# DETERMINING SIGNIFICANT PARAMETERS ON HEALTH AND WELL-BEING OF BUILDING OCCUPANTS TOWARDS RE-ENGINEERED INCLUSIVE ENVIRONMENT

S. N. Kamaruzzaman[1], A. Razali[2], E. M. Ahmad Zawawi[3], M. L., Riley[4]
[1, 2]*Department of Building Surveying, Faculty of Built Environment, University of Malaya, Kuala Lumpur, Malaysia*
[3]*Faculty of Architecture, Planning & Surveying, University Technology MARA, Shah Alam, Selangor, Malaysia*
[4]*School of Built Environment, Liverpool John Moores University, Liverpool, United Kingdom.*
Corresponding author: syahrulnizam@um.edu.my

## ABSTRACT
People spend over 90% of their time in the buildings. A building is a place where people are spending more time doing activities, thus an inclusive environment of the buildings is very important to ensure that people are having a healthy life. An inclusive environment is important for the well-being of building occupants. Indoor environmental quality is one of the essential elements in creating an inclusive environment in which a poor quality of indoor environment affects the health of the occupants both physically and mentally, their performance, productivity, comfort, satisfaction, and well-being. Even though people are towards creating an inclusive environment but it is a limited study on the parameters of the inclusive environment. Thus, this paper is to study the parameters of the inclusive environment by focused on the element of the indoor environmental quality for building occupants based on literature reviews of articles between the year 2006 and 2016. Based on the content analysis, it has been discovered that there are various parameters of an inclusive environment which are visual comfort, thermal comfort, acoustic comfort, indoor air quality, buildings factors, occupants' factors, and climate condition factors. The parameters can be very useful as guidelines and development of policy in providing inclusive environment for the healthy lifestyle of building occupants.

**Keywords**: Indoor environmental quality, Inclusive environment, Building, Occupant.

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## INTRODUCTION
People are spending 90% of their activities in the buildings (Vardoulakis et al., 2015; Frontczak and Wargocki, 2011). Thus, a good condition and living environment of the building is very important as to ensure people are having a healthy life. Nowadays, people lifestyles are towards creating an inclusive environment for their healthy life. An inclusive environment is a place provides a well-being and healthy place for human being. An inclusive environment is a new growing research topic and the study is still lacking particularly on the parameters required to create an inclusive environment. Even though previous researchers such as Goodman and Burton, (2010) and Oyelola, (2014) have studied on the inclusive environment, but they did not study the parameters that need to take into account in creating an inclusive environment. Thus, this paper is the initial start to study the parameters of the inclusive environment for the building occupants in the scope of indoor environmental quality (IEQ).

Langer et al., (2016) agreed that the quality of life determined by the quality of the indoor environment. Therefore, an inclusive environment can be created by having a good quality of indoor environment. Having a good quality of indoor environment is very important because a poor quality of indoor environment will lead to a various risk of health problems (Carlucci et al., 2015; Abdul-Wahab et al., 2015) both in short and long-term (Vardoulakis et al., 2015; Al Horr et al., 2016). Poor quality of indoor environment not only harmful occupants but it gives bad impact on the occupant's performance, productivity, and physical and mental health development (IOM, 2011).

An inclusive environment can be created by having a good IEQ and whatever influence the IEQ will also influence the inclusive environment. Thus, in order to develop parameters of the inclusive environment is by studying the factors that influence the IEQ. Therefore, this paper will develop parameters of the inclusive environment by exploring the factors that influence the IEQ.

## METHODS
The rationale of this literature review was to document the state of the art literature and analyze the key elements regarding the inclusive environment. The comprehensive literature reviews were conducted covering several sources between the year 2006-2016 such as refereed journal articles, books, the internet, conference proceedings and some reports available on the internet and books.

Figure 1 shows the distribution of the sources of the research papers. Overall are 33 numbers of reviewed from several sources and the most sources reviewed are from journal articles (22) and the rest are reports (4), articles (4), books (2) and conference paper (1).

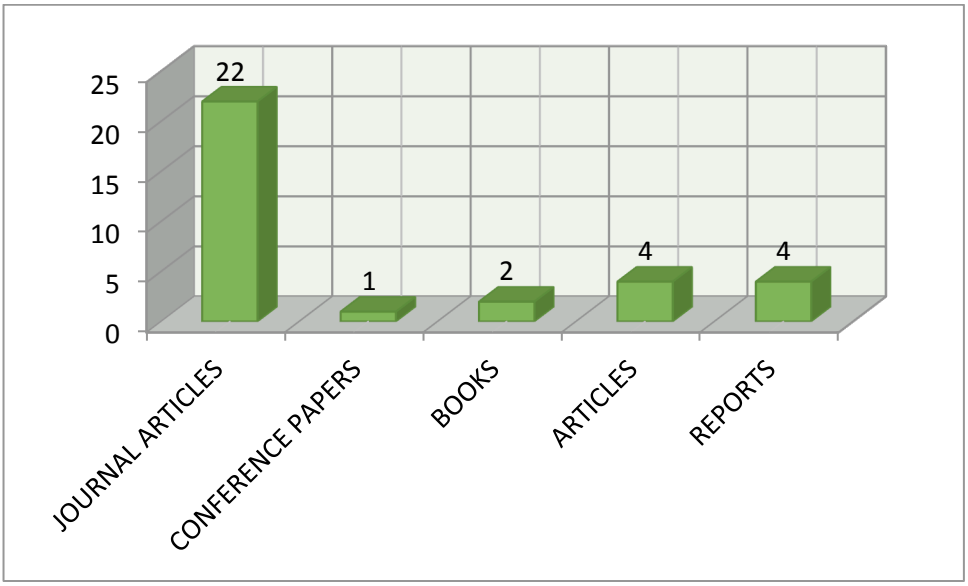


Figure 1: Sources of the paper

The major databases such as Google Scholar, Research Gates and Science Direct engines were used to search for the literature reviews within the keywords: *occupant well-being, building, indoor environmental quality, occupants' health*, *inclusive environment.*

The data collected are analyzed by using content analysis as the nature of this study is to generate generable conclusions from written text (Neuendorf, 2002). The procedure of content analysis of this research followed the procedure that is suggested by Gillham (2008) which is producing analysis grid in the form of tabulation as Table 1.

