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Sick Building Syndrome: Are We Doing Enough?

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ABSTRACT
Health and wellbeing is a vitally important aspect of people centric building design and is the root of productivity. Sick building syndrome (SBS) is a collection of factors that can negatively affect physical health in several ways. Besides physical health is also related to psychological wellbeing because the human body is one interactive biological system. This paper focuses on reviewing the current state of knowledge on building sickness syndrome which has been prevalent as a building illness since the 1970s especially in offices and schools. While the concepts of intelligent, smart and sustainable buildings have gained considerable attention during recent decades, there is now increasing attention being given to designing healthy buildings.

Exposure of occupants to unhealthy indoor conditions increases their risk of illness and this influences their well-being. The prevalence of SBS can result in a wide array of concerns which affect the occupants' health and hence their work performance. This study endeavors to provide a holistic background knowledge about SBS symptoms. Several negative effects of SBS are identified and potential solutions are advocated. Finally, the study stresses the role of built environment and concludes that ongoing research towards tackling SBS and developing healthy indoor environments should not be limited to a single formula as any health-related building design approach is dependent on several interacting factors.

Keywords: *Healthy Buildings; Sick Building Syndrome (SBS); Indoor Environments; Well-being; Sustainability*

1. Introduction

Attitudes to well-being and healthy environments are beginning to change, both within the government and society, with a shift away from the idea that a flourishing life is primarily connected to material prosperity towards one that positions well-being as a significant goal for public policy (Barton, et.al, 2010; Barton, 2016; AlWaer and Illsley, 2017). This shift is being accompanied by a commitment to the design of healthy environments that would encourage productive workplaces, occupants' health and improvement of natural environments/ecosystems. Together, these changes provide opportunities to secure healthier lifestyles, sustain urban development, safeguard ecological-integrity, promote greater equity and support more resilient places in the low carbon future (Barton, et.al, 2010; AlWaer and Illsley, 2017).

Recently, development of greener and smarter buildings, through the application of innovative technologies, has seen growing interests. Future buildings, embracing intelligent, smart, green and responsive attributes, have become a common topic of various academic debates, research investigations and practical implementations related to the architecture, engineering and construction industry. Besides, recent studies have focused on the sustainable dimension of buildings, their embodied intelligence, and responsive potentials as well as their contribution to smart cities { ADDIN EN.CITE <EndNote><Cite><Author>Ahvenniemi</Author><Year>2017</Year><RecNum>98</RecNum><DisplayText>(Ahvenniemi, 2017)</DisplayText><record><rec-number>98</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479560417">98</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M</author></authors></contributors><titles><title>What are the differences between sustainable and smart cities?</title><secondary-title>Cities</secondary-title></titles><periodical><full-title>Cities</full-title></periodical><pages>234-245</pages><volume>60</volume><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>**}**; **{** ADDIN EN.CITE <EndNote><Cite><Author>Bibri</Author><Year>2016</Year><RecNum>101</RecNum><DisplayText>(Bibri, 2016)</DisplayText><record><rec-number>101</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479656869">101</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bibri, S. E., & Krogstie, J</author></authors></contributors><titles><title>On the Social Shaping Dimensions of Smart Sustainable Cities: A Study in Science, Technology, and Society</title><secondary-title>Sustainable Cities and Society</secondary-title></titles><periodical><full-title>Sustainable Cities and Society</full-title></periodical><volume>In Press</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**; **{** ADDIN EN.CITE <EndNote><Cite><Author>Martos</Author><Year>2016</Year><RecNum>100</RecNum><DisplayText>(Martos, 2016)</DisplayText><record><rec-number>100</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479562177">100</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Martos, A., Pacheco-Torres, R., Ordóñez, J., & Jadraque-Gago, E</author></authors></contributors><titles><title>Towards successful environmental performance of sustainable cities: Intervening sectors. A review</title><secondary-title>Renewable and Sustainable Energy Reviews</secondary-title></titles><periodical><full-title>Renewable and Sustainable Energy Reviews</full-title></periodical><pages>479-495</pages><volume>57</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**; **{** ADDIN EN.CITE <EndNote><Cite><Author>Yang</Author><Year>2016</Year><RecNum>99</RecNum><DisplayText>(Yang, 2016)</DisplayText><record><rec-number>99</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479561977">99</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Yang, B., Xu, T., & Shi, L</author></authors></contributors><titles><title>Analysis on sustainable urban development levels and trends in China's cities</title><secondary-title>Journal of Cleaner Production.</secondary-title></titles><periodical><full-title>Journal of Cleaner Production.</full-title></periodical><pages>868–880</pages><volume>141</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**; **{** ADDIN EN.CITE <EndNote><Cite><Author>Alalouch</Author><Year>(2016)</Year><RecNum>201</RecNum><DisplayText>(C. Alalouch, Saleh, M. S. E., & Al-Saadi, S, (2016))</DisplayText><record><rec-number>201</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509170276">201</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Alalouch, C., Saleh, M. S. E., & Al-Saadi, S</author></authors></contributors><titles><title>Energy-Efficient House in the GCC Region</title><secondary-title>Procedia-Social and Behavioral Sciences, </secondary-title></titles><periodical><full-title>Procedia-Social and Behavioral Sciences,</full-title></periodical><pages>736-743</pages><volume>216</volume><dates><year>(2016)</year></dates><urls></urls></record></Cite></EndNote>**}**. This study reviews the increasing attention to the impacts of buildings on health and well-being of occupants **{** ADDIN EN.CITE <EndNote><Cite><Author>Gens</Author><Year>2014</Year><RecNum>104</RecNum><DisplayText>(Gens, 2014; X. Li, Su, S., Zhang, Z., Kong, X, 2017)</DisplayText><record><rec-number>104</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479658048">104</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gens, A., Hurley, J. F., Tuomisto, J. T., & Friedrich, R.</author></authors></contributors><titles><title>Health impacts due to personal exposure to fine particles caused by insulation of residential buildings in Europe</title><secondary-title>Atmospheric Environment</secondary-title></titles><periodical><full-title>Atmospheric Environment</full-title></periodical><pages>213-221</pages><volume>84</volume><dates><year>2014</year></dates><urls></urls></record></Cite><Cite><Author>Li</Author><Year>2017</Year><RecNum>103</RecNum><record><rec-number>103</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479657717">103</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Li, X., Su, S., Zhang, Z., Kong, X</author></authors></contributors><titles><title>An integrated environmental and health performance quantification model for pre-occupancy phase of buildings in China </title><secondary-title>Environmental Impact Assessment Review</secondary-title></titles><periodical><full-title>Environmental Impact Assessment Review</full-title></periodical><pages>1-11</pages><volume>63</volume><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>**}** ; **{** ADDIN EN.CITE <EndNote><Cite><Author>Park</Author><Year>2016</Year><RecNum>102</RecNum><DisplayText>(Park, 2016)</DisplayText><record><rec-number>102</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1479657378">102</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Park, H. S., Ji, C., & Hong, T.</author></authors></contributors><titles><title>Methodology for assessing human health impacts due to pollutants emitted from building materials</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>133-144</pages><volume>95</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote >**}**. Nevertheless, it should be argued that rather than using a deterministic approach (as currently used for green buildings), a more transactional model could be useful for human building interactions. Having said that, healthy buildings are a good example of a 'wicked problem' - one that defies a clear definition, has contradictory elements, concerns a multiplicity of stakeholder views, and is difficult to solve (Churchman, 1967). Faced with the complexity of these contending forces, there is no single paradigm around based on which to organise thought and action towards a resolution for such concern. Instead, there are competing view-points about how to deliver better and healthier buildings, and indeed about how much priority should be given to them.

