INFLUENCE OF INDOOR AIR QUALITY (IAQ) ON THE SICK BUILDING SYNDROME (SBS) AT TWO SELECTED HOSPITALS

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MASTER OF SCIENCE

UNIVERSITI UTARA MALAYSIA

April 2017

INFLUENCE OF INDOOR AIR QUALITY (IAQ) ON THE SICK BUILDING SYNDROME (SBS) AT TWO SELECTED HOSPITALS

By:

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Thesis Submitted to

Othman Yeop Abdullah Graduate School of Business,

Universiti Utara Malaysia,

in Fulfillment of the Requirement for the Degree of Master of Science

Pusat Pengajian Pengurusan Perniagaan
SCHOOL OF BUSINESS MANAGEMENT
Universiti Utara Malaysia

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ABSTRACT

Attention on buildings' Indoor Air Quality (IAQ) tend to show an increased due to time spending indoors is relatively higher than workers being outdoors. One major problem often associated with IAQ is Sick Building Syndrome (SBS). This study has its objectives of identifying current status of IAQ and investigating its relationship with SBS inside of the building served by the mechanical ventilation and air-conditioning (MVAC) system in two selected hospitals in Selangor and Pahang. The findings of study are useful as they provide data to ensure that the health, comfort and well-being of workers are not to be affected or continuously affected by problems associated to IAQ. Self-administered questionnaire was used to obtain current SBS symptoms experienced by workers. Then, technical assessments comprised of walkthrough survey and measurements of IAQ parameters were carried out to understand the current status of IAQ in building. The important IAQ parameters considered in this study were air temperature, relative humidity, air changes per hour (ACH), carbon dioxide (CO_2), carbon monoxide (CO), total volatile organic compounds (TVOC), formaldehyde (HCHO) and respirable particulate (RP). Measurements were performed using calibrated IAQ equipment. A questionnaire was distributed to workers in selected departments and a 76% response rate was achieved, giving a sample of 76 workers. The prevalence of SBS was significantly higher at hospital in Selangor (38.9%) compared to Pahang (7.5%) and of all the reported symptoms, irritated, stuffy or runny nose was the most reported symptoms in this study (11.1%). The average results for IAQ parameters at both hospitals were well below the acceptable limits or within recommended acceptable range of Malaysian Industry Code of Practice on Indoor Air Quality 2010 (MICOP IAQ 2010). Meanwhile, the average results for ACH have failed to achieve the minimum limit of 10 as stated in the Factories and Machineries (Safety, Health and Welfare) Regulations 1970 (FMA(SHW) 1970). Nevertheless, there were no direct causal link and no significant association between IAQ parameters and SBS symptoms. Further study with wider scope including personal and psychosocial factors should be conducted especially within healthcare facilities in order to obtain more accurate results.

Keywords: Indoor air quality (IAQ), sick building syndrome (SBS), building, air changes per hour