## PARAMETERS OF INCLUSIVE ENVIRONMENT

The main aspects that influenced the IEQ are; thermal comfort, indoor air quality (IAQ), acoustic comfort and visual comfort (Sarbu and Sebarchievici, 2013). Others related factors that influenced the IEQ are building-related factors (Turunen et al., 2014) occupants' factors, and climate condition factors (Frontczak and Wargocki, 2011). Therefore, parameters of the inclusive environment are the visual comfort, acoustic comfort, thermal comfort, indoor air quality, building factors, occupant factors, and climate factors that will be discussed in respective section. Table 1 shows the summary of the parameters for creating an inclusive environment.

### Visual Comfort

Visual comfort is one of the aspects influenced the quality of the indoor environment in buildings. Inadequate design of visual of the building affect the occupants in terms of well-being, health, performance, comfort, productivity, and satisfaction of the building occupants (Nimlyat and Kandar, 2015; Kamaruzzaman et al., 2011; Al Horr et al., 2016; Martellotta et al., 2016; Lee et al., 2011; Frontczak and Wargocki, 2011; Lai et al., 2009). By referring to Table 1, there are several factors need to be considered in designing a comfort visual of buildings. The factors of visual comfort in creating an inclusive environment of buildings are the amount of light, glare, the uniformity of light and the rendering quality of light (Carlucci et al., 2015; Nimlyat and Kandar, 2015; Martellotta et al., 2016; Kamaruzzaman et al., 2011; Frontczak and Wargocki, 2011; Al Horr et al., 2016; Lai et al., 2009; Lee et al., 2011).

Carlucci et al., (2015), mentioned that the amount of light is one of the important roles of visual factors in which insufficient light affects the ability of occupants to see objects. According to Carlucci et al., (2015), one of the phenomenon due to inadequate design of visual of buildings is "glare". Glare is a condition where the occupants feeling difficulty to see objects due to excessive bright from artificial or natural light. Due to glare, the human eye adapted to receive a wide range of luminance and cause to disability glare, which then led the human feeling annoyance, discomfort, immediately reduced of visual performance and inability to see objects.

There are two sources of light, artificial light and natural light in which, artificial light refers to electric light and natural light is daylight (Carlucci et al., 2015). According to Lee et al., (2011) daylighting influenced the visual comfort of occupants in terms of their psychological health. Daylighting provides a natural view and with senses of openness in the residential space, it considers as therapeutics to occupants (Al Horr et al., 2016).

Another aspect of visual comfort is colour rendering. According to Lai et al., (2009) mentioned that illuminance level and colour rendering level is the component of quality of lights that need to take into consideration of visual comfort in designing indoor lighting. The light quality contributes to the quantity of colour spectrum to reach the comfort and satisfaction level of visual. Too high or too low level of light discomfort the visual of occupants. The quality of rendering colour can be improved by the natural lighting.

Uniformity of light is the even light spread over task area is also need to be highlighted in creating an inclusive environment for the well-being of building occupants. According to Carlucci et al., (2015) unevenly light spreads over a task area lead to visual stress due to frequent open-closed eyelids for focusing on objects.

Thus, visual comfort is considered a parameter in order to create an inclusive environment for the comfort of the building occupants and there are several factors of visual comfort need to be fulfilled such as the amount of light, glare, the uniformity of light and the rendering quality of light.

