stated that visitors exhibit various reasons, particularly in terms of obtaining information, reading news (newspapers), engaging in discussion, and using the library facilities to unwind (Fransisca, 2013).

These results showed the importance of room design as a moderating variable on the comfort of users and librarians. In line with the concept of "library as a place", Silver (Silver, 2006) described a redesigned library space for the academic community to consider psychosocial aspects. Therefore, libraries do not only offer reading room services and books, but also play a genuine social role, in terms of providing a place for the community to discuss, learn, enhance experiences, or acquire inspiration. Furthermore, the ergonomic arrangement tends to encourage users to utilize the facilities as the main place to visit, enjoy and crave.

Conclusion

Based on the results and discussion, excessive exposure to light intensity showed a negative impact on subjective complaints, including eye fatigue, reading difficulty, dizziness, shoulder and back pains, as well as the impaired concentration among library staff and visitors. Also, the light intensity and reading frequency greatly contributed to these conditions. Furthermore, the high frequency of reading and working increased the eyes' accommodation, causing eye strain and accelerating fatigue. This damage occurred more rapidly at low light intensities as well as high reading and working frequencies.

The results of this research developed a concept on the impact of exposure to lighting intensity directly affecting the library room design. In addition, the layout design, work equipment placement, and color arrangement demonstrated a direct significant effect on the comfort state. This circumstance confirmed that the integration between health, social and science, and technology disciplines possible reduces eye fatigue, reading difficulty, dizziness, shoulder and back pains, as well as impaired concentration, leading to an improved convenience. Also, spatial planning appears neccessary in reducing these complaints from the staff and visitors. Furthermore, the frequency reduction in reading and working tends to prevent the negative impact of exposure to light intensity. This outcome is possibly achieved by observing a break after 2 hours.

It is necessary to improve the design of the library space such as: setting the layout of the light, placing the reading table, providing room facilities for discussion so as to increase the social role of the library for academics. Doing socialization reduces eye fatigue, by: taking a break after 2 hours of reading and working, looking at a distance of 20 feet for 20 seconds to prevent more serious eye damage.

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