Nonetheless, this study argues that; the majority of recent attempts, both in practice and academia, by architects, engineers and designers, are limited to the latter area of focus. Hence, less attention has been paid to evaluating the crucial impacts of SBS on occupants' well-being, health status and productivity. Furthermore, for long, an ideal representation of future buildings was repeatedly shaped to embrace green and intelligent attributes while being intertwined with sophisticated automated and ICT-based technologies **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. Despite these common technology-oriented viewpoints, only a limited amount of studies (with limitation to indoor environmental quality (IEQ) have attempted to define and envisage future buildings from the SBS perspective as being more responsive to occupants' behavior, preferences, health, social and psychological well-being.

SBS is a particularly "hot topic", not least because of the rise in cases of overheating, inadequate ventilation and poor indoor air quality, and growing global awareness of the role of the built environment on human health. This paper evaluates the state of knowledge on SBS by providing a holistic understanding of the impact of SBS on occupant health, wellbeing and productivity; the factors that contribute to these symptoms; and potential solutions. The paper provides useful synthesis and visualisation of research on SBS contributors, mitigation strategies, and the evolution of healthy building design (in light of recent technological advances), that will undoubtedly be of interest to researchers in the fields of public health, architecture, engineering, sustainability, and indoor performance of buildings.

Looking at the methodological approach, the study attempted to review and critically analyze the core SBS sympthoms, contributors and their potential impacts through an exploratory review approach. We aim to begin a re-conceptualization of SBS that offers an analytic framework for more systematic enquiry. In this regard, using systematic literature review following preferred reporting items for systematic reviews (Moher, et al, 2009), a comprehensive literature search based on the 'title/ abstract/keyword' components was carried out. The keywords used in the literature search were generally wide ranging and included terms related to 'sick building syndrome (SBS)', 'healthy buildings', 'indoor environments', 'well-being', and 'sustainability' based on the available academic journal databases including: Web of Science, Google Scholar, Scopus, Proquest, ACM digital library and Sciencedirect. Likewise, exploring the references of the already found articles, few papers not covered in the above databases, yet considerably important for the review, were identified. During this review approach, a collection of over 200 articles were identified and classified while through employing content analysis, all collected data were critically analyzed. This paper uses the issues identfied to call for a future agenda based on improving professional practice, as well as preparing the ground for more detailed research work in this field. It does not present answers and solutions to all the downsides of trying to reconceptualise the practice of SBS. Nor does it test the proposed framework against real projects or case studies. This study was generally limited to the identification and demonstration of the crucial impacts of SBS from built environment perspectives and the review aimed at providing new insights regarding the importance of healthty living environments from SBS angle.