Table 1 Parameter of Inclusive Environment for Building Occupants

| PARAMETER | ELEMENT | BREAKDOWN OF ELEMENT | IMPACT ON HEALTH | REFERENCES |
|---|---|---|---|---|
| Visual Comfort | -the amount of light<br>-glare<br>-the uniformity of light<br>-the rendering quality of light | -daylight<br>-electric light(artificial light)<br>-sight, and view<br>-illumination level,<br>-colours effect<br>-attractiveness<br>-outward appearance | -annoyance,<br>-the loss in visual performance and visibility<br>-premature tiring of eyes,<br>-headache<br>-photophobic response | Carlucci et al., (2015); Nimlyat and Kandar, (2015); Martellotta et al., (2016); Kamaruzzaman et al., (2011); Frontczak and Wargocki, (2011); Al Horr et al (2016); Lai et al (2009); Lee et al (2011) |
| Thermal Comfort | -Temperature<br>-Relative humidity,<br>-Air movement<br>-ventilation systems,<br>-air permeability | -mean radiant temperature<br>-Indoor temperature,<br>-control environment performance<br>-air velocity<br>-air exchange<br>-ventilation rate<br>-air moisture content | -Sick Building Syndrome (SBS),<br>-respiratory problems,<br>-bronchitis,<br>-airborne infections,<br>-draught, cold/warm feet, legs, torso, heads, arms, and hands.<br>-increase the number of death,<br>-decreased the ability to concentrate,<br>-fever over 37°C,<br>-wheezing | Abdul-Wahab et al., (2015); Nimlyat and Kandar, (2015); Sarbu and Sebarchievici, (2013); Martellotta et al., (2016); Vardoulakis et al., (2015); Turunen et al., (2014); Pekkonen et al., (2015); Frontczak and Wargocki, (2011); Al Horr et al (2016); Lai et al (2009); Lee et al (2011) |
| Acoustic Comfort | -noise level,<br>-sound privacy, | -outdoor noise (road traffic, aircraft, railway, construction work, commercial, above apartment, within apartment),<br>-housing crowding<br>-sound pressure level,<br>-indoor noise | annoyance (feeling being bothered: a headache, fatigue, irritability),<br>-sleep disturbance,<br>-psychological stress,<br>-mental health,<br>-adverse pathophysiological effects,<br>-myocardial infarction (cardiovascular disease) | Nimlyat and Kandar, (2015); Martellotta et al., (2016); Turunen et al., (2014); Kamaruzzaman et al., (2011); Onakpoya et al., (2015); Willich et al., (2006); Frontczak and Wargocki, (2011); Al Horr et al (2016); Lai et al (2009); Lee et al (2011); Nakazato and Fujihara (2015) |
| Indoor air quality (IAQ) | -Particulate matters<br>-total volatile organic compound (TVOCs)<br>-ventilation<br>-relative humidity (RH) | -$PM_{2.5}$ and $PM_{10}$<br>nitrogen dioxide ($NO_2$),<br>Carbon dioxide ($CO_2$),<br>carbon monoxide (CO),<br>sulfur dioxide ($SO_2$),<br>formaldehyde (HCHO), benzene and other aromatic hydrocarbons (building materials, furniture, paints, consumer products tobacco smoke)<br>-(3 compounds group:- 1,4-dichlorobenzene, 1-methoxy-2-propanol, 2-butoxyethanol),<br>-four aldehydes, (formaldehyde with hexane, acetaldehyde with acrolein, tetrachloroethylene with trichloroethylene, decane with undecane, all monoaromatic: BTEX, 1,2,4-trimethylbenzene and styrene)<br>-air exchange,<br>-cleanliness, smell/odorant, dust or dirtiness, | -Sick Building Syndrome (SBS),<br>-drowsiness,<br>-shortness of breath,<br>-fatigue,<br>-death if concentration are high,<br>-cancer if concentration are high, (lung cancer)<br>-respiratory infections, illness and diseases, (cough, asthma)<br>-pulmonary and cardiovascular diseases, (heart attack, stroke)<br>-dizziness,<br>-psychic emotion,<br>-airborne infectious disease,<br>-domestic injuries and poisoning,<br>-long-lasting neurological effects.<br>-allergic reactions, (vomiting, diarrhea) | Abdul-Wahab et al., (2015); Nimlyat and Kandar, (2015); Sarbu and Sebarchievici, (2013); Martellotta et al., (2016); Vardoulakis et al., (2015); Nurhidayah et al., (2013); Langer et al., (2016); Turunen et al., (2014); Kamaruzzaman et al., (2011); Persily, (2015); Pekkonen et al., (2015); Jarnstrom et al., (2006); Frontczak and Wargocki, (2011); Al Horr et al (2016); Lai et al (2009); Lee et al (2011); Lai et al., (2004); Wolkoff and Kjaergaard (2007); |

| | | | | |
|---|---|---|---|---|
| | | -indoor sources of pollutants (gas cookers, stoves, fireplaces, building and furnishing materials), indoor combustion,<br>-moulds, bacteria, allergens, | | |
| Building factors | -building characteristics/design<br>-types of building<br>-location of the building, | -design or technical flaw in the building system,<br>-building envelope,<br>-space of the housing,<br>-housing size (room per person),<br>-housing condition (age of house), -basic amenities (shower),<br>-room interior,<br>-control over the environment),<br>-acoustics materials properties,<br>-sound insulation, and absorption<br>-(a single housing, multiple housing),<br>-orientation and direction of the building | similar with the abovementioned impact on human health | (Martellotta et al., 2016) (Vardoulakis et al., 2015); Lai et al (2009); Lee et al (2011); Al Horr et al., (2016); Frontczak and Wargocki (2011) |
| Occupant factors | -activities<br>-lifestyle<br>- gender<br>-age<br>-country origin<br>-behaviour | -human thermoregulation,<br>-selection of garment,<br>-job typology,<br>-economic status,<br>-adaptive behaviour,<br>-cooking activities<br>-cleaning activities<br>-knowledge/education<br>-male/female | similar with the abovementioned impact on human health | (Sarbu and Sebarchievici, 2013) (Martellotta et al., 2016) (Vardoulakis et al., 2015); Lai et al (2009); Norhidayah et al., (2013); Frontczak and Wargocki (2011) |
| Climate Condition Factors | -extreme temperature<br>-higher sea levels<br>-drought<br>-wildfires<br>-ozone level increased<br>-increased pollen levels<br>-changes geographic ranges of pests<br>-extreme weather | -increased energy consumption (changes in loads of HVAC system)<br>-damage of building materials<br>-flooding and water damage<br>-increased airborne particulates<br>-increased release of pollutants<br>-changes allergen levels<br>-greater use of pesticides<br>-power interruption and loss of mechanical ventilation system | -decreased productivity<br>-infectious respiratory disease transmission<br>-exposure to chemical emissions from damaged materials<br>-water and vector borne diseases<br>-dampness, mould symptoms/illness<br>-physical and psychologic stress<br>-allergen-mediated distress and illness<br>-distress and illness from pesticides exposures<br>-exposure to excessive heat/cold and CO | (IOM, 2011); (Martellotta et al., 2016) (Vardoulakis et al., 2015) |

