Journal of Behavioral and Brain Science, 2017, 7, 125-136
http://www.scirp.org/journal/jbbs
ISSN Online: 2160-5874
ISSN Print: 2160-5866

Light Pollution Associated with Delayed Sleep Time: A Major Hygienic Problem in Saudi Arabia

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How to cite this paper: Ahmed, H.G., Alogla, S.A., Ismael, R.M., Alqufayi, A.A., Alamer, S.O., Alshaya, H.K. and Alshammari, A.E.M. (2017) Light Pollution Associated with Delayed Sleep Time: A Major Hygienic Problem in Saudi Arabia. *Journal of Behavioral and Brain Science*, **7**, 125-136.
https://doi.org/10.4236/jbbs.2017.73012

Received: February 10, 2017
Accepted: March 11, 2017
Published: March 14, 2017

Abstract

Background: It was well established that exposure to nighttime light was responsible of a diverse negative health effect. Therefore, the aim of this study was to assess the epidemiologic exposure to artificial light at night time and negative health consequences that associated with prolonged nighttime lighting exposure. **Methodology**: This is a cross-sectional survey, involving a total of 266 Saudi residents living in the city of Hail, Northern KSA. Essential information regarding exposure to light at night time was obtained. **Results:** The overall incidence of nighttime light exposure in the present study was 65.8% for general population, was 61.5% males and was 38.5% for females. About 75.6% persons used to sleep for <6 hours and 36.8% individuals used to sleep on light exposure. **Conclusion:** Prolonged exposure to the light at nighttime is prevalent in Saudi Arabia. This exposure usually results from late sleep in the nighttime and the late awake in the daytime.

Keywords

Nighttime, Sleep Time, Light Pollution, Saudi Arabia

1. Introduction

Nighttime is no longer dark with existence of electric light everywhere in the modern world. Prolonged exposure to electric light is harm to animal, plant life, and human. The science on photo transduction for the circadian system and on clock gene function is developing quickly to find out a justification for the clue that circadian disruption from artificial light at night could be responsible for several

diseases [1]. Circadian rhythm is a daily biological sleep/wake cycle in human based on a 24-hour period. This cycle (biological clock) is influenced by environmental variations, such as amendments of sleeping and awaking. In humans, this clock is sited within the brain's hypothalamus and pineal gland, which releases melatonin in response to the signals that receive from photoreceptors in the retina [2]. Melatonin is responsible of regulation of circadian rhythm. It is synthesized when pineal gland is stimulated by darkness and inhibited by light [3]. Melatonin has several actions including detoxification of free radicals, protecting various cells and tissues from the damaging effects of oxidative stress in medical disorders such as: ischemia/reperfusion injury (stroke, heart attack), ionizing radiation, and drug toxicity [4]. Since melatonin has the potent anti-cancer activity, the International Agency for Research on Cancer (IARC) has classified night work shifts that suppress melatonin secretion (circadian interruption) as a possible carcinogenic factor (Group 2A) [5] [6] [7] [8].

The bulk intensification in the lighting devices in regard to the concept of "maximum coverage area" and multistoried buildings of cities offered huge rise to light pollution. Analysis of modern lighting devices and installations has shown that approximately 30% - 45% of the shining flux develops the light pollution. Night lighting of cities causes both direct and indirect destruction to the environment, and human. Light pollution disturbs the human hormonal system (melatonin disturbance), causing many health abnormalities, such as insomnia and depression as a consequence [9].

At present, several countries have recognized the problem and delivered national programs to change the concept of the designing of lighting devices and installations.

To conserve a sufficient melatonin's secretion, it is important to know the real proportion of day-to-nighttime light. However, this proportion in most instances is unknown because it differs from place to another and from population to another. Besides, modern life exposure to light at nighttime can be determined by social and behavioral factors linked to early or late sleeping time. In Kingdom of Saudi Arabia, light pollution is prevalent due to late night's sleep habits [10]. Therefore, the objective of the present study was to assess the epidemiologic exposure to artificial light at nighttime and negative health consequences that associated with prolonged nighttime lighting exposure.

