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Sleep Timing, Light at Night Exposure and it's Health Effects Among Staff and Students of Bayero University, Kano

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Abstract
The invention of electricity has pervasively challenged our evolutionary adaptation of dusk to down limited light exposure leading to a conflict between our endogenous biological clocks and the environmental time thus posing a significant health concern. This study therefore explored sleep timing habits, light at night exposure and awareness of its health effects among staff and students of Basic Medical Sciences Faculty of Bayero University, Kano. Data were obtained using a semi-structured, interviewer assisted data capturing form while analysis was done using the statistical package for social sciences ($SPSS_{V20.0}$) software. Quantitative data were summarized using mean±SD while qualitative data were summarized using frequencies and percentages. Independent samples t-test and person's Chi-square were used to compare discrete and categorical variables respectively, in all cases, statistical significance was considered at $P \leq 0.05$. The results indicated that all the respondents were exposed to LAN. The mean duration of LAN exposure was found to be 5.2±1.4 hours. Late retirement to bed was observed higher among male gender with male students sleeping at 00:21±1.4 hrs and female staff sleeping at 22:20±1.5 hrs. Bivariate analysis reveals a strong positive relationship between LAN exposure duration and sleep timing (r=+0.802; p=0.001) as well as sleep duration (r=-0.552; 0=0.001). On the other hand, awareness about the health effects of LAN exposure was observed to be low (17.4%) among the respondents with staff being more aware (38.5%) than students (9.1%). Finding of the present study shows that the respondents are highly exposed to LAN, had less sleep and lower awareness of the consequences of LAN exposure.

Keywords: Light-at-night (LAN), sleep timing, staff and students, Bayero University Kano.

INTRODUCTION
The 2017 Nobel Prize in Physiology or Medicine was awarded jointly to Jeffrey C. Hall, Michael Rosbash and Michael W. Young for their discoveries of molecular mechanisms controlling the circadian rhythm (Jiang & Turek 2018). This rhythm, controlled by the circadian system, dictates behavioral and physiological processes in an oscillatory manner over an approximate of 24 hour period (Matsuo *et al*., 2003; Gréchez-Cassiau *et al*., 2008). The circadian system is a genetically encoded anticipatory mechanism comprising of a hierarchical collection of biological peripheral clocks controlled by a master clock within the suprachiasmatic nucleus (SCN) of the anterior hypothalamus (Mohawk *et al*., 2012). Through the control of activity/rest, feeding/fasting, sleep/wake cycles, pineal melatonin and other hormonal secretions, the SCN coordinate downstream tissues to adopt a specific temporal

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relationship with one another and at the same time, with the external environment (Evans & Davidson, 2013). The entrainment of the circadian system is principally by environmental light transmitted to the SCN via the retinohypothalamic tract (Takahashi *et al.,* 2008; Arble *et al.,* 2010; Evans & Davidson, 2013; Su *et al.,* 2018). This allows the organism synchronize to the 24 hour environmental local time at both molecular, cellular and systemic levels such that physiological functions like feeding and physical activity occurs during the light while cellular repair, sleep and related functions would occur during the dark portions of the day (Arble *et al.,* 2010; Wright *et al.,* 2012).

Despite the many supporting effects of light in our everyday life, the invention of electric lighting and light-emitting electronic devices in the past 130 years has pervasively transformed our nights and challenged our circadian system by extending our exposure to light far beyond dusk or even round the clock (Stevens *et al.*, 2007; Akacem *et al.*, 2016). Also the increasing penetration of our natural dark hours by this pervasive global illumination disrupts the natural connections between rest/activity, sleep/wake cycle and the environmental dark/light cycles (Bass & Lazar, 2016). These breaches have been reportedly linked to later entrainment of our circadian clock, later sleep phenotypes and delayed melatonin production (Redlin, 2001; Wright, *et al*., 2013) thus, Perhaps, explaining the globally decreasing trend of average human sleep duration (Ekirch, 2001), increasing global burden of metabolic (Jha et al., 2015) and metastatic (Blask, *et al.*, 2009; Stevens *et al.*, 2007; Roenneberg & Merrow 2016) diseases. Importantly, work or social schedules that are not in synchrony with the natural light/dark cycle (social jetlags) such as staying up late at night in a lightened environment, reading with electronic devices, television viewing, playing games, surfing the internet using computers or mobile phones, are perhaps highly pandemic especially among professionals and people within the academic circle. Despite these however, very little is known about these behaviors in this part of the world and also information regarding the awareness of the health effects of light at night (LAN) especially among people in the academic circle is grossly lacking. This study therefore aimed to explore sleep timing habits, light at night exposure and awareness of its health effects among staff and students of Basic Medical Sciences Faculty of Bayero University, Kano.