**Thermal Comfort**

Thermal is another factor that needs to be considered in creating an inclusive environment of buildings. Thermal factors should be considered during the design stage of the buildings (Al Horr et al., 2016) because without considering thermal in designing building will lead to dissatisfaction, discomfort and bad impact on health condition of occupants and more energy intake of the buildings (Martellotta et al., 2016; Al Horr et al., (2016; Nimlyat and Kandar 2015). Thermal factor need to be considered in creating inclusive environment because poor thermal indoor environment leads to various of potential health risks of occupants such as Sick Building Syndrome (SBS) symptoms, respiratory problems, bronchitis, airborne infections, draught, decreased the ability to concentrate, ocular, fever over 37°C, and wheezing. Table 1 shows that there are several elements need to be highlighted in producing thermal comfort of building such as temperature, relative humidity, air movement or air velocity, and ventilation systems (Abdul-Wahab et al., 2015; Nimlyat and Kandar, 2015; Sarbu and Sebarchievici, 2013; Martellotta et al., 2016; Vardoulakis et al., 2015; Turunen et al., 2014; Pekkonen et al., 2015; Frontczak and Wargocki, 2011; Al Horr et al., 2016; Lai et al., 2009; Lee et al., 2011).

Turunen et al., (2014), indicated that ventilation rate plays important roles in thermal conditions. This is to avoid the temperature tend to too high or too low that exposed to symptoms such as fatigue, headache, dry or sore throat symptoms, fever over 37°C, nasal, wheezing, cough with wheezing and difficulties in concentration.

Relative humidity (RH) and air movements are the two thermal factors affecting the comfort level of occupants and excessive thermal exposed them to SBS symptoms such as coughing, sneezing, eye irritation, lethargy, congestion skin irritation, headache, dizziness, and nausea (Abdul-Wahab et al., 2015). Levels of humidity may affect the occupant in which, low levels of humidity decrease of mucus and leads to drying of the eyes and nose and cause irritations. However, if a high level of humidity allows to transfer airborne with dust particles and affect the respiratory systems of human and worse diseases such as bronchitis (Abdul-Wahab et a;., 2015). High levels of humidity also can cause moulds and microbes growth and increase the level of chances pollutants emission from the building materials (Abdul-Wahab et al., 2015).

Air movement or air velocity is another factor of thermal comfort in IEQ that have indirect impact on the occupant health condition in which high velocity of air also contribute to drying of skin (Abdul-Wahab et al., 2015) including draught, cold of feet, torso, head, arms and hands (Martellotta et al., (2016).

Therefore, thermal comfort is another parameter in providing an inclusive environment for the comfort of building occupants and the factors influenced the thermal comfort are temperature, ventilation systems, air velocity and RH.

**Acoustic Comfort**

Acoustic is another factor plays an important role in creating an inclusive environment of a building. Table 1 show there are two elements of acoustic comfort factors which are noise level and sound privacy (Nimlyat and Kandar, 2015; Martellotta et al., 2016; Turunen et al., 2014; Kamaruzzaman et al., 2011; Onakpoya et al., 2015; Willich et al., 2006; Frontczak and Wargocki, 2011; Al Horr et al., 2016; Lai et al., 2009; Lee et al., 2011; Nakazato and Fujihara, 2015). The acoustic comfort is very crucial factor in creating inclusive environment because poor acoustic environment can lead to short and long-term effects on the health of occupants and contribute to a few potential health risks of mentally and physically such as annoyance (feeling being bothered: a headache, fatigue, irritability), sleep disturbance, psychological stress, adverse pathophysiological effects, and myocardial infarction (cardiovascular disease) (Al Horr et al., 2016; Willich et al., 2006; Onakpoya et al., 2015).

According to Al Horr et al., (2016), acoustics comfort is to create a good acoustic environment and protect the occupants from noise with the aim to provide a private space. Lee et al., (2011), mentioned that the noise emanates from indoor and outdoor such as airborne sounds, outdoor noise, noise from adjacent spaces, noise from equipment, the sound of nearby facilities, people talking, telephones ringing and any irregular sounds. Those sources may cause annoyance and disturbance to the building occupants (Al Horr et al., 2016). Willich et al., (2006) mentioned that noise burden harmful to the occupants in which it affects pathophysiological and cardiovascular systems. A chronic noise diurnal may cause myocardial infarction, hypertension and coronary heart diseases (Willich et al., 2006). Onakpoya et al., (2015) reported that a poor acoustic environment of occupants leads to the reduction in quality of their life. Onakpoya et al., (2015) further mentioned that the occupants living in a poor acoustic environment experienced sleep disturbance and annoyance and annoyance usually associated with others symptoms such as a headache, fatigue, and irritability.

Nimlyat and Kandar (2015) mentioned that sound privacy is another factor in creating a good acoustic environment. The factors that need to be highlighted in providing sound privacy are the types

of the buildings, the function of the room and the distance of the location of the building from the source of noise (Willich et al., 2006; Onakpoya et al., 2015). Those factors are important in providing sound privacy since Lai et al., (2009) indicated that any distracting, annoying or harmful sounds are considered noises and the aural comfort depends on the noise pressure level that occupants can tolerate with. Moreover, Nakazato and Fujihara (2015) mentioned that occupants in multi-unit housing are exposed more to negative impacts of noise. This is due to the nature of the housing that cannot control social interaction with other residents, housing crowding that provides less privacy due to various noises and lack of private communications, and noises from the upper unit housing.