2. Materials and Methods

In this cross sectional survey, a total of 266 Saudi residents living in the city of Hail, Northern KSA were selected by random simple method during the period from May 2015 to May 2016. The sample size was determined using: The Survey System software (available at: http://www.surveysystem.com/sscalc.htm). As the data were collected during summer season and the night was relatively shorter, the time 1:00 am was used to group the study population into two groups (early sleepers for those who used to sleep before 1:00 am and late sleepers for those who sleep after 1: 00 am). Sleeping after 1:00 am was ascertained for elongated night-

time light exposure. Enhanced Arabic questionnaire containing variables was collected from several sleeping habits questionnaires. A purposeful questionnaire was designed to obtain essential variables regarding sleeping habits, perceptional health disorders factors. The most important variables included in the questionnaire were, demographical characteristics, sleeping habits, tobacco smoking, perceptional questions including; academic achievement, work success, work satisfaction, happiness (next day), depression (next day), Frequency of sicknesses and chronic diseases.

2.1. Data Analysis

Statistical Package for Social Sciences (version 16) was used for analysis and to perform Pearson Chi-square test for statistical significance (P value). The 95% confidence level and confidence intervals were used. P value less than 0.05 was considered statistically significant.

2.2. Ethical Consent

Each participant was asked to sign a written ethical consent during the questionnaire's interview, before the filling of the questionnaire. The informed ethical consent form was designed and approved by the ethical committee of the College of Medicine (University of Hail, KSA) Research Board.

3. Results

This study evaluated the effects of extended light exposure at night for 266 apparently healthy volunteers living in the city of Hail, aged from 18 to 70 years with a mean age of 32 years, of whom 174 (65.4%)were males and 92 (34.6%) were females, giving males' females' ration of 1.89:1.00. Of the 266 investigated individuals, 175 (65.8%) used to sleep after 1:00 am and the remaining 91 (34.2%) used to sleep before 1:00 am. Of the 174, exposed persons, 107/174 (61.5%) were males and 67/174 (38.5%) were females. Moreover, 201 (75.6%) persons used to sleep for <6 hours and the remaining 65 (24.4%) used to sleep for ≥6 hours per day. Additionally 98 (36.8%) individuals used to sleep on light exposure. The light types were bright, faint and external light representing 13 (4.9%), 57 (21.4%) and 28 (10.5%), respectively, as shown in **Figure 1**.

As indicated in **Table 1**, of the 174 individuals used to sleep after 1:00 am, 107 (61.1%) were males and 68(38.9%) were females, for the age groups; <24 years, 25 - 34, 35 - 44 and 45+, constituted 44 (25%), 49 (28%), 60 (34.3%) and 22(12.6%), respectively for those used to sleep after 1:00 am. For occupation, most of those used to sleep after 1:00 am were employees followed by others with different jobs and students, representing 84 (48%), 52 (29.7%) and 30 (17%), in this order. For education, the great majority of those used to sleep after 1:00 am were at university level followed by secondary constituting 140 (80%) and 26 (15%) respectively.

When making the association for each group, males and females 107/174 (61.5%) and 68/92 (74%), respectively were used to sleep after 1:00 am. Age ranges <24 years, 25 - 34, 35 - 44, and 45+, those who used to sleep after 1:00 am

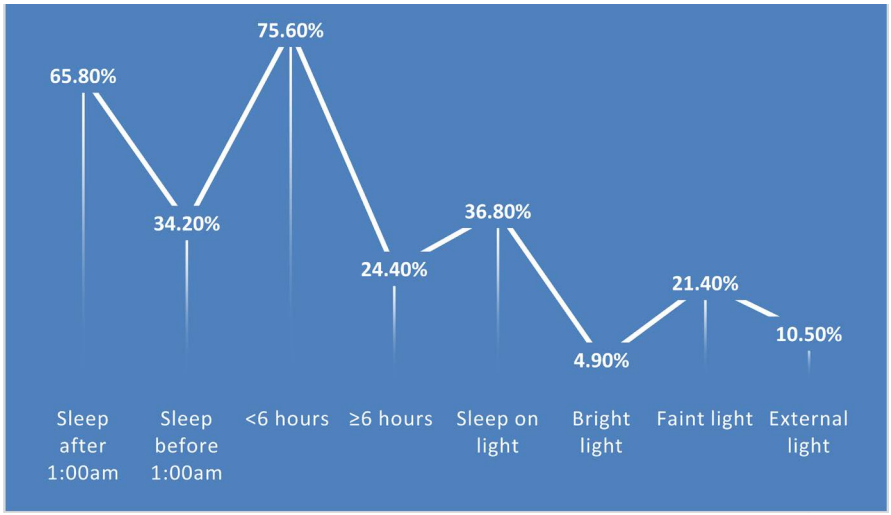

Figure 1. Description of light exposure by time and type of light.