2. Sick Building Syndrome

2.1 Introductory Overview

The concept of SBS was initially developed by the World Health Organization (WHO) in 1983 **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>WHO</Author><Year>1983</Year><RecNum>7</RecNum><Prefix>WHO`, </Prefix><DisplayText>(Lim, et al., 2015; WHO, 1983)</DisplayText><record><rec-number>7</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469709121">7</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>WHO</author></authors></contributors><titles><title>World Health Organization. Indoor air pollutants: exposure and health effects</title><secondary-title>EURO reports and studies</secondary-title></titles><periodical><full-title>EURO reports and studies</full-title></periodical><pages>1-42</pages><volume>78</volume><dates><year>1983</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}**. In the definition presented by WHO, SBS has been defined as '*a collection of nonspecific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritations, which seem to be linked with occupancy of certain workplaces*' **{** ADDIN EN.CITE <EndNote><Cite><Author>WHO</Author><Year>1983</Year><RecNum>7</RecNum><DisplayText>(WHO, 1983)</DisplayText><record><rec-number>7</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469709121">7</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>WHO</author></authors></contributors><titles><title>World Health Organization. Indoor air pollutants: exposure and health effects</title><secondary-title>EURO reports and studies</secondary-title></titles><periodical><full-title>EURO reports and studies</full-title></periodical><pages>1-42</pages><volume>78</volume><dates><year>1983</year></dates><urls></urls></record></Cite></EndNote>**}**. Later, the Commission of the European Communities published a report titled "*Sick Building Syndrome: A practical Guide*" emphasizing the severity of the negative effects of the phenomenon (**{** ADDIN EN.CITE <EndNote><Cite><Author>Molina</Author><Year>(1989)</Year><RecNum>202</RecNum><DisplayText>(Molina, (1989))</DisplayText><record><rec-number>202</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509179276">202</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Molina, C., Anthony, C., Pickering, C., Valbjorn, O., and Bortoli, M. </author></authors></contributors><titles><title>Sick Building Syndrome; A practical guide</title><secondary-title>Commission of the European communities, Luxembourg. Accessed via: http://www.buildingecology.com/publications/ECA_Report4.pdf </secondary-title></titles><periodical><full-title>Commission of the European communities, Luxembourg. Accessed via: http://www.buildingecology.com/publications/ECA_Report4.pdf</full-title></periodical><volume>Last accessed: 18 October 2017</volume><dates><year>(1989)</year></dates><urls></urls></record></Cite></EndNote>**}**. In another definition presented by **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Greer</Author><Year>2007</Year><RecNum>181</RecNum><Prefix>Greer`, </Prefix><DisplayText>(Greer, 2007)</DisplayText><record><rec-number>181</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801116">181</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Greer, C</author></authors></contributors><titles><title>Something in the air: A critical review of literature on the topic of sick building syndrome</title><secondary-title>World Saf J</secondary-title></titles><periodical><full-