From the above discussion, instead of visual and thermal comfort, acoustic comfort also is a parameter that needs to be included in creating an inclusive environment for the comfort of building occupants. Acoustic comfort is to provide privacy and to control noise burden to building occupants. In order to provide a good acoustic environment, several factors need to be considered such as the types of the buildings, the functions of the space, the distance of the buildings from the sources of noise and the types of building materials used.

**Indoor Air Quality**

Others than thermal, visual and acoustic factors, indoor air quality (IAQ) is another factor need to be included in creating an inclusive environment for building occupants. According to Al Horr et al., (2016) poor quality of indoor air leads the occupants to exposure with SBS and building related illness (BRI). According to Al Horr et al., (2016), common symptoms of SBS are irritation of the eyes, nose, and throat, headache, cough, wheezing, cognitive disturbances, depression, light sensitivity, gastrointestinal distress, and flu symptoms. Others potential health problems of building occupants due to poor IAQ are fatigue, death and cancer if concentration is high, respiratory infections, illness and diseases, chest pain, inability to breath, pulmonary and cardiovascular diseases, deep breathing, pulse, dizziness, psychic emotion, airborne infectious disease, domestic injuries and poisoning, nausea, long-lasting neurological effects, cough, and COPD, coronary artery diseases, stroke, allergic reactions, vomiting, and diarrhea.

Based on Table 1, the factors of IAQ are particulate matters (PM), Total Volatile Organic Compound (TVOCs), ventilation, and relative humidity (RH). Nimlayat and Kandar (2015), studied the ventilation as a factor influencing the quality of indoor air. The ventilation systems are to supply air exchange that can manage to control odours, freshness, humidity and thermal of the indoor environment. Therefore, in order to design ventilation system of the buildings, several factors need to be considered such as the location of the building whether it is located in urban areas or suburban areas. Urban areas have a higher temperature and a higher risk of air pollution compared to suburban areas, thus the design of ventilation system might be different. Ventilation systems are very important is having good IAQ because as indicated by Al Horr et al., (2016) that a poor ventilation system will expose the occupant to moulds, dust, mite, allergens, indoor aldehydes, volatile organic compounds (VOC), airborne fungi, pesticides, tobacco smoke, lighting, air exchange or circulation rates, carbon monoxide (CO), and carbon dioxide ($CO_2$). An example of the inadequate ventilation system is the reduction of ventilation rates in a tightly sealed building, the use of synthetic materials, furnishing and chemical formulated personal will put occupant at higher risk being polluted.

Furthermore, others factors influenced the IAQ as studied by Lai et al., (2004), are the concentration of microenvironments such as Particulate Matter ($PM_{2.5}$), Volatile Organic Compounds (VOC), Nitrogen Dioxide ($NO_2$), and Carbon Monoxide (CO). $PM_{2.5}$, VOC, $NO_2$, and CO are the agent of multiple air pollutants and dangerous exposure to building occupants. Lai et al., (2004) categorized $PM_{2.5}$ for 37 elements such as silver, aluminium, arsenic, barium and etc., and Total Volatile Organic Compounds (TVOCs) categorized into various compounds such as alkanes (hexane, nonane, decane etc.), aromatics (benzene, ethylbenzene, etc.), alcohols (1-butanol, 2-methyl-1-propanol etc.), esters (2-butoxyethanol), alkanes (hexane, benzaldehyde etc.), halogenated (1,1,2-trichloroethane, trichloroethene etc.), and miscellaneous (alpha-pinene, d-limonene etc.). According to Lai et al., (2009), the agent of indoor air pollutants that need to be monitored is the levels of carbon dioxide ($CO_2$) because of high concentration of $CO_2$ consequence to death.

Norhidayah et al., (2013), relates that the poor quality of indoor air due to combustion of fuels, emission of toxic gas from construction materials and indoor equipment. According to Norhidayah et al., (2013), various characteristics need to be considered in providing a good quality of indoor air such as adequate ventilation air, control of airborne contaminant, maintenance of acceptable temperature and RH. Norhidayah et al., (2013) also relates the poor of indoor air with the SBS symptoms such as itchy eyes, skin rashes, nasal allergy symptoms, fatigue, aches and pains, sensitivity to odour, difficulty in concentration, unusual tiredness, drowsiness, dizziness, asthma (wheezing), dry and sore

throat, difficulty to breath, stuffy nose, runny nose, sinus congestion, sneeze, cough, tension, nausea, upset stomach, and feeling depressed.

Another factor of IAQ, according to Wolkoff and Kjaergaard, (2007) is RH. Wolkoff and Kjaergaard (2007) studied indoor air quality from the factors of low RH (dry air) and high RH. According to Wolkoff and Kjaergaard (2007), low RH cause to dry air and associated with mucous membrane irritation of eyes, upper airways, and SBS symptoms. Wolkoff and Kjaergaard (2007) stated that low RH contribute to thinner the precorneal tear film (PTF) of human eyes and let human blink their eyes frequently (reduction of interblink duration) and cause discomfort and sensory of irritation. Many factors contribute to low RH in the indoor air such as the present of VOCs and formaldehyde (HCHO) (from building materials, consumer products), ozone and $NO_2$, particles, and Visual Display Unit (VDU). The effect of low RH due to VDU hours can cause people to loss of visual acuity, musculoskeletal tiredness and overloading the eye (asthenopia). However, excessive high RH also impact the health of occupants (Wolkoff and Kjaergaard, 2007) such as increased risk of dust and mite proliferation due to dampness and exposed to the dampness-related syndrome.