Table 1. Distribution of sleeping time by demographical characteristics of study subjects.

Variable	Category	Sleeping Time		Total
		After 1:00 am	Before 1:00 am	
Sex	Males	107	67	174
	Females	68	24	92
	Total	175	91	266
Age	<24 years	44	23	67
	25 - 34	49	26	65
	35 - 44	60	28	88
	45+	22	14	36
Occupation	Students	30	18	48
	Employees	84	32	116
	Non-working	9	9	18
	Others	52	36	88
Education	Basic	9	2	11
	Secondary	26	14	40
	University	140	73	213

represented 44/67 (65.7%), 49/65 (75.4%), 60/88 (68%), and 22/36 (61%), in this order. For the occupation, for those used to sleep after 1:00 am, employees represent the majority, followed by others with scattered occupations and students representing 84/116 (72.4%), 52/88 (59%) and 30/48 (62.5%), respectively. For education, basic education represented 9/11 (82%), followed by university and secondary constituting 140/213 (66%) and 26/40 (65%), respectively, as shown in Figure 2.

Of the 266 individuals, 201/266 (75%) were used to sleep for less than six hours per day, of whom 138/201 (68.7%) were late sleepers and 63/201 (31.3%) were early sleepers. Of the 266 individuals, 130/266 (48.9%) were used to awake after 7:00 am, of whom 103/130 (79%) were late sleepers and 27/130 (21%) were early

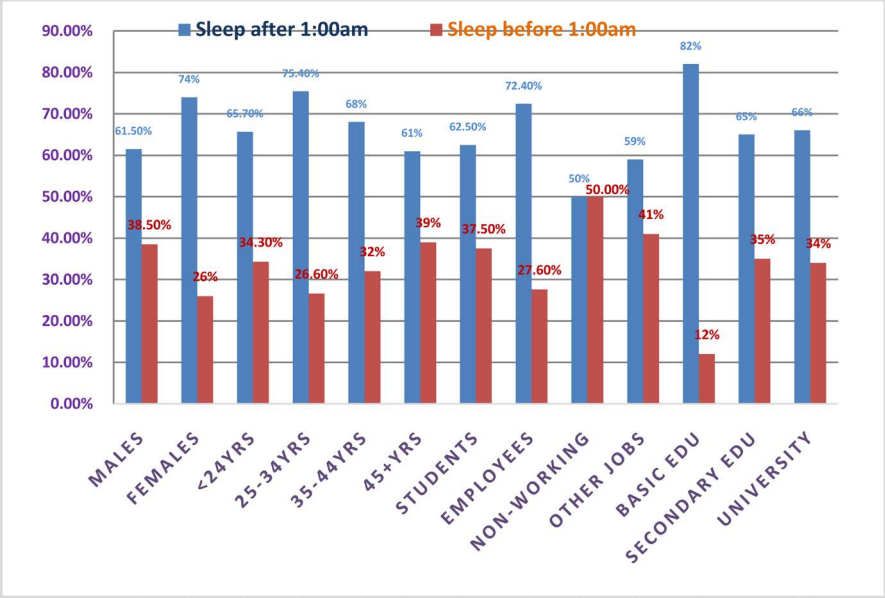

Figure 2. Description of sleeping time by demographical characteristics within each variable.

Table 2. Distribution of sleeping time by perception.

Variable	Category	Sleeping Time		Total
		After 1:00 am (late)	Before 1:00 am (early)	
Sleeping hours				
	<6 hours	138	63	201
	>6 hours	32	33	65
	Total	170	96	266
Awake time				
	Before 7:00 am	55	65	120
	After 7:00 am	103	27	130
	Total	158	92	250
Late sleep associated with bad temper (*next day*)				
	Yes	82	36	118
	No	88	60	148
	Total	170	96	266
Late sleep affects academic achievement				
	Strongly	70	64	134
	Average	95	31	126
	Weakly	5	1	6
Late sleep affects work success				
	Strongly	93	63	156
	Average	75	33	108
	Weakly	2	0	2
Late sleep decreases work satisfaction				
	Yes	142	85	227
	No	28	11	39
Early sleep brings				
	Happiness	159	90	249
	Depression	11	6	17