ABSTRAK

Pada masa kini, kebimbangan terhadap kualiti udara dalaman (IAQ) di bangunan-bangunan cenderung menunjukkan peningkatan kerana kebanyakan pekerja menghabiskan masa mereka di dalam bangunan berbanding di luar bangunan. Satu masalah yang sering dikaitkan dengan IAQ adalah Sindrom Bangunan Sakit (SBS). Kajian ini dijalankan untuk mengenal pasti status semasa IAQ dan menyiasat hubungannya dengan SBS di dalam bangunan yang menggunakan sistem pengudaraan mekanikal dan penghawa dingin (MVAC) di dua buah hospital di Selangor dan Pahang. Dapatan kajian adalah berguna untuk memastikan bahawa kesihatan, keselesaan dan kesejahteraan pekerja tidak terjejas atau terus terjejas oleh masalah yang berpunca daripada IAQ. Soal selidik yang ditadbir sendiri telah digunakan untuk mendapatkan gejala SBS semasa yang dialami oleh pekerja. Kemudian, penilaian teknikal yang terdiri daripada kajian secara langsung dan ukuran parameter IAQ telah dijalankan untuk memahami status semasa IAQ di dalam bangunan. Parameter penting IAQ yang dikaji dalam kajian ini ialah suhu udara, kelembapan relatif, pertukaran udara sejam (ACH), karbon dioksida (CO2), karbon monoksida (CO), jumlah sebatian organik meruap (TVOC), formaldehid (HCHO) dan habuk boleh terhirup (RP). Ukuran telah dijalankan menggunakan peralatan IAQ yang telah ditentukur. Soal selidik telah diedarkan kepada pekerja-pekerja di jabatan-jabatan terpilih dan kadar maklumbalas yang diterima ialah 76%, iaitu bersamaan dengan jumlah pekerja seramai 76 orang. Kes SBS adalah jauh lebih tinggi di hospital yang terletak di Selangor (38.9%) berbanding Pahang (7.5%) dan di antara semua gejala yang dilaporkan, gatal-gatal, tersumbat atau hidung berair adalah gejala yang paling tinggi dilaporkan di dalam kajian ini (11.1%). Keputusan bacaan purata bagi setiap parameter IAQ di kedua-dua hospital adalah di bawah had yang boleh diterima atau dalam julat yang boleh diterima seperti dinyatakan dalam Kod Amalan Industri Kualiti Udara Dalaman 2010 (MICOP IAQ 2010). Sementara itu, keputusan bacaan purata untuk ACH telah gagal mencapai had minimum 10 seperti yang dinyatakan dalam Akta Kilang dan Jentera (Keselamatan, Kesihatan dan Kebajikan) Peraturan- peraturan 1970 (FMA (SHW) 1970). Walau bagaimanapun, tiada hubungan kaitan secara langsung dan tiada hubungan yang signifikan di antara setiap parameter IAQ dan gejala SBS. Kajian lanjut dengan skop yang lebih luas termasuk faktor peribadi dan psikososial perlu dijalankan terutamanya untuk kemudahan penjagaan kesihatan bagi mendapatkan keputusan yang lebih tepat.

Kata kunci: Kualiti udara dalaman (IAQ), sindrom bangunan sakit (SBS), bangunan, pertukaran udara sejam (ACH)

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent and the Most Merciful.

I would like to take this opportunity to extent my sincere appreciations to all of those who supported and encouraged me during the completion of the master project paper.

First, and most importantly, I would like to thank to my project supervisor, Dr. Zuraida Hassan from the Universiti Utara Malaysia, for her patience, support and guidance which were immensely helpful in completing this project on time. Also, I would like to thank to Ms. Chan Kah Yin, my mentor and former colleague from Bureau Veritas (M) Sdn. Bhd., who has trained, guided and sharing her wide expertise in Industrial Hygiene and motivated me to be an Industrial Hygienist.

I would like to extend my appreciation to National Institute of Occupational Health (NIOSH), Malaysia who has appointed me as their principal consultant to execute the IAQ assessment at four hospitals in Malaysia using their resources. Special thanks to En Nor Mohd Razif Noraini from NIOSH and practical students of local universities who have dedicated their time, energy and expertise to help me with the assessment. Also, thanks to all hospital workers and maintenance team for their participation in the assessment. Without them, this project would definitely have failed to be completed.

Not to forget, my appreciation goes to BASF Asia- Pacific Service Centre Sdn. Bhd., my current employer for allowing me to complete my project without hesitations. Last but not least, my appreciation goes to my wife, daughter and mother for their love, understanding and support.

Any errors from this project are my own and should not tarnish the reputations of these esteemed persons. May Allah, the Almighty bless all of you and your family and repay all your good deeds and support given to me.

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LIST OF ABBREVIATION/ NOTATIONS/ GLOSSARY OF TERMS

ACH	- Air changes per hour
CO_2	- Carbon dioxide
CO	- Carbon monoxide
FMA(SHW)	- Factories and Machineries (Safety, Health and Welfare) Regulations 1970
HCHO	- Formaldehyde
IAQ	- Indoor air quality
mg/m^3	- Milligram per cubic meter
MICOP IAQ	- Malaysia Industry Code of Practice on Indoor Air Quality
MVAC	- Mechanical ventilation and air conditioning
n	- Sample size
ppb	- Parts per billion
ppm	- Parts per million
RP	- Respirable particulates
SBS	- Sick building syndrome
TVOC	- Total volatile organic compound
%RH	- Percentage of relative humidity
°C	- Degree celcius
$\chi 2$	- Chi square
<	- Not less than

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

One of the important elements to ensure the health and comfort level of people in the physical environment especially in a building is Indoor Air Quality (IAQ). IAQ refers to the quality of air within and around a particular building and its structure. It highly relates to the health of its occupants. Poor IAQ can certainly lead to a variety of environmental health problems and potentially affect comfort and well-being.