Vardoulakies et al., (2015), indicated that there are several internal factors affecting the indoor air quality such as the physical and chemical properties of pollutants (gaseous or particulate, reactivity, deposition) that emanate from gas cooker, stoves, fireplaces, building and furnishing materials, and ventilation. According to Vardoulakies et al., (2015), combustion products contribute to air pollutants such as $NO_2$ and CO. $NO_2$ harmful the occupants such as asthma, respiratory infects whereas CO can cause poisoning to occupants, headache, dizziness, nausea, coma and death, and long-lasting neurological effects. Particulate matter exposure to occupant can cause to cardiovascular and respiratory illness (wheezing, cough, asthma, Chronic Obstructive Pulmonary Diseases (COPD), lung cancer, stroke, irritation of the eyes, and upper airways. The health effects due to VOCs include irritation to the eyes, nose, headaches, dizziness, nausea, and allergic reactions, wheezing, vomiting, and diarrhea.Vardoulakis et al., (2015), mentioned that quality of indoor air also ruined due to indoor allergens and infections such as dust, mites, damp and mould, pets, pests, and insects. Mould and bacteria are microbial contaminants can affect the human health such as lethargy (allergic), hypersensitivity reactions, exposure to toxins and infections.

Abdul-Wahab et al., (2015), mentioned that human exposure to indoor air pollutants has potential health risks. The weakening of IAQ is $CO_2$, CO, HCHO, $NO_2$, Sulphide Dioxide ($SO_2$), TVOCs, $PM_{2.5}$, and $PM_{10}$ (Abdul-Wahab et al., 2015). Effect of CO is reducing the ability of oxygen-carrying capacity of red blood cells and creating carboxyhemoglobin and this exposed occupant to a range of symptoms such as nausea and fatigue, and death. Formaldehyde (HCHO) emanates from constituents adhesive used in particle boards, carpeting and furniture and HCHO is a carcinogen that can cause cancer of the nasal cavity of occupants and irritations symptoms such as the temporary burning of the eyes or nose and sore throat. Langer et al.,(2016) studied IAQ with several factors such as 18 organic compounds (14 VOCs, 4 aldehydes), $CO_2$, $PM_{2.5}$ and $PM_{10}$ related to ventilation rates. Sarbu and Sebarchievici (2013) studied IAQ factor on odorants that depend on people's sensation. According to Langer et al., (2016) and Sarbu and Sebarchievici (2013), poor IAQ affects the health, comfort, and productivity of the occupants.

From the above discussions, IAQ is one of the parameters in creating an inclusive environment for the comfort of building occupants. IAQ is a crucial parameter in creating an inclusive environment and improper action taken will expose the occupants to the air pollutions. The factors that need to be considered for a good IAQ are Particulate Matters ($PM_{2.5}$ and $PM_{10}$), nitrogen dioxide ($NO_2$), Carbon dioxide ($CO_2$), carbon monoxide (CO), sulfur dioxide ($SO_2$), Total Volatile Organic Compound (TVOCs), ventilation, and relative humidity (RH).

**Building-Related Factors**

Based on Table 1, building-related factors are another parameter that needs to be looked at in creating an inclusive environment for the comfort of building occupants. Al Horr et al., (2016), Vardoulakis et al., (2015), Kamaruzzaman et al., (2011), and Frontczak and Wargocki (2011) mentioned that, in order to design a good quality of indoor environment of a building, several building-related factors should be considered at the initial stage of designing the building. According to Al Horr et al., (2016), in order to achieve the comfort level and healthy lifestyle of the occupants, the building design and characteristics are important to control the indoor factors such as in order to control the quality of indoor air is to design the appropriates ventilation of the buildings.

As mentioned by Al Horr et al., (2016), indoor air quality can be improved by increasing the ventilation rates. However, in designing the ventilation of the building, pollutants factors should be taken into account. Ventilation can be provided in natural ways or use mechanical ventilation systems. However, in order to implement mechanical ventilation system, sustainability of the building need to

consider such as in terms of the energy intake and health of the building occupants as indicated by Al Horr et al., (2016) that mechanical ventilation systems exposed occupants to fewer SBS symptoms. In order to design natural ventilation, factors such as pollutants from outdoor also need to be looked for particularly in urban areas that have a high density of transportations. The inappropriate design of natural and mechanical ventilation exposed the occupant to moulds, dust, mite, allergens, air pollutants and these consequences to several diseases and symptoms such as asthma, allergic, irritation symptoms, SBS symptoms and hypersensitivity pneumonitis (Al Horr et al., 2016). Design ventilation system of the building not only refers to the good quality of indoor air but it covers visual, acoustic and thermal comfort factors (Al Horr et al., 2016). Al Horr et al., (2016) mentioned that criteria of the ventilation (opening) of buildings affect the type of view, quality of view and social density of occupant. Thus the opening such as the pattern of windows (geometry), surface, the amount of glazing all has an impact to supply for illuminance levels in occupants. Thus the architectural design of indoor lighting design such as opening (daylighting), artificial lighting (electric lights) and rendering quality of light are the factors influenced the quality of the indoor environment of buildings.

