Gender-based sleep disorder prediction in the 2050s of Jakarta

2019 September 13 Department of Environment Systems
47-176815 Zhang Dian
Supervisor: Associate Professor Ihara Tomohiko
Keywords: global warming, sleep disorder, Jakarta, gender differences

1. Introduction

Since the 19th century, the average surface temperature of the earth has risen by 0.9 °C over the past 100 years [1]. The impacts of the elevated temperature have become a major issue on human health, in particularly concerned about the onset of heat stroke and the inhibition of sleep[2]. Severe heat stroke is lethal and it has been studied and assessed for human health damage repeatedly based on clinical or epidemiological data such as the number for emergency transfers, and preventive measures have been applied. On the other hand, sleep disorder due to temperature rise that do not lead to death but widely exists among the residents, has not been studied adequately yet since its damage and preventive measures have limitedly been clarified.

Sleep quality is influenced by multiple factors including body metabolism, hormone level, and outdoor environment elements. Thermal environment is one of dominant factors. Kusama [3] quantified the sleep disorder impact on human health and confirmed the effect of air conditioner on relieving sleep disorder. However, previous studies on relationship between sleep and temperature have not considered the gender difference on sleep quality, which is widely accepted as a sleep quality effective factor considering the respective sex chromosomes and gonadal hormones levels. What is more, according to thermal comfort study[4], women have higher thermal comfort temperature, which may weak in air conditioning, so when the sleep quality was impacted by ambient thermal environment, using air conditioner for women may be not as helpful as men. However, it has been barely considered in previous studies.

Jakarta urban population is prospected to become the largest in the world in 2030[5]. It is important to understand sleep performance of men and women affected by rising temperature and air conditioner utilization effect in mega cities like Jakarta, which have large population and higher air temperature in the future. Thus, this study is aiming to (1) quantifying the relationship between air temperature variation and sleep disorder prevalence of men and women in Jakarta, Indonesia. (2) assessing the impact of temperature change on sleep disorder of men and women and the air conditioner's effect on sleep disorder. (3) predicting sleep loss of Jakarta in 2050 in which climate change will further proceed.

2. Methodology

2.1 Epidemiological survey

An epidemiological survey was conducted on Tuesday, Wednesday, and Thursday of the three consecutive weeks of February 2016 (1st time) and October – November (2nd time) by placement method. The subjects were extracted from men and women aged 20 living in Jakarta, taking into consideration age composition, occupation, and social class (SEC). The sample sizes were 263 in 1st and 264 in 2nd.

2.1.1 Pittsburgh Sleep Quality Index(PSQI)

The Pittsburgh Sleep Quality Index (PSQI) was used in our questionnaire. It is a questionnaire asking for sleep quality in the past month. It is classified into the following

seven components: (1) sleep quality, (2) sleep latency, (3) sleep duration, (4) habitual sleep efficiency, (5) sleep disturbance, (6) use of sleeping medication, and (7) daytime dysfunction. Each component has a possible range of 0–3 points and is summed to the global score (0–21 points). The higher global score is interpreted as worse sleep quality. PSQI is used in many contexts, including research and clinical activities, and has been used to diagnose sleep disorders. A global score of 5.5 points (between 5 and 6 points) has been shown to coincide with a high percentage of diagnostic criteria for sleep disorders [6]

Table 1 Pittsburgh Sleep Quality Index [6]

Pittsburgh Sleep Quality Index (PSQI)						
C1	C2	C3	C4	C5	C6	C7
Sleep quality	Sleep latency	Sleep duration	Habitual sleep efficiency	Sleep disturbance	Use of sleeping medication	Daytime dysfunction

2.1.2 Sleep Quality Index for Daily Sleep(SQIDS)

As PSQI evaluates the past month's sleep, so its evaluation results may be not affected by the daily temperature. Therefore, PSQI Sleep disordered people are unrelated to nighttime high temperature. Meanwhile, to assess the deterioration of sleep due to daily temperature, it is necessary to investigate the quality of sleep every day. SQIDS was developed referring to PSQI. The criteria for determining sleep disorders with SQIDS are consistent with PSQI.