title>World Saf J</full-title></periodical><pages>23-26</pages><volume>16</volume><number>1</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}**, SBS has been defined as '*a group of non-specific symptoms with a temporal connection to a particular building, but with no specific or obvious cause*'. To this end, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Murphy</Author><Year>2006</Year><RecNum>182</RecNum><Prefix>Murphy`, </Prefix><DisplayText>(Murphy, 2006)</DisplayText><record><rec-number>182</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801341">182</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Murphy, M</author></authors></contributors><titles><title>Sick building syndrome and the problem of uncertainty: Environmental politics, technoscience, and women workers</title><secondary-title>Duke University Press</secondary-title></titles><periodical><full-title>Duke University Press</full-title></periodical><dates><year>2006</year></dates><urls></urls></record></Cite></EndNote>**}** points out that symptoms of SBS are mainly minor, being varied with each episode of exposure. Similarly, Transport Salaried Staffs' Association (**{** ADDIN EN.CITE <EndNote><Cite><Author>TSSA</Author><Year>2010</Year><RecNum>183</RecNum><DisplayText>(TSSA, 2010)</DisplayText><record><rec-number>183</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801583">183</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>TSSA</author></authors></contributors><titles><title>Sick building syndrome</title><secondary-title>Accessed: 29/03/2017. Available: http://www.tssa.org.uk/article-47.php3?id_article=1001</secondary-title></titles><periodical><full-title>Accessed: 29/03/2017. Available: http://www.tssa.org.uk/article-47.php3?id_article=1001</full-title></periodical><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}** in the UK defined SBS as '*a generic term used to describe common symptoms which, for no obvious reason, are associated with particular buildings*'. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Gomzi</Author><Year>2009</Year><RecNum>184</RecNum><Prefix>Gomzi & Bobić`, </Prefix><DisplayText>(Gomzi & Bobić, 2009)</DisplayText><record><rec-number>184</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801729">184</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author><style face="normal" font="default" size="100%">Gomzi, M., & Bobi</style><style face="normal" font="default" charset="238" size="100%">ć, J</style></author></authors></contributors><titles><title><style face="normal" font="default" charset="238" size="100%">Sick building syndrome</style><style face="normal" font="default" size="100%">.</style><style face="normal" font="default" charset="238" size="100%"> Do we live and work in unhealthy environment?</style></title><secondary-title><style face="normal" font="default" charset="238" size="100%">Periodicum biologorum</style></secondary-title></titles><periodical><full-title>Periodicum biologorum</full-title></periodical><pages><style face="normal" font="default" charset="238" size="100%">79-84</style></pages><volume><style face="normal" font="default" charset="238" size="100%">111</style></volume><number><style face="normal" font="default" charset="238" size="100%">1</style></number><dates><year><style face="normal" font="default" charset="238" size="100%">2009</style></year></dates><urls></urls></record></Cite></EndNote>**}** describes SBS as '*an environmentally related condition with increased prevalence of non-specific symptoms among the population of certain buildings, often without clinical signs and objective measures of symptoms*'. From another perspective, SBS has been defined as 'the density of workers' complaints', in which the WHO defined this density to be 20% of the building occupants presenting with the symptoms of SBS **{** ADDIN EN.CITE <EndNote><Cite><Author>Jansz</Author><Year>2011</Year><RecNum>186</RecNum><DisplayText>(Jansz, 2011a)</DisplayText><record><rec-number>186</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491055034">186</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jansz, J</author></authors></contributors><titles><title>Introduction to sick building syndrome. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg.</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg.</full-title></periodical><pages>1-24</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. In fact, the first reports of health and comfort complains among building occupants of artificially ventilated buildings started to pop up in the literature during 1970's **{** ADDIN EN.CITE <EndNote><Cite

ExcludeAuth="1"><Author>Graudenz</Author><Year>2011</Year><RecNum>190</RecNum><Prefix>Graudenz`, </Prefix><DisplayText>(Graudenz, 2011)</DisplayText><record><rec-number>190</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491122837">190</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Graudenz, G. S</author></authors></contributors><titles><title>Building Related Illnesses. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg</full-title></periodical><pages>341-352</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. Similarly, other related studies stressed that there are two main criteria for the existence of SBS in a building: a) at least 20% of buildings users are concerned about an identical medical problem b) that identical medical problem is observed for at least 2 weeks (Abdul-Wahab, 2011; Clements-Croome, 2018). Table 1 demonstrates various definitions extracted from the literature.

Table 1. SBS definitions

Reference	Definition	Key Attributes
WHO (1983)	A collection of nonspecific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritations, which seem to be linked with occupancy of certain workplaces.	-SBS symptoms are nonspecific.
Rostron (2008)	SBS is a syndrome of complaints covering nonspecific feelings of malaise, the onset of which is associated with occupancy of certain modern buildings	-Direct correlation with the occupancy in certain building.
Molina, et al. (1990)	SBS is the name given to a set of varied symptoms experienced predominantly by people working in air conditioned buildings, although it has also been observed in naturally ventilated buildings.	-The recognized symptoms are similar amongst the group of people residing in a certain environment.
EPA (1991)	SBS is used to '*describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified*'.	-The signs are nonspecific -Direct relationship with the occupancy in certain building. -The appearance of same acute symptoms amongst the residents of a certain building.
Goldman (1996)	SBS is where the occupants of a building are affected over an indefinite period, and is directly connected with the building itself.	-Building is the main source of SBS appearance.
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Greer</Author><Year>2007</Year><RecNum>181</RecNum><Prefix>Greer`, </Prefix><DisplayText>(Greer, 2007)</DisplayText><record><rec-number>181</rec-number><foreign-keys><key	A group of non-specific symptoms with a temporal connection to a particular building, but with no specific or obvious cause.	-The causes are indefinite. -Symptoms are nonspecific and transient.

app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801116">181</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Greer, C</author></authors></contributors><titles><title>Something in the air: A critical review of literature on the topic of sick building syndrome</title><secondary-title>World Saf J</secondary-title></titles><periodical><full-title>World Saf J</full-title></periodical><pages>23-26</pages><volume>16</volume><number>1</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}**		
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Gomzi</Author><Year>2009</Year><RecNum>184</RecNum><Prefix>Gomzi & Bobić`, </Prefix><DisplayText>(Gomzi & Bobić,	An environmentally related condition with increased prevalence of non-specific symptoms among the population of certain buildings, often without clinical signs and objective measures of symptoms.	-The symptoms are nonspecific. -The signs are prevalent amongst the occupants residing in a certain building. -Majority of these signs are not clinical.