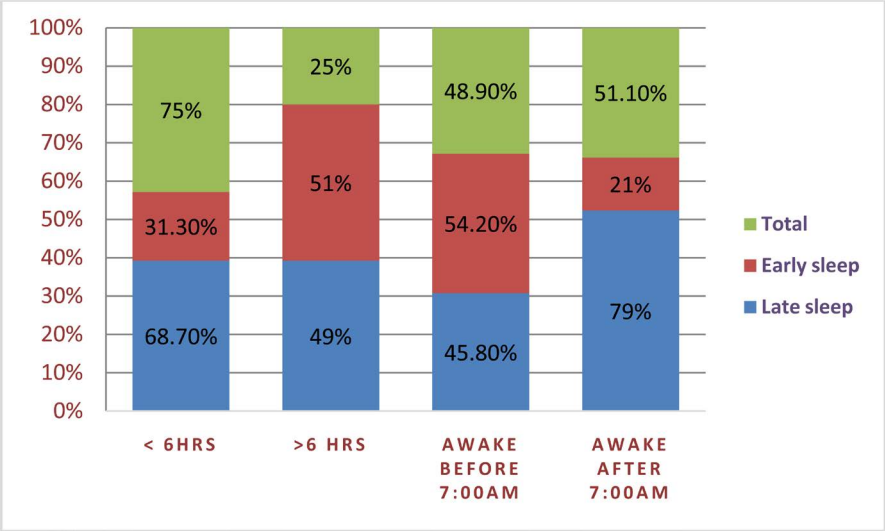

Figure 3. Description of sleeping time by sleeping and awake times.

sleepers, as shown in **Table 2**, **Figure 3**.

On asking participants whether "Late sleep associated with bad temper (next day)", 118 persons emphasized that late sleep used to bring them bad temper, of whom 82/118 (69.5%) used to sleep late and 36/118 (30.5%) used to sleep early. On asking them whether "Late sleep affects their academic achievement", 134/266 (50.4%), 126/266 (47.4%) and 6/266 (2.2%), have indicated that late sleep affects their academic achievement somehow, strongly, average and weak, respectively. With these categories (late and early) sleep for strongly, average and weak were (70 and 64), (95 and 31) and (5 and 1), respectively. On asking them whether "Late sleep affects their work success", 156/266 (58.6%), 108/266 (40.6%) and 2/266 (0.8%), have indicated that late sleep affects their work success somehow, strongly, average and weak, respectively. With these categories (late and early) sleep for strongly, average and weak were (93 and 63), (75 and 33) and (2 and 0), respectively.

On asking them whether "Late sleep decreases their work satisfaction", 227/266 (85.3%), agreed that late sleep decreased their chance of work satisfaction; of whom 142/227 (53.3%) were used to sleep late and 85/227 (37.4%) used to sleep early. On asking them whether "Early Sleep brings happiness", 249/266 (93.6%), agreed that early sleep brings happiness next day; of whom 159/249 (63.9%) were used to sleep late and 90/249 (36.1%) used to sleep early. Nevertheless, 17 participants thought early sleep leads to depression; of whom 11/17 (64.7%) were used to sleep late and 6/17 (35.3%) used to sleep early, as indicated in **Table 2**, **Figure 4**.

Out of the 266 participants, 36/266 (13.5%) were current smokers; of whom 24/36 (66.7%) were from those accustomed to late sleep and 12/36 (33.3%) were early sleep category. Of the 266 participants, 154/266 (57.9%) were using stimulus (coffee, Tea, power drinks); of whom 99/154 (64.3%) were from those accustomed to late sleep and 55/154 (35.7%) were early sleep category. For Frequency of temporary sicknesses, 127, 27 and 17 were caught by temporary sickness, Once, Twice and More per month, in this order. Of the 127 persons who were caught