According to the United States Environmental Protection Agency (US EPA), poor IAQ can be associated with many known environmental health problems such as Sick Building Syndrome (SBS), Building Related Illness (BRI), and Multiple Chemical Sensitivity (MCS). However, the most well-known environmental health problem associated with poor IAQ is SBS (U.S EPA, 2016). SBS describes situations in which people employed in building experience acute health and comfort effects that seem to be linked to time spent in a building. Even though there is yet specific illness or cause to be strongly associated to SBS, common symptoms of SBS may include headache, fatigue, irritated throat, itchy skin, eyes and nose, coughing and nausea (Godish, 1995). These symptoms are generic and varied where most of them are found to be temporary as the SBS complainants report relief soon after leaving the building.

According to Berardil, Leoni, Marchesini, Cascella and Raffil (1991), SBS is a known issue in Malaysia due to the construction of buildings designed to be energy-

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APPENDIX A- QUESTIONNAIRE

INDOOR AIR QUALITY

QUESTIONAIRE FOR BUILDING OCCUPANTS

This short questionnaire has been given to you to facilitate the identification of potential sources of indoor air quality (IAQ) pollutants and to identify adverse health effects that may be associated with exposure to these pollutants. Your answers will remain confidential. Please complete the form as accurately as possible before returning to us.

Completed by :
Disediakan oleh
Date/ Tarikh : _____

General Information/ Maklumat Am

1. Building/Company name : _____
2. Department/Division : _____
3. Has your Company carried out any assessment related to IAQ?
   Adakah syarikat anda pernah menjalankan apa-apa ujian kualiti udara dalaman?
   ☐ Yes ☐ No ☐ In Progress ☐ Not Sure

Background factor/ Latar Belakang

4. Sex : ☐ Male ☐ Female
5. Age : ☐ <25 yrs ☐ 25- 39 yrs ☐ 40- 55 yrs ☐ >55 yrs
6. Do you smoke? ☐ Yes ☐ No

Nature of Occupation

7. Occupation/ Position : _____
8. How long you have been at your present place of work? _____ yr(s) _____ mth(s)
9. No. of hours spent per day at your main workstation : _____ hr(s)
10. Brief description of your work/ *Ringkasan tugas-tugas anda di tempat kerja* :

_____
_____

Environmental Conditions/ Keadaan Persekitaran

11. Type of workstation : ☐ Enclosed Room ☐ Open Concept
12. How is your area air-conditioned? ☐ Central Unit ☐ Local Unit (split unit)
13. Please indicate if you work with or near the following equipment:

	Everyday	2-3 times weekly	Never
a) Typewriter	☐	☐	☐
b) Video display unit (VDU)/ computer	☐	☐	☐
c) Photocopier	☐	☐	☐
d) Fax machine	☐	☐	☐

14. Have you been bothered during the last three (3) months by any of the following factors at your workstation/ workplace?/ Adakah anda rasa terganggu sejak 3 bulan lepas dengan mana-mana faktor yang berikut di tempat kerja?

	Yes, often (every week)	Yes, sometimes	No, never
a) Draught/ *Aliran udara dalam bilik*	☐	☐	☐
b) Room temperature too high/ *Suhu bilik yang terlalu tinggi*	☐	☐	☐
c) Varying room temperature/ *Suhu bilik yang tidak menentu*	☐	☐	☐
d) Room temperature too low/ *Suhu bilik yang terlalu rendah*	☐	☐	☐
e) Stuffy "bad" air/ *Udara yang menyesakkan pernafasan*	☐	☐	☐
f) Dry air/ Udara yang kering	☐	☐	☐
g) Unpleasant odour/ *Bau yang kurang menyenangkan*	☐	☐	☐
h) Passive smoking/ *Merokok pasif*	☐	☐	☐
i) Dust and dirt/ *Habuk dan kotoran*	☐	☐	☐

APPENDIX A- (CONTINUED)

INDOOR AIR QUALITY

QUESTIONAIRE FOR BUILDING OCCUPANTS

This short questionnaire has been given to you to facilitate the identification of potential sources of indoor air quality (IAQ) pollutants and to identify adverse health effects that may be associated with exposure to these pollutants. Your answers will remain confidential. Please complete the form as accurately as possible before returning to us.