2009)</DisplayText><record><rec-number>184</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801729">184</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author><style face="normal" font="default" size="100%">Gomzi, M., & Bobi</style><style face="normal" font="default" charset="238" size="100%">ć, J</style></author></authors></contributors><titles><title><style face="normal" font="default" charset="238" size="100%">Sick building syndrome</style><style face="normal" font="default" size="100%">.</style><style face="normal" font="default" charset="238" size="100%"> Do we live and work in unhealthy environment?</style></title><secondary-title><style

face="normal" font="default" charset="238" size="100%">Periodicum biologorum</style></secondary-title></titles><periodical><full-title>Periodicum biologorum</full-title></periodical><pages><style face="normal" font="default" charset="238" size="100%">79-84</style></pages><volume><style face="normal" font="default" charset="238" size="100%">111</style></volume><number><style face="normal" font="default" charset="238" size="100%">1</style></number><dates><year><style face="normal" font="default" charset="238" size="100%">2009</style></year></dates><urls></urls></record></Cite></EndNote>**}**		
Passarelli (2009)	SBS is a range of non-specific illnesses that are experienced by an occupant while inside a particular building or within a specific area of the inside environment. The symptoms experienced usually disappear hours, or in some cases days, after the occupant is away from the enclosed environment.	-The symptoms are nonspecific -The environment is the main cause of appearing SBS. -The symptoms will be improved once the occupants leave the place.
{ ADDIN EN.CITE <EndNote><Cite><Author>TSSA</Author><Year	A generic term used to describe common symptoms which, for no obvious reason, are associated with particular buildings.	-The symptoms are nonspecific -The main cause of appearing SBS signs is the building itself.

>2010</Year><RecNum>183</RecNum><DisplayText>(TSSA, 2010)</DisplayText><record><rec-number>183</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490801583">183</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>TSSA</author></authors></contributors><titles><title>Sick building syndrome</title><secondary-title>Accessed: 29/03/2017. Available: http://www.tssa.org.uk/article-47.php3?id_article=1001</secondary-title></titles><periodical><full-title>Accessed: 29/03/2017. Available: http://www.tssa.org.uk/article-47.php3?id_article=1001</full-title></periodical><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}**

Crook and Burton (2010)	SBS is a complex spectrum of ill health symptoms associated with the indoor environment. In broad terms, these	-The main cause of appearing SBS signs is the building itself.

	symptoms can be divided into mucous membrane symptoms related to eyes, nose and throat; dry skin; general symptoms of headache and lethargy. These symptoms should improve within hours of leaving the problem building.	-Signs will be improved once users leave the building.
{ ADDIN EN.CITE <EndNote><Cite><Author>Jansz</Author><Year>2011</Year><RecNum>186</RecNum><DisplayText>(Jansz, 2011a)</DisplayText><record><rec-number>186</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491055034">186</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jansz, J</author></authors></contributors><titles><title>Introduction to sick building syndrome. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg.</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg.</full-title></periodical><pages>1-24</pages><date	SBS is the density of workers' complaints', in which the WHO defined this density to be 20% of the building occupants presenting with the symptoms of SBS	-The existence of SBS in a certain place can be quantified.

s><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**		
Imai and Imai (2011)	SBS symptoms are related to the environments, with a focus on chemical exposure and indoor moulds, where mucosal symptoms and general symptoms such as headache, dyspnoea, loss of consciousness, and visual disturbance start appearing shortly after people move into a new house or into a remodeled house.	-The main cause of SBS symptoms is the building itself. -The SBS symptoms can be even manifested in new house or into a remodeled house.
Jansz (2011b)	SBS is a clinical diagnosis without any cause, or causes, being specifically identified	-The signs of SBS are nonspecific.
Abdul-Wahab (2011); Clements-Croome (2018)	SBS is referred to scenarios where over 20% of buildings users are concerned about a similar medical issue while being in the building as a result of an unidentified reason during a minimum cycle of 2 weeks.	- 20% of building occupants and at least 2 weeks to be considered SBS.
Takigawa et al. (2012)	SBS is characterized by various nonspecific subjective symptoms, including irritation of the eyes, nose, and throat, headache and general fatigue, in rooms with deteriorated indoor air quality.	-SBS symptoms are nonspecific -SBS symptoms may concern certain parts of the body.
Norhidayah, et al. (2013)	SBS is the exposure of common symptoms amongst certain individuals working or living in an environment, where the appearance of these signs depends on their presence in that place.	-SBS symptoms prevail among occupants of a certain building. -The building is the main cause for appearing the SBS signs.
Shan et al. (2016)	SBS is a group of symptoms related but not limited to the irritation of the eyes, nose, throat, skin, breath, and other general symptoms such as headache and lethargy that temporally occur among occupants of a certain building	-The extent of SBS signs cannot be limited. -These symptoms are temporal