METHODOLOGY

Using a descriptive cross sectional study design, one hundred and thirty eight (138) consented participants were derived from among Staff and Students of Basic Medical Sciences Faculty of Bayero University, Kano. Using a semi structured interviewer assisted data capturing form, data on light at night (LAN) exposure, sleep timing habits, nighttime lights off and awareness of the ill effects of LAN exposure were obtained. Night sleep duration and light/dark cycle ratio (L:D) were computed from the data obtained on time of retiring to bed and waking up as well as the hours spent under lightened and dark environmental conditions.

DATA ANALYSIS

The data obtained was subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) version 20.0 and were summarized using mean±SD as well as counts and percentages for both quantitative and qualitative variables respectively. Inferential statistics was employed using an independent samples t-test, Pearson's correlation and Pearson's chi-square for quantitative and qualitative data respectively. In all cases, statistical significance was assumed at $p \leq 0.05$.

RESULTS

The distribution of the respondents were 59.4% (n=82) males and 40.6% (n=56) females. Staff members constituted 28.3% (n=39) while 71.7% (n=99) were students. There were 34 (24.6%) male staff and 51 (36.9%) female students accordingly. The results indicated that all (100%) the respondents are exposed to Light at night with eighty seven percent (87%) of the respondents habitually turning off their lights before going to bed while 18% sleep with their room lights on. The mean±SD age, duration of LAN exposure, sleep timing, sleep duration and L:D cycle of the respondents was found to be 26.8±9.8 years, 5.2±1.4 hours, 23.6±1.4hours, 6.3±1.7 hours and 2.7±1.0 respectively (table 1). Both male and female staff were noted to be of similar statistical ages (table 3) while female students were significantly younger than their male counterparts (table 4). In general, students sleep late, had longer hours of LAN exposure and shorter sleep duration than staff (table 1). On the other hand, females were observed to habitually retire to bed earlier and to have longer hours of night sleep than males (table 2). Similarly, across both staff and students, females were seen to have lower duration of exposure to LAN than males (tables 3 and 4). Sleeping late at night was observed to be higher among male gender (p=0.017) (table 2) and students (p=0.009) (table 1) with male students sleeping at 00:21±1.4 hrs (table 4) and female staff sleeping at 22:20±1.5 hrs (table 3). Although the L:D ratio of the respondents was so high (2.7±1.0) (table 1), staff had significantly (p=0.006) lower values (2.4±1.0) than students (2.9±1.0) (table 1) while males had slightly higher values than females (table 2). Correlational analysis revealed a significant association between age and LAN-exposure duration (r=-0.377; p=0.001), night time sleep time (r=-0.244; p=0.004) and sleep duration (r=+0.167; p=0.050) (table 5). Equally, LAN exposure was strongly correlated to timing of night sleep (r=+0.802; p=0.001) and duration the sleep (r=-0.552; 0=0.001) (table 5).
On the other hand, awareness about the health effects of LAN exposure was noted to be low (17.4%) among respondents with staff being more aware (38.5%) than students (9.1%) and female staff demonstrating more (60%) awareness than male staff (35.3%), female students (9.8%) and male students (8.3%) accordingly (table 6).