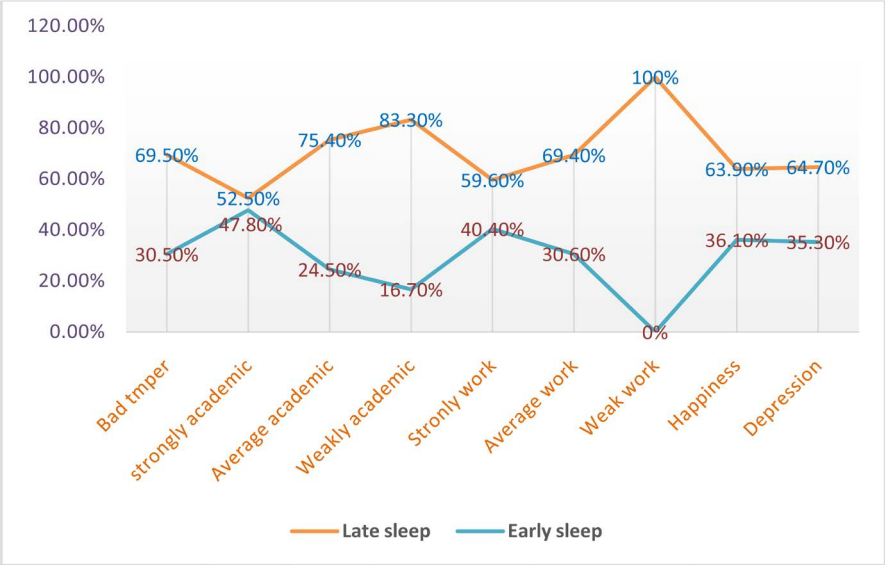

Figure 4. Sleeping time by perception.

once a month, 75/127 (59%) were late sleepers and 52/127 (41%) were early sleepers. Of the 27 persons who were caught twice a month, 22/27 (81.5%) were late sleepers and 5/27(18.5%) were early sleepers. Of the 17 persons who were caught once a month, 11/17 (%) were late sleepers and 5/17 (%) were early sleepers.

Diabetes Miletus (DM), hypertension, rheumatoid arthritis, allergies, tumors and other scattered diseases were identified in (13 & 7), (13 & 5), (15 & 2), (9 & 3), (4 & 1) and (28 & 8) of (Late sleepers & Early sleepers), respectively, as indicated in **Table 3**, **Figure 5**.

4. Discussion

As it is well established that prolonged exposure to artificial light at night has adverse effects resulting in hurtful health disorders including cancer, the current study aimed at assessing the epidemiologic exposure to artificial light at night time and negative health consequences that associated with prolonged nighttime lighting exposure. As the data were collected during summer season and the night was relatively shorter, the time 1:00 am was used to group the study population into two groups (early sleepers for those who used to sleep before 1:00 am and late sleepers for those sleep after 1:00 am). Sleeping after 1:00 am was ascertained for elongated nighttime light exposure.

The overall incidence of nighttime light exposure in the present study was 65.8% for general population, and 61.5% for males and 38.5% for females. These values were very high, particularly when we look to the time of grouping 1:00 am. There is a lack of literature regarding the epidemiologic patterns of light exposure. Most studies investigated the effects of light pollution on diverse health disorders. A recent study from Saudi Arabia had published relatively similar findings. The study found that around 62.6% of the study subjects were found to sleep after 1:00 am, and about 46.6% of them awake before sunrise [10]. About 75.6% of

Table 3. Distribution of sleeping time by use of stimulus and frequency of illnesses.

Variable	Category	Sleeping Time		Total
		After 1:00 am (late)	Before 1:00 am (early)	
Current cigarette smoking				
	Yes	24	12	36
	No	146	84	230
	Total	170	96	266
Using stimulus (*coffee, tea, power drinks*)				
	Yes	99	55	154
	No	71	41	112
	Total	170	96	266
Frequency of temporary sicknesses				
	None	56	24	80
	Once/month	75	52	127
	Twice/month	22	5	27
	More	11	5	17
	Total	164	86	251
Chronic illnesses				
	Diabetes miletus	13	7	20
	Hypertension	13	5	18
	Rheumatoid	15	2	17
	Allergies	9	3	12
	Tumors	4	1	5
	Others	28	8	36
	Total	82	26	108