The common characteristic that is frequently repeated amongst the presented definitions is the '*non-specific'* essence of SBS symptoms. This indicates that the signs of SBS can be highly variable, affecting diverse parts of human body in which correlating them to SBS could be challenging in the first place. Nonetheless, several health-related symptoms can be associated with SBS including: i) general symptoms (i.e. hoarseness of voice, allergies, flulike symptoms, respiratory diseases, nausea, dizziness, headache, fatigue, and inability to concentrate), ii) mucous symptoms (i.e. eye, throat and nose irritations or coughing) and iii) dermal symptoms (i.e. itching skin, face, hands or scalp) **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. The negative effects of SBS are interconnected, as the occurrence of one effect can lead to the manifestation of another. Majority of the discussed SBS's effects can negatively affect the occupants' well-being. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Amin</Author><Year>2015</Year><RecNum>4</RecNum><Prefix>Amin`, et al.`, </Prefix><DisplayText>(Amin, et al., 2015)</DisplayText><record><rec-number>4</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624956">4</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Amin, N. D. M., Akasah, Z. A., & Razzaly, W.</author></authors></contributors><titles><title>Architectural Evaluation of Thermal Comfort: Sick Building Syndrome Symptoms in Engineering Education Laboratories</title><secondary-title>Procedia-Social and Behavioral Sciences</secondary-title></titles><periodical><full-title>Procedia-Social and Behavioral Sciences</full-title></periodical><pages>19-28</pages><volume>204</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}** investigated thermal conditions and SBS symptoms in three air-conditioned engineering education laboratories of a university in Malaysia. The results showed that majority of students in each lab experienced all the SBS symptoms. Among the symptoms, dry skin received the highest percentage of contribution, followed by runny nose, dry eyes, blocked/stuffy nose, tiredness and flu-like symptoms. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Jafari</Author><Year>2015</Year><RecNum>50</RecNum><Prefix>Jafari`, et al.`, </Prefix><DisplayText>(Jafari, et al., 2015)</DisplayText><record><rec-number>50</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22"

timestamp="1473957736">50</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jafari, M. J., Khajevandi, A. A., Najarkola, S. A. M., Yekaninejad, M. S., Pourhoseingholi, M. A., Omidi, L., & Kalantary, S	</author></authors></contributors><titles><title>Association of sick building syndrome with indoor air parameters</title><secondary-title>Tanaffos</secondary-title></titles><periodical><full-title>Tanaffos</full-title></periodical><pages>55</pages><volume> 14</volume><number>1</number><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>
} endeavored to assess the association of SBS with individual factors and indoor air pollutants among employees in two office buildings in Iran. They found that, the chief contributors of SBS amongst the employees were recycling of air in rooms using fan coils, traffic noise, poor lighting, and buildings located in a polluted metropolitan area. The most common symptoms found among the employees were malaise (a sense of discomfort) and headache. They also identified throat dryness, cough, sputum, wheezing, skin dryness and eye pain as other signs of SBS effects among the employees.

Notwithstanding the various determinants contributing to the emergence of SBS symptoms, this study classified major causes of SBS under two general categories: individual-related factors and ambiance-related factors.

Individual-related factors can be gender, history of atopy (genetic tendency towards developing allergic diseases)/allergic disorders, low status of individuals in an organization, working on more routine tasks and smoking status **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lu</Author><Year>2016</Year><RecNum>2</RecNum><Prefix>Lu`, et al.`, </Prefix><DisplayText>(Bullinger, et al., 1999; Lu, et al., 2016)</DisplayText><record><rec-number>2</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624654">2</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lu, C., Deng, Q., Li, Y., Sundell, J., & Norbäck, D. </author></authors></contributors><titles><title>Outdoor air pollution, meteorological conditions and indoor factors in dwellings in relation to sick building syndrome (SBS) among adults in China</title><secondary-title>Science of The Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>186-196</pages><volume>560</volume><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Bullinger</Author><Year>1999</Year><RecNum>177</RecNum><Prefix>Bullinger`, et al.`, </Prefix><record><rec-number>177</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490643378">177</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bullinger, M., Morfeld, M., Von Mackensen, S., & Brasche, S</author></authors></contributors><titles><title>The Sick-Building-Syndrome-Do women suffer more?: Das Sick-Building-Syndrom-Leiden Frauen mehr?</title><secondary-title>Zentralblatt für Hygiene und Umweltmedizin</secondary-title></titles><periodical><full-title>Zentralblatt für Hygiene und Umweltmedizin</full-title></periodical><pages>235-241</pages><volume>202</volume><number>2-4</number><dates><year>1999</year></dates><urls></urls></record></Cite></EndNote>**}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bachmann</Author><Year>1995</Year><RecNum>174</RecNum><Prefix>Bachmann & Myers`, </Prefix><DisplayText>(Bachmann & Myers, 1995)</DisplayText><record><rec-number>174</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490636633">174</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bachmann, M. O., & Myers, J. E</author></authors></contributors><titles><title>Influences on sick building syndrome symptoms in three buildings</title><secondary-title>Social Science & Medicine</secondary-title></titles><periodical><full-title>Social Science & Medicine</full-title></periodical><pages>245-251</pages><volume>40</volume><number>2</number><dates><year>1995</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the correlations between typical symptoms of SBS, musculoskeletal symptoms, psychological state, work stress and interpersonal relationships at work among 624 office workers in three buildings. It was stated that psychological state is among the key predictors of symptoms. Furthermore, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sahlberg</Author><Year>2009</Year><RecNum>168</RecNum><Prefix>Sahlberg`, et al.`, </Prefix><DisplayText>(Sahlberg, et al., 2009)</DisplayText><record><rec-number>168</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22"