Vardoulakis et al., (2015), mentioned that location of buildings and building characteristics is related to the quality of indoor environment. The location mentioned by Vardoulakis et al., (2015) referred to urban areas or countryside in which urban areas means to a higher temperature compared to the countryside. Vardoulakis et al., (2015) stated that type of building such as highrise building, the location refers to floor level and orientation of the building for shading purposes. Types of building such as flat and semi-detached also differ in thermal condition, in which flats exposure to higher temperature compare to semi-detached houses. The location of building considers as a factor related to IEQ because the location differs in affecting the IEQ. For instance, in order to control the usage of daylighting and acoustic adaptation, the design of building might vary due to the location of the building (Vardoulakis et al., 2016; Frontczak and Wargocki, 2011). Vardoulakis et al., (2015) further detailed that characteristics of the building also give impact to human health if avoiding some factors during designing stage of the buildings. The building characteristics include the building envelope, the built form, and ventilation strategy. The built form and building envelope referring to the levels of air permeability of the building. Air permeability or airtightness of the building influenced by factors such as the age of the building, type of wall and floor, and the types of construction materials used. Buildings built from timber less airtightness compared to the concrete panel. Heavy construction materials such as concrete and stone influenced the thermal condition of the building.

According to Turunen et al., (2014), building age and construction materials are the building-related factors of IEQ. Old and aging buildings, their designed and construction materials used might be different such as old building relied more on natural ventilation rather than mechanical system ventilation. Lee et al., (2011), mentioned that the building characteristics and design influenced the IEQ, this is to balance the design and providing the adequate natural ventilation and mechanical ventilation. Design ventilation of buildings covers the factors of indoor air quality, visual comfort, thermal comfort and acoustic comfort.

Willich et al., (2006), and Onakpoya et al., (2015) mentioned on the location of the building that located near to industrial area. The design of acoustic environment of building nearest to the industrial area might be different to avoid exposure of noise burden to the occupant (Willich et al., 2006; Onakpoya et al., 2015). According to Frontczak and Wargocki (2011), the building-related factors need to consider in creating an inclusive environment of housing is the room interior, types of building, and control over the indoor environment.

Therefore, building-related factors are parameter of inclusive environment and the factors of building-related factors are building characteristics/design such as design or technical flaw in the building system, building envelope, space of the building, building size (room per person), building condition (age of house), basic amenities (shower), room interior, control over the environment), acoustics materials properties, sound insulation, and absorption, types of building (a single housing, multiple housing), location of the building, orientation and direction of the building. Without considering the building design, types or purposes of the building and location and orientation of the building will ruin the visual, thermal and acoustic comfort and quality of indoor air.

**Occupant factors**

The inclusive environment of a building influenced not only due to building-related factors but also depends on the occupants' factors (Martellotta et al., 2016; Vardoulakies et al., 2015). Based on Table 1, the influenced of occupants factors that need to be highlighted in creating inclusive environment are activities, age, gender, country origin, behaviour, lifestyles, knowledge and education (Frontczak and Wagocki, 2011; Vadoulakis et al., 2015).

Vardoulakis et al., (2015) mentioned that occupant' factors such as behaviour and activities are important in order to achieve the comfort level of occupants within a good quality of indoor environment. The study on occupants' factors is essential because it allowed some ideas in controlling the indoor environment of buildings (Frontczak and Wargocki, 2011). According to Frontczak and Wargocki (2011), the factors of occupants that need to be considered are gender, age and country origin of the occupants as to get a comfortable indoor environment suite with occupants' activities and types of their clothing. Lai et al., (2009) mentioned that occupant factors need to consider are their metabolic rate and clothing value in order to design appropriate air temperature, relative humidity, air velocity and mean radiant temperature. Vardoulakis et al., (2015) mentioned that occupant behaviour including opening windows, shading tools and using cooling systems and their behaviour reflected with socio-economic status, age, and personal knowledge and preferences. The occupant's behaviour spontaneously due to heat and some control on altering the indoor temperature is beneficial to achieve occupants comfort (Vadoulakis et al., 2015).

However, in certain circumstances, occupants' factors contribute to weakening the quality of the indoor environment as according to Lai et al., (2004) occupant behaviour such as smoking tobacco leads occupants to high exposure of $PM_{2.5}$, TVOC, CO and $NO_2$ including cooking and various activities. Norhidayah et al., (2013), mentioned the occupants' activities such as combustion of fuels for cooking contribute to weak of the indoor air quality. According to IOM (2011), occupants' activities such as choice of types of furnishings, decorative materials, cleaning products, appliances, and equipment that can emit particles and gasses into the interior of buildings influenced ventilation and hence contaminant concentrations and moisture in the indoor environment.

Thus, occupants' factors such as occupants' activities, behaviour/lifestyle, knowledge, age, gender, and country origin are the parameter of the inclusive environment. The occupants' factors need to be highlighted in creating an inclusive environment is purposely to design adequately of control indoor environment system of the buildings (thermal sensation and lighting), the application of suitable construction materials and the building characteristics.

**Climate Conditions Factors**

Institute of Medicine (IOM, 2011) has addressed that climate change affects the indoor environment quality and health of the building occupants. Thus, climate condition also is considered as one of the parameters in creating an inclusive environment for the comfort of building occupants. Figure 2 illustrates the effects of climate change on the indoor environment and health of building occupants by six potential consequences of climate change.

The first potential consequence of climate change is leading to an extreme temperature in the building which consumes heavy loads in using heating, ventilation and air condition (HVAC) systems which potentially give impact to respiratory systems of building occupant. Occupants may get respiratory illness and infections.

The second potential consequence of climate change is leading to increasing the sea levels. The increasing of the sea levels will damage the building materials due to flooding and water damage and will lead the building occupant exposed to chemical emissions and flooding lead to dampness and mould symptoms and physical and psychological stress.

The third potential consequence of climate change such as drought, wildfires, and changes in irrigation practices will affect the indoor environment in terms of increase in number the airborne particulate and potential of respiratory distress and illness on the building occupants.