Table 2 Sleep Quality Index for Daily Sleep(SQIDS)[3]

Sleep Quality Index for Daily Sleep (SQIDS)						
C1	C2	C3	C4	C5	C6	C7
Sleep quality	Sleep latency	Sleep duration	Habitual sleep efficiency	Sleep disturbance	Use of sleeping medication	Daytime dysfunction

2.1.3 Generalized Additive Models (GAMs)

A generalized additive model (GAM) is a generalized linear model (GLM) in which the linear predictor is given by a user specified sum of smooth functions of the covariates plus a conventional parametric component of the linear predictor.

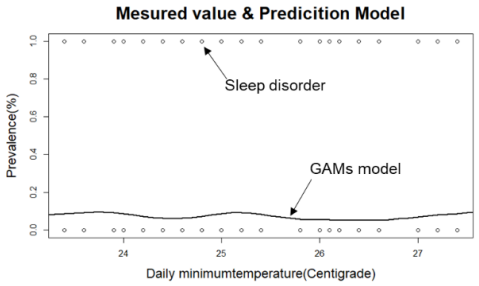

Figure 1.Generalized Additive Models (GAMs)

2.1.4 Daily minimum temperature

Jakarta daily minimum temperatures at three stations (Tanjung Priok, Observatory, and Soekarno-Hatta) for analyzing the relation with sleep quality were obtained from OGIMET[7].

2.1.5 Disability-adjusted life year (DALY)

One DALY is equal to one year of healthy life lost. DALY is sum of year of life lost (YLL) and years lived with disability (YLD). Sleep disorder is not lethal and its DALY was calculated from YLD only. Its disability weight is 0.1[9], and its duration is set to 1/365 year because sleep disorder is assessed every day in this study.

3. Results

3.1 Subjects

According to the survey result, the respondents with diseases may give huge impact on human sleep. Those with diseases were excluded from analysis in this study.

Table 3 Respondents with diseases

February		October	
First time	263	First time	264
Two weeks later	263	Two weeks later	264
total	526	total	528
February		October	
heart disease	1	mental disease	1
respiratory disease	5	respiratory disease	1
connective tissue disease	1	rheumatism	5
rheumatism	1	sleep disorder	4
sleep disorder	2	other disease	5
other disease	6		
total	16	total	16
February		October	
First time	247	First time	248
Two weeks later	247	Two weeks later	248
Samples	494	Samples	496

3.2 Epidemiological survey

12.9% of the subjects had sleep disorder in total (11.1% in February and 14.7% in

October) according to PSQI. Also 7% had sleep disorder (8.1% in February and 5.9% in October) according to SQIDS. As PSQI has high level of validity and precision in judging sleep disorder, SQIDS may have possibly underestimated sleep disorder prevalence. Therefore, men and women SQIDS sleep disorder prevalence was revised by PSQI. SQIDS was conducted to assess the same periods as PSQI by utilizing temperature-sleep disorder function (February: period1 1/9–2/9, period2 1/23–2/23; October: period1 9/18–10/18, period2 10/1–11/1). SQIDS could assess 48.0% in total who suffering from sleep disorder judged by PSQI(Men: 53.5%; Women: 42.0%).