timestamp="1486712626">168</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sahlberg, B., Mi, Y. H., & Norbäck, D</author></authors></contributors><titles><title>Indoor environment in dwellings, asthma, allergies, and sick building syndrome in the Swedish population: a longitudinal cohort study from 1989 to 1997</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>1211-1218</pages><volume>82</volume><number>10</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** identified smoking and indoor painting as the two potential predictors of SBS symptoms through conducting an 8-year follow-up period to investigate the changes of SBS and different types of indoor exposures at home.**{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Runeson-Broberg</Author><Year>2013</Year><RecNum>48</RecNum><Prefix>Runeson-Broberg & Norbäck`, </Prefix><DisplayText>(Runeson-Broberg & Norbäck, 2013)</DisplayText><record><rec-number>48</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473846678">48</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Runeson-Broberg, R., & Norbäck, D</author></authors></contributors><titles><title> Sick building syndrome (SBS) and sick house syndrome (SHS) in relation to psychosocial stress at work in the Swedish workforce</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages> 915-922</pages><volume>86</volume><number>8</number><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>**}** studied the association between SBS symptoms and physical and environmental conditions at both home and work through distributing postal questionnaire. Their findings confirmed the positive association existed between the perceptions of poor physical environmental conditions and emergence of common medical symptoms. They stated that atopy, poor air quality at work, and low social support, especially low supervisor support, were significantly associated with both SBS symptoms at work and home.

However, the prevalent complaints of SBS are more likely to be related to the ambient issues, including building dampness **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lu</Author><Year>2016</Year><RecNum>2</RecNum><Prefix>Lu`, et al.`, </Prefix><DisplayText>(Lu, et al., 2016; Norbäck, et al., 2016)</DisplayText><record><rec-number>2</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624654">2</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lu, C., Deng, Q., Li, Y., Sundell, J., & Norbäck, D. </author></authors></contributors><titles><title>Outdoor air pollution, meteorological conditions and indoor factors in dwellings in relation to sick building syndrome (SBS) among adults in China</title><secondary-title>Science of The Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>186-196</pages><volume>560</volume><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2016</Year><RecNum>6</RecNum><Prefix>Norbäck`, et al.`, </Prefix><record><rec-number>6</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469640899">6</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., Hashim, J. H., Markowicz, P., Cai, G. H., Hashim, Z., Ali, F., & Larsson, L</author></authors></contributors><titles><title>Endotoxin, ergosterol, muramic acid and fungal DNA in dust from schools in Johor Bahru, Malaysia-Associations with rhinitis and sick building syndrome (SBS) in junior high school students</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>95-103</pages><volume>545</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**. Building dampness is the presence of unwanted moisture in the building structure, which can be either the result of intrusion from outside or condensation within the structure. This phenomenon may stimulate the appearance of respiratory illness such as asthma in occupants **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Takeda</Author><Year>2009</Year><RecNum>157</RecNum><Prefix>Takeda`, et al.`, </Prefix><DisplayText>(Takeda, et al., 2009)</DisplayText><record><rec-number>157</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485956409">157</key></foreign-keys><ref-type name="Journal Article">17</ref-