Past/Present Diseases/Symptoms/ ***Penyakit/ Simptom Dulu/ Sekarang :***

	Yes	No
15. Have you ever had asthmatic problems/ *respiratory- related diseases* ?	☐	☐
If yes, during last year?	☐	☐
16. Have you ever suffered from sinusitis/ *nose-related diseases* ?	☐	☐
If yes, during last year?	☐	☐
17. Have you ever suffered from eczema/ *skin diseases* ?	☐	☐
If yes, during last year?	☐	☐

Present Symptoms/ ***Simptom Sekarang***

18. During the last three (3) months, have you had any of the following symptoms at work (Answer every question even if you have not had any symptoms)?/ *Sejak 3 bulan lepas, adakah anda mengalami mana-mana simptom yang berikut di tempat kerja?*

	Yes, often (every week)	Yes, sometimes	No, never	If Yes, do you believe that is due to your work environment: Yes	No	Unsure
a) Fatigue/ *Letih*	☐	☐	☐	☐	☐	☐
b) Feeling heavy-headed/ *Lembab*	☐	☐	☐	☐	☐	☐
c) Headache/ *Sakit Kepala*	☐	☐	☐	☐	☐	☐
d) Nausea/dizziness/ *Mual/ Pening*	☐	☐	☐	☐	☐	☐
e) Difficulties concentrating/ *Sukar menumpukan perhatian*	☐	☐	☐	☐	☐	☐
f) Itching, burning or irritation of the eyes/ *Gatal, pedih atau merengsa pada mata*	☐	☐	☐	☐	☐	☐
g) Irritated, stuffy or runny nose/ *Merengsa, tersumbat atau hidung berair*	☐	☐	☐	☐	☐	☐
h) Hoarse, dry throat/ Serak, *kering Tekak*	☐	☐	☐	☐	☐	☐
i) Cough/ *Batuk*	☐	☐	☐	☐	☐	☐
j) Dry or flushed facial skin *Kulit muka kering atau kemerahan*	☐	☐	☐	☐	☐	☐
k) Scaling/itching scalp or ears/ *Pengelupasan/ Kegatalan kulit kepala atau telinga*	☐	☐	☐	☐	☐	☐
l) Hand dry, itching, redskin *Tangan kekeringan, gatal, kemerahan*	☐	☐	☐	☐	☐	☐

19. When do these symptoms occur? ☐ Mornings
Bila simptom-simptom selalu terjadi? ☐ Afternoons
☐ No noticeable trend

20. When do you experience relief from these symptoms? ☐ Mornings
Bila anda akan berasa lega daripada simptom-simptom yang dinyatakan? ☐ Afternoons
☐ No noticeable trend

APPENDIX B- WORKPLACE INSPECTION CHECKLIST

Checklist for Walkthrough Inspection

Date of Inspection: _____

Inspected by: _____

Location: _____ **Time:** _____

1.0 GENERAL CONSIDERATIONS

	Yes	No	N/A
1.1 Ensured that temperature and humidity are maintained within acceptable ranges	☐	☐	☐
1.2 Ensured that no obstructions exist in supply and exhaust vents	☐	☐	☐
1.3 Checked for odors	☐	☐	☐
1.4 Checked for signs of mold and mildew growth	☐	☐	☐
1.5 Checked for signs of water damage	☐	☐	☐
1.6 Checked for evidence of pests and obvious food sources	☐	☐	☐
1.7 Checked for presence of hazardous substances	☐	☐	☐
1.8 Dirty or unsanitary conditions	☐	☐	☐
1.9 Inadequate ventilation (e.g stuffy, stale air)	☐	☐	☐
1.10 Poor conditions (e.g drain pans, cooling towers, filters, air cleaners)	☐	☐	☐
1.11 Overcrowding	☐	☐	☐

2.0 GROUND LEVEL

	Yes	No	N/A
2.1 How many occupants in the work area?	☐	☐	☐
2.2 How long are they in the work area?	☐	☐	☐
2.3 Is the indoor temperature regulated by thermostats?	☐	☐	☐
2.4 Is there discomfort from heat radiation from visual display units?	☐	☐	☐
2.5 Is there discomfort due to radiant heat from warm window surfaces?	☐	☐	☐
2.6 Are temperature, relative humidity and air flow rates checked regularly during working hours?	☐	☐	☐
2.7 Does air reach all parts of the office or there are no dead spaces?	☐	☐	☐
2.8 Is the building is still being used for the purpose it was intended?	☐	☐	☐
2.9 Have partitions/ walls been added or removed?	☐	☐	☐
2.10 Have occupancy levels changed?	☐	☐	☐