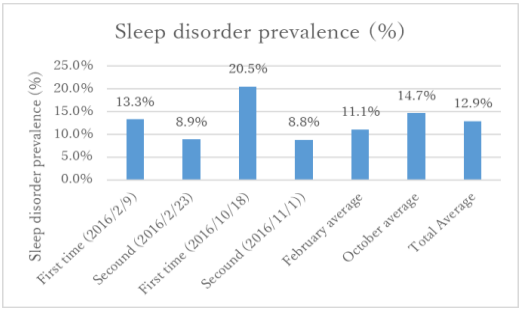

Figure 2 Sleep disorder prevalence of PSQI

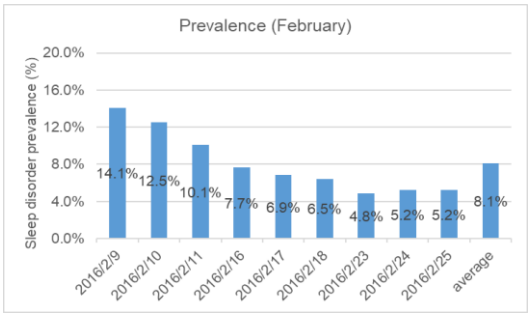

Figure 3 Sleep disorder prevalence of SQIDS

Table 4 SQIDS and PSQI

		SQIDS	PSQI	SQIDS/PSQI	Averag
Men	February	6.4%	13.9%	0.46	0.535
	October	5.9%	9.6%	0.61	
Women	February	5.9%	16.3%	0.36	0.420
	October	5.8%	12.0%	0.48	
Total	February	6.3%	15.1%	0.42	0.480
	October	5.8%	10.8%	0.54	

3.3 Gender differences on sleep quality

Student-test was conducted to test the gender differences on sleep scores and sleep disorder prevalence. Table 5 shows that gender differences existing in sleep latency, sleep duration, daytime dysfunction, and global scores.

Table 5 SQIDS average scores of total subjects of men and women

	Male	Female	t	p
C1	0.77±0.5	0.78±0.52	-0.89	0.37
C2	0.46±0.66	0.41±0.62	2.53	0.01
C3	0.93±0.87	0.71±0.76	9.1	0
C4	0±0.03	0±0.03	-0.06	0.95
C5	0.13±0.38	0.16±0.42	-1.86	0.06
C6	0±0.07	0.01±0.12	-1.62	0.11
C7	0.84±0.62	0.92±0.68	-4.15	0
total	3.13±1.72	2.98±1.67	2.96	0

3.4 Statistical regression analysis

The subjects who used air conditioner had lower sleep disturbance prevalence than those who did not use. With daily minimum temperature rising, those sleep quality without air conditioner deteriorates while air conditioner users do not. This may be because air conditioner user would not be affected by daily minimum temperature change. Men who used air conditioner were predicted to have decreasing on sleep disorder with daily minimum temperature when no air conditioning group would not have much variation accompanying with temperature rising while in women was opposite.

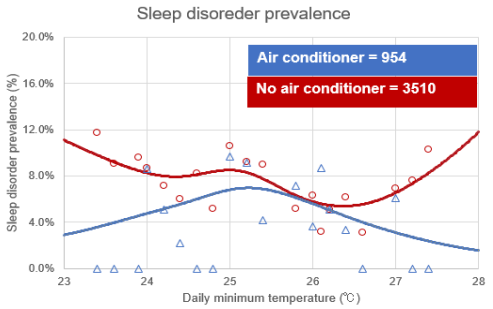

Figure 4 Air conditioner effect on sleep disorder

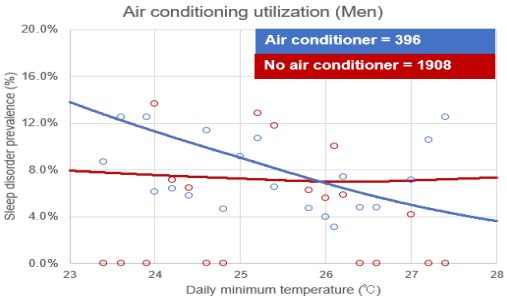

Figure 5 Air conditioner effect on sleep disorder of Men

3.5 Sleep disorder impact assessment

To assess the impact of sleep disorder by the future climate change, DALY was calculated under three scenarios below.