Table 1: differences in age, sleep and LAN exposure characteristics among staff and students

variables	staff	students	total	t-value	p-value
age (years)	40.3±8.2	21.5±2.7	26.8±9.8	20.284	**0.001**
LAN Exposure duration (hours)	4.5±1.5	5.5±1.3	5.2±1.4	-3.802	**0.001**
time of night sleep (hours)	23.1±1.2	23.8±1.4	23.6±1.4	-2.639	**0.009**
duration of night sleep (hours)	6.7±1.6	6.2±1.8	6.3±1.7	1.591	**0.114**
L:D cycle	2.4±1.0	2.9±0.9	2.7±1.0	-2.765	**0.006**
length of daily activity (hours)	17.3±1.6	17.8±1.8	17.7±1.7	-1.553	**0.123**

All variables are expressed in mean±SD

Table 2: gender differences in age, sleep and LAN exposure characteristics

variables	males	females	t-value	p-value
age (years)	29.9±10.8	22.4±5.7	4.769	**0.001**
LAN exposure duration (hours)	5.3±1.4	5.1±1.5	0.816	**0.416**
time of night sleep (hours)	23.8±1.4	23.2±1.3	2.416	**0.017**
duration of night sleep (hours)	6.1±1.6	6.6±1.9	-1.919	**0.057**
L:D cycle	2.8±1.0	2.6±0.9	0.725	**0.470**
length of daily activity (hours)	17.9±1.6	17.4±1.9	1.866	**0.064**

All variables are expressed in mean±SD

Table 3: gender differences in age, sleep and LAN exposure characteristics among staff

variables	males	females	t-value	p-value
age (years)	40.7±8.6	37.8±5.0	0.726	**0.473**
LAN exposure duration (hours)	4.6±1.4	3.7±1.5	1.305	**0.200**
time of night sleep (hours)	23.2±1.2	22.2±1.5	1.749	**0.089**
duration of night sleep (hours)	6.7±1.6	6.4±1.6	0.407	**0.687**
L:D cycle	2.4±1.0	2.0±0.5	-0.983	**0.332**
length of daily activity (hours)	17.3±1.6	17.6±1.6	-0.407	**0.687**

All variables are expressed in mean±SD

Table 4: gender differences in age, sleep and LAN exposure characteristics among students

variables	males	females	t-value	p-value
age (years)	22.3±2.5	20.9±2.7	2.683	**0.009**
LAN exposure duration (hours)	5.8±1.2	5.2±1.4	2.068	**0.041**
time of night sleep (hours)	24.2±1.4	23.3±1.3	3.301	**0.001**
duration of night sleep (hours)	5.6±1.5	6.7±1.9	-3.039	**0.003**
L:D cycle	3.0±0.9	2.7±0.9	1.607	**0.111**
length of daily activity (hours)	18.4±1.4	17.3±1.9	2.974	**0.004**

All variables are expressed in mean±SD

Table 5: correlation between age, LAN exposure, time and duration of night sleep

Correlation of variables among respondents				
variable		**LAN exposure**	**time of night sleep**	**duration of night sleep**
age	**r**	-0.377	-0.244	+0.167
	p-value	0.001	0.004	0.050
LAN exposure	**r**	1	+0.802	-0.552
	p-value	-	0.001	0.001

r=Pearson's correlation

Table 6: χ^2 and percentage awareness on the harmful effects of LAN among respondents

	staff			students		
	males	**females**	**statistics**	**males**	**females**	**statistics**
OF(EF)	12(13.1)	3(1.9)	χ^2=1.124	4(4.4)	5(4.6)	χ^2=0.065
	35.3%	60%	p=0.354	8.3%	9.8%	p=1.000