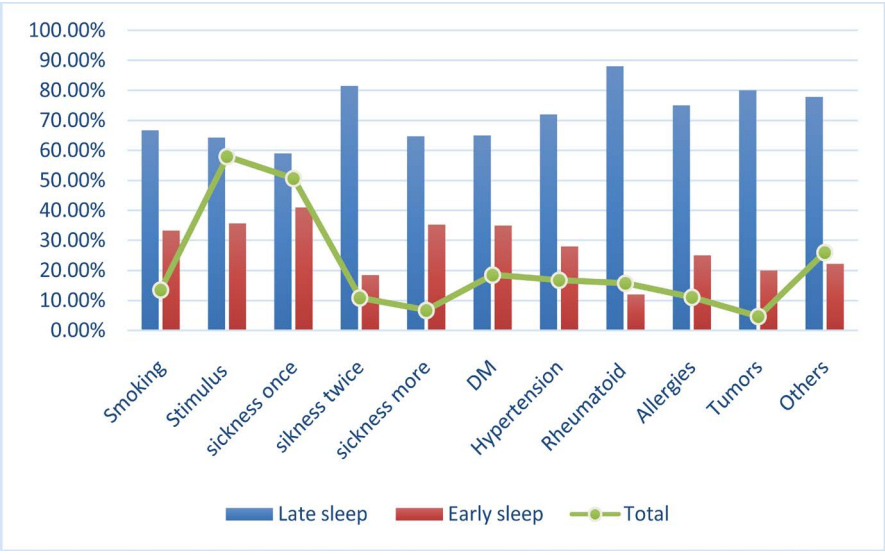

Figure 5. Description of sleeping time by use of stimulus and frequency of illnesses.

the participants of the present study used to sleep for less than 6 hours including daytime. These findings indicate intensified light pollution in northern Saudi Arabia, particularly among middle aged (35 - 45 years old) males (employees). In another cross-sectional survey covered 1035 high school students, ages 14 - 23 years, in Jeddah, western KSA; students slept an average of 7.0 hours on school nights, with an average delay of 2.8 and 6.0 hours in weekend sleep and awake times, respectively. About 1 in 10 students remained up all night and slept after returning from school (revealing a reversed sleep cycle) on weeknights. Such pattern was more prevalent amongst boys and students with poorer grade point averages. The prevalence of sleep disruption was 65%, and excessive daytime sleepiness was identified in 37% of the students. Indicators of extreme daytime sleepiness were school type, stress, napping and caffeine use, although gender was a predictor of upset sleep [11]. Another study has shown that one out of five of the general Saudi inhabitants has excessive daytime sleepiness, which is influenced by hours of sleep per night [12]. These literatures show that Saudi population has a high proportion of deprived sleep quality. Compared with inhabitants from other countries [13], they had a greater delay in weekend asleep and awake times. A terrible upturned sleep cycle particularly on weekdays is existent which necessitate the need for further assessment and control strategies.

In the present study, education level was expected to play a role in the negative consequences of prolonged light exposure, but surprisingly, the great majority of late sleepers were at university level. But this might be attributed to large participants in this category. On the other hand if bulk of participants were with lower levels of education, high incidence of light exposure might be registered.

The findings of this study also showed that late sleep time accompanied by late awake time which may have further social, economic negative impact, particularly among those without night work.

In regard to the perceptual and experienced factors, on asking participants whether "Late sleep associated with bad temper (next day)", 44.4% persons emphasized that late sleep used to bring them bad temper. It was well established that melatonin hormone anti-depressive effects [14], therefore, the mode changes reported by those persons might be attributed to low melatonin. Such evidences were reported in light therapy for seasonal affective disorder which is a seasonal pattern of recurrent major depressive episodes that occurs in countries experience major changes among different seasons [15]. Recent reports have proposed that mood regulation may be influenced by the function of circadian clocks [16].

On the other hand, the great majority of the participants have stressed that late sleep, affected their academic achievement, their work success and work satisfaction. When comparing these categories for late and early sleep, it is apparent that all increased among late sleep category and decreased among early sleep category, as shown in **Figure 4**.

Smoking was more frequent among late sleepers compared to early sleepers which might indicate mood changes [17] [18].

Frequencies of temporary sicknesses, as well as chronic diseases are very high

among late sleepers compared to early sleepers, as shown in Figure 5. Such findings support several studies in this context. Melatonin insufficiency which was associated with prolonged light exposure at night have been evidenced to cause several diseases such as; neurodegenerative diseases [19] diabetic kidney disease [20], cancer [21], Parkinson's disease [22] Alzheimer's disease [23], and others health problems [24].

The limitations in the current study include, its cross sectional setting, relatively small sample size and dependence on questionnaire rather than quantitative analysis. But the study brought about a number of clues for the current situation of Saudi population in this matter, as well as, it provides a number of future research orientations, gaps and alerts to the policy makers to think about future control strategies.

5. Conclusion

Prolonged exposure to the light at night time is prevalent in Saudi Arabia. This exposure usually results from late sleep in the nighttime and the late awake in the daytime. A terrible upturned sleep cycle is existent which necessitates the need for further assessment and control strategies.

Conflict of Interest

The authors declare no conflict of interest.

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