APPENDIX B- (CONTINUED)

3.0 Potential Sources of Contaminants

	Yes	No	N/A
3.1 Are they any occupants smoking?	☐	☐	☐
If yes, indicate where and if no, is there any designated area?	_____		
3.2 Are they furniture, carpets etc that emit noticeable odours?.....	☐	☐	☐
3.3 Have detergents, pesticides or other chemicals been used in the Building?	☐	☐	☐
3.4 Has there been any recent renovation or maintenance in any part of the building?	☐	☐	☐
3.4.1 Done during working hours?	☐	☐	☐
3.4.2 That can be a source of contaminants (e.g painting, carpet Installation/ cleaning, pesticide application etc)?	☐	☐	☐
3.4.3 That can alter air flow patterns such as installation of ..... Partitions or relocation of air intake or exhaust?	☐	☐	☐
3.5 Is there a kitchen or pantry where cooking is done?	☐	☐	☐
If yes, is exhaust ventilation provided?	☐	☐	☐
3.6 Is the building adequately clean?.....	☐	☐	☐
3.7 Is regular dusting of office furniture, ledges, shelves etc. carried out to help keep dust to a minimum?	☐	☐	☐
3.8 Are the carpets vacuum- cleaned regularly?.....	☐	☐	☐
3.9 Are they any office equipment giving off gases or fumes such as photocopying machines, blueprint machines and other office machines	☐	☐	☐

4.0 Ventilation and air-conditioning

	Yes	No	N/A
4.1 Is there at least one supply air and exhaust air vents in every area?	☐	☐	☐
If yes, how many vents provided in each area?	_____		
4.2 Are supply air or exhaust air vents blocked in any way by partitions, files or other structures that obstruct air flow			
4.3 Has dust collected around the air vents?	☐	☐	☐
4.4 Is the air-conditioning system turned off.....	☐	☐	☐
4.4.1 any time during the day?	☐	☐	☐
4.4.2 after office hours?	☐	☐	☐
4.4.3 are there still occupants in the building after office hours?	☐	☐	☐
4.5 Where is the outdoor air intake duct located?	☐	☐	☐
4.5.1 near the cooling tower in the building?	☐	☐	☐
4.5.2 near adjacent buildings?	☐	☐	☐

APPENDIX B- (CONTINUED)

4.5.3 at street level?	☐	☐	☐
4.5.4 near a car park?.....	☐	☐	☐
4.5.5 is it obstructed?.....	☐	☐	☐
4.5.6 others, please specify?	_____		
4.6 Are heavy industries located nearby?	☐	☐	☐
4.7 Are there any construction work going on nearby?	☐	☐	☐
4.8 Is outdoor air actually getting into the building?	☐	☐	☐
4.9 Is there regular schedule for cleaning and maintenance of the ..... air- conditioning system in the building?	☐	☐	☐
4.10 Are all the components of the air- conditioning system regularly... Inspected for leaks, breaches etc.?	☐	☐	☐

APPENDIX C- PHOTOS OF SITE ASSESSMENT

Photo 1
Fresh air intakes were located near to vehicles parking area

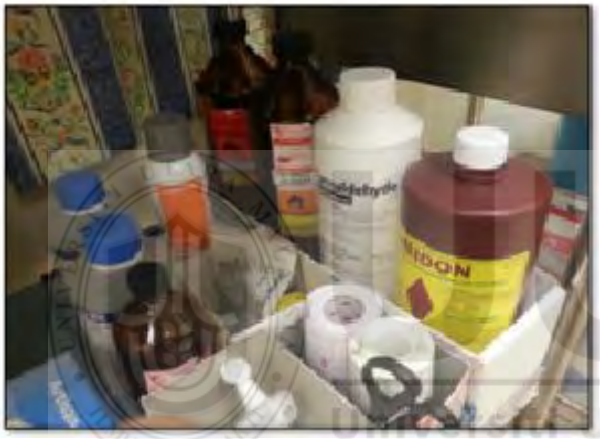

Photo 2
TVOC sources in indoors

Photo 3
MVAC and the log book for maintenance activities

APPENDIX C- (CONTINUED)

Photo 4
Fresh air dampers in the AHU room were closed

Photo 5
Example of IAQ equipment and its sampling location