The fourth potential consequence of climate change is increased the outdoor ozone levels. Increased the outdoor ozone levels leads to increase indoor ozone layers and this exposed the building occupants to a chemical which harmful to respiratory systems of building occupants.

The fifth potential consequence of climate change is increased pollen levels and changes in geographic ranges of pests. This phenomenon modifies indoor allergens levels and consumes more usage of pesticides as consequences building occupants exposed to allergen-mediated distress and illness.

The last potential consequence of climate change is a frequent interruption of power supply due to excessive weather condition and leads to loss of mechanical systems and exposed building occupants to extreme hot and cold environment.

Therefore, climate condition factors are another parameter in creating an inclusive environment for the well-being of the building occupants. Climate condition factors are global factors that give impact on the thermal comfort, visual comfort and IAQ of the indoor environment. the common factors influenced by the climate factor that needs to be put concentration on are the ventilation systems in which ventilation plays multi-roles such as providing ambient temperature, balance RH, control air pollution as well as avoid the imbalance of electrical light and daylight.

## CONCLUSIONS

As a conclusion, there are seven parameters of the inclusive environment for the healthy lifestyle of the building occupants. The parameters of the inclusive environment are visual comfort factors, acoustic comfort factors, thermal comfort factors, indoor air quality factors, occupants' factors, building-related factors, and climate condition factors. The most important factor that is covered by all of the parameters is the ventilation system. The ventilation system is the main factor of the seven parameters that need to have more concentration on. The parameters discovered can be as guidelines, indicators and strategies to create an inclusive environment in which the idea of an inclusive environment is to provide healthy lifestyles, satisfaction, comfort, well-being, good performance, and high productivity of the building occupants.

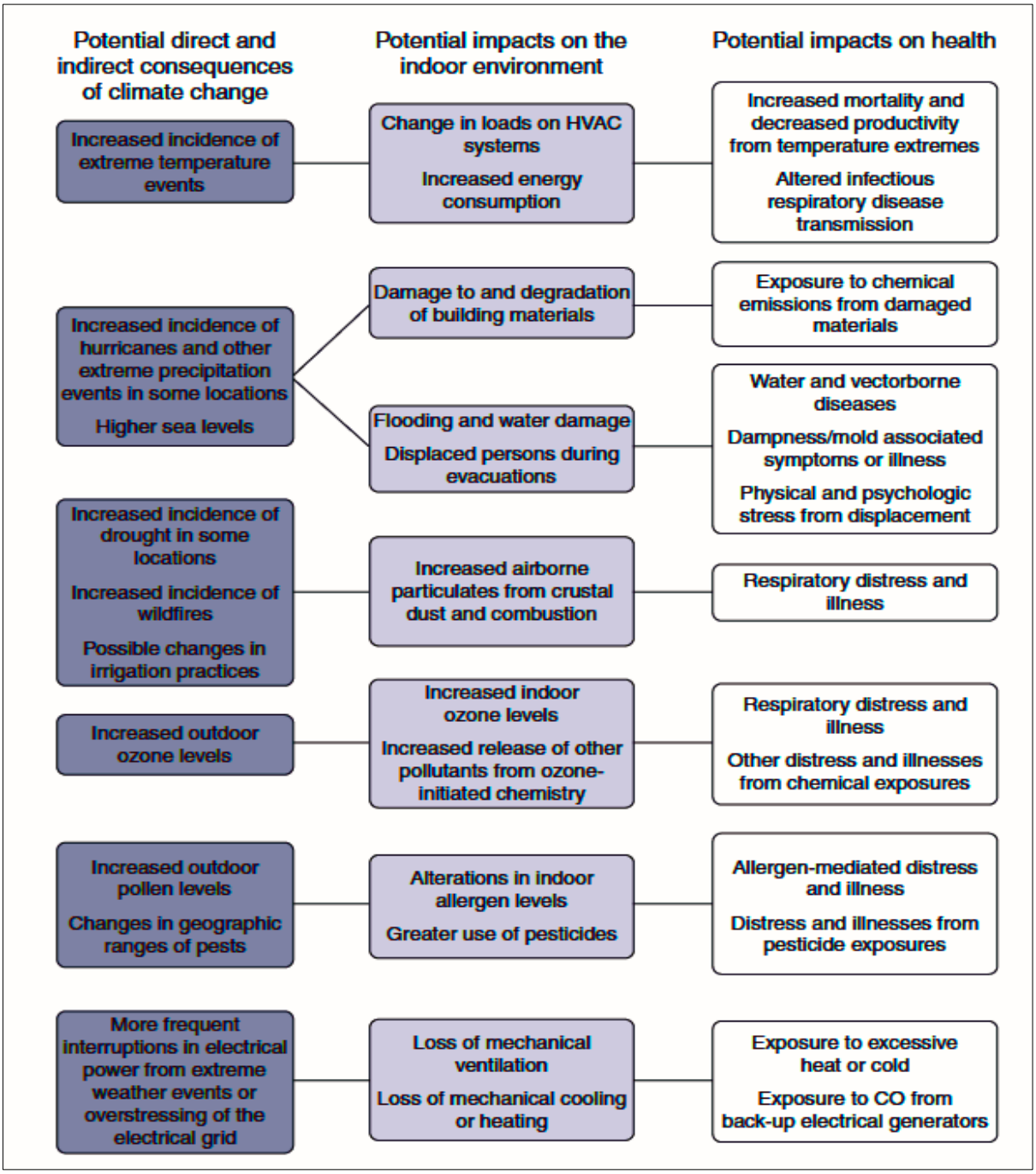


Figure 2 Possible pathways by which climate change could affect the indoor environment and health (IOM, 2011)

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