Table 6 conditions of scenarios

	Scenario A	Scenario B	Scenario C
	2006 Aug	2050 Aug	2050 Aug
Air conditioner rate	15%	15%	60%
Population	26,582,770	47,640,698	47,640,698
Monthly minimum temperature	25.81	27.29	27.34
Male/Female	100.8/100	99.9/100	99.9/100

In current scenario, there was 342.6 × 10^3DALY happening due to sleep disorder, in which residential without air conditioner took the most part of DALY. In future scenario, there was 372.4 × 10^3DALY(8.46 × 10^3DALY per year) increased comparing with 2006, 1% air conditioner popularity rate increase brought about 5.21 × 103DALY reliving among Jakarta residential(2.44 × 10-4DALY per person per month).

In men, 1℃ rising would bring about 29.0 × 103DALY impact in male residential of Jakarta. 1% popularity rate increase brought about 1.12 × 103DALY increasing among male Jakarta residential (1.05 × 10-4DALY per person per month).

In women, 1℃ rising would bring about 56.3 × 103DALY impact in male residential of Jakarta. 1% popularity rate increase brought about 0.56 × 103DALY increasing among male Jakarta residential (5.22× 10-5DALY per person per month).

Table7 the disability-adjusted life years (DALY)[10^3 year]

		2006（15%）	2050（15%）	2050（60%）
Total	air conditioner	50.7	38.7	154.8
	no air conditioner	291.9	676.3	325.9
Male	air conditioner	26.2	48.2	192.8
	no air conditioner	153.1	174	80
Female	air conditioner	18.5	49.3	200.2
	no air conditioner	184.5	237	111.5

4. Conclusion

In Jakarta, residential without sleep would be impacted by daily minimum temperature, with temperature rising it will deteriorate, while the air conditioner user does not sleep. Gender difference on sleep quality exists in sleep latency, sleep duration, and daytime dysfunction. Men and women sleep quality had inverse performance correlating to daily temperature variation. In total, sleep quality would deteriorate with temperature rising and air conditioner would relive the morbidity, while women who use air conditioner would get higher sleep disorder prevalence.

5. Reference

[1] National Aeronautics and Space Administration. Goddard Institute for Space Studies: GISS Surface Temperature Analysis (v4). https://data.giss.nasa.gov/gistemp/graphs_v4/

[2] Doi Yuriko. Prevalence and health impacts of sleep disorders in Japan[J]. Journal of the National Institute of Public Health. 2012 Feb,61(1): 3-10.

[3] Kusama. Quantitative evaluation of mild health effects and air conditioner introduction effects associated with heat in Jakarta[Japanese][D]. Tokyo University, 2017 Mar 23.

[4] MadhaviIndraganti et,al. Effect of age, gender, economic group and tenure on thermal comfort: A field study in residential buildings in hot and dry climate with seasonal variations[J]. Energy and Buildings. 2010 Mar,42(3): 273-281.

[5] Jakarta to Topple Tokyo as World's Biggest City by 2030. Economics. https://www.bloomberg.com/news/articles/2018-10-09/jakarta-to-topple-tokyo-as-world-s-most-populous-city-by-2030

[6] Buysse;et,al. "The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research"[J]. Psychiatry Research.1989 May, 28 (2): 193–213.

[7] OGIMET. https://www.ogimet.com/home.phtml.en

[8] Tadahiro KUWAYAMA et al. Reduction Effect of DALY of Sleep Disturbance and Fatigue by Air Conditioner -Evaluation in Jakarta, Indonesia-[J]. Journal of Life Cycle Assessment. 2019,15(1): 2-9.

[9] S. Fukuda, T. Ihara, Y. Genchi, and D. Narumi, “Japanese sleep disturbance and fatigue disability weights in evaluating the effects of increasing temperatures on health by a life cycle approach,”[J].International journal of life cycle assessment 2013,18(5): 1089-1097