χ^2=chi-square

DISCUSSION

The overall findings indicate an inclination to the typical modern civic lifestyle reported by Kantermann (2013). This lifestyle breaches the central dogma of our circadian system of ensuring brighter light exposure in the daytime and darkness over the nights. At the beginning of the day, bright light perceived by the intrinsically photosensitive retinal ganglion cells (**ipRGC**) is relayed to the SCN via the retinohypothalamic tract (Gooley *et al.*, 2001). This causes heterodimerization of Circadian Locomotor Output Cycles Kaput (CLOCK) and Brain and Muscle Aryl hydrocarbon receptor nuclear translocator Like-1 (BMAL-1) proteins (Wilking *et al.,* 2013). The heterodimer acts as a transcription factor to induce expression of Period and Cryptochrome proteins which accumulates cyclically throughout the day to reach a specific threshold, form hetero or homodimers, enter the nucleus and repress the transcription of CLOCK and BMAL1 genes (Partch *et al.*, 2014). Degradation of Period and Cryptochrome repressor elements then relieves the inhibition on CLOCK/BMAL1, allowing the cycle to begin anew once every 24 hours (Evans & Davidson, 2013). This allows the organism synchronize fairly to 12 hours of light and 12 hours of darkness (12L:12D) over the 24 hour environmental local time (Takahashi *et al.,* 2008; Evans & Davidson, 2013) such that light to dark exposure ratio (L:D) of 0.85 to 1.2 remains fairly constant.

The exposure to light long into the dusk observed among our subjects has increased their L:D to 2.7 which may lead to a conflict between their endogenous biological clocks and the astronomical time as consistently reported (Stevens *et al.,* 2007; Arble *et al.,* 2010; Savvidis & Koutsilieri, 2012; Kantermann, 2013; Roenneberg *et al*., 2013; Akacem *et al*., 2016; Gupta et al., 2017; Nelson & Chbeir, 2018). The result showed that LAN exposure significantly delays timing of night sleep (r=+0.802, p=0.001) and its duration (r= -0.552, p=0.001) perhaps, due to the reported ability of LAN to delay the timing of our circadian clock (Khalsa *et al.,* 2003) and produce later sleep phenotypes (Wright *et al.,* 2013). Equally, the delay and suppressive effects of LAN on melatonin rhythm and amplitude (Zeitzer *et al.,* 2000; Gooley, 2008) may primarily account for our findings. Melatonin has its acrophase in the astronomical dark portion of the L/D cycle (Jung-Hynes *et al*., 2010) and plays a critical role in sleep promotion (Zhdanova *et al.,* 1997; Wulff *et al.,* 2009), blood pressure regulation (Simko & Paulis, 2007; Agarwal, 2010), glucose homeostasis (Owino *et al.,* 2016) and also inactivates hydrogen peroxide and protects against its DNA-damaging actions (Sliwinski, *et al.,* 2007) and, as well, resynchronizes dysregulated circadian rhythm circuitry and expression patterns of various genes responsible for oncogenesis (Jung-Hynes *et al.,* 2010). Hence LAN exposure may potentially disrupt these physiological roles of melatonin therefore, in addition to our observed delay in timing and reduced duration of night sleep, may equally increases the risk of cardiovascular, metabolic and mitotic disorders. As circadian synchronization and coordination is necessary for harmonious timing across molecular pathways within a cell and across tissues and organs of the body (Jiang & Turek 2018), our findings of extended light exposure through dusk, delayed timing of night sleep and reduced night time sleep duration have an important health implication.

CONCLUSION

Findings of the present study have shown the effects of LAN on delay in sleep timing, amount of sleep and disruption of circadian rhythm.

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APPENDIX 1: QUESTIONNAIRE USED FOR THE RESEARCH WORK

A DATA CAPTURING FORM ON HEALTH EFFECTS OF LIGHT AT NIGHT EXPOSURE, ITS PERCEPTION AND PREVALENCES AMONG STAFF AND STUDENTS OF BASIC MEDICAL SCIENCE FACULTY, BAYERO UNIVERSITY, KANO.

1. Age……………………………........
2. Gender……………………………………
3. Occupation (staff/Student)----------------------------------
4. What time do you habitually wake up for the day?------------------------------
5. What time do you habitually retire to bed?---
6. Do you often, wake up at night and switch your room light on?---------------------------
7. Do you habitually get exposed to light during the dark hours of the day?----------------
8. If yes to '7' above, from what time to what time do you get exposed?------------------
9. Do you switch the 'lights' off before going to bed?---
10. Do you think exposure to light during the dark hours of the day is harmful?------------

Thank you for your responses