type><contributors><authors><author>Takeda, M., Saijo, Y., Yuasa, M., Kanazawa, A., Araki, A., & Kishi, R</author></authors></contributors><titles><title>Relationship between sick building syndrome and indoor environmental factors in newly built Japanese dwellings</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>583-593</pages><volume>82</volume><number>5</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** identified dampness as one of the critical factors associated with SBS symptoms in newly built dwellings. Similarly, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Zhang</Author><Year>2012</Year><RecNum>12</RecNum><Prefix>Zhang`, et al.`, </Prefix><DisplayText>(Zhang, et al., 2012)</DisplayText><record><rec-number>12</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469956911">12</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Zhang, X., Sahlberg, B., Wieslander, G., Janson, C., Gislason, T., & Norback, D</author></authors></contributors><titles><title>Dampness and moulds in workplace buildings: Associations with incidence and remission of sick building syndrome (SBS) and biomarkers of inflammation in a 10 year follow-up study</title><secondary-title>Science of the total environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>75-81</pages><volume>430</volume><dates><year>2012</year></dates><urls></urls></record></Cite></EndNote>**}** identified the damp and moldy environment as a simulator for occurrence of SBS symptoms, as the presence of occupants in these environments can increase the incidence of work-related symptoms, whilst the possibility for remission may decrease. In damp buildings, mold and bacteria grow by enjoying the hospitable environment existing in settled dust **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}**. Endotoxin (found in the outer cell membrane of gram-negative bacteria) **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Gehring</Author><Year>2008</Year><RecNum>153</RecNum><Prefix>Gehring`, et al.`, </Prefix><DisplayText>(Gehring, et al., 2008)</DisplayText><record><rec-number>153</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485946256">153</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gehring, U., Strikwold, M., Schram-Bijkerk, D., Weinmayr, G., Genuneit, J., Nagel, G., ... & Di Domenicantonio, R</author></authors></contributors><titles><title>Asthma and allergic symptoms in relation to house dust endotoxin: Phase Two of the International Study on Asthma and Allergies in Childhood (ISAAC II)</title><secondary-title>Clinical & Experimental Allergy</secondary-title></titles><periodical><full-title>Clinical & Experimental Allergy</full-title></periodical><pages>1911-1920</pages><volume>38</volume><number>12</number><dates><year>2008</year></dates><urls></urls></record></Cite></EndNote>**}** and (1,3)-β-glucan (found in the cell-walls of mold) **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Iossifova</Author><Year>2007</Year><RecNum>154</RecNum><Prefix>Iossifova`, et al.`, </Prefix><DisplayText>(Iossifova, et al., 2007)</DisplayText><record><rec-number>154</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485946502">154</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Iossifova, Y. Y., Reponen, T., Bernstein, D. I., Levin, L., Kalra, H., Campo, P., ... & LeMasters, G</author></authors></contributors><titles><title><style face="normal" font="default" size="100%">House dust (1–3)-</style><style face="normal" font="default" charset="161" size="100%">β</style><style face="normal" font="default" size="100%">-d-glucan and wheezing in infants</style></title><secondary-title>Allergy</secondary-title></titles><periodical><full-title>Allergy</full-title></periodical><pages>504-513</pages><volume>62</volume><number>5</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}** are the two common compounds living in building dampness, causing pro-inflammatory effects { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>}. Given these explanations, it can be inferred that the level of seriousness and the period of emerging symptoms once the occupants are exposed to sick environments can be highly variable. This mainly depends on the level of exposure and susceptibility of occupants to environmental contaminants { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Jansz</Author><Year>2011</Year><RecNum>187</RecNum><Prefix>Jansz`, </Prefix><DisplayText>(Jansz, 2011b)</DisplayText><record><rec-number>187</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491056316">187</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jansz, J</author></authors></contributors><titles><title>Theories and knowledge about sick building syndrome. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg</full-title></periodical><pages>25-58</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>}.

SBSs were found across the world in different building types. Table 2 presents a summary of a selected set of studies from different countries that investigated SBS. Therefore, literature indicates the significant impacts of SBS on occupants. These symptoms may result in affecting the residents' well-beings, or diminishing their productivities rates once they are working. Majority of these symptoms are found to be transient and their effects will be dissipated when the occupants leave the place such as work-related symptoms { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, though some of these symptoms can have a long-lasting effects on residents' health namely respiratory-related issues { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Zhang</Author><Year>2012</Year><RecNum>12</RecNum><Prefix>Zhang`, et al.`, </Prefix><DisplayText>(Crook & Burton, 2010; Zhang, et al., 2012)</DisplayText><record><rec-number>12</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469956911">12</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Zhang, X., Sahlberg, B., Wieslander, G., Janson, C., Gislason, T., & Norback, D</author></authors></contributors><titles><title>Dampness and moulds in workplace buildings: Associations with incidence and remission of sick building syndrome (SBS) and biomarkers of inflammation in a 10 year follow-up study</title><secondary-title>Science of the total environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>75-81</pages><volume>430</volume><dates><year>2012</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Crook</Author><Year>2010</Year><RecNum>59</RecNum><Prefix>Crook & Burton`, </Prefix><record><rec-number>59</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474181973">59</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Crook, B., & Burton, N. C</author></authors></contributors><titles><title>Indoor moulds, sick building syndrome and building related illness</title><secondary-title>Fungal Biology Reviews</secondary-title></titles><periodical><full-title>Fungal Biology Reviews</full-title></periodical><pages>106-113</pages><volume>24</volume><number>3</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>}. In order to better understand SBS, the following sections review the major causes of SBS and their negative effects aiming at assisting practitioners to be familiarized with the effects of SBS and its relative symptoms as well as how to mitigate its effect on the occupants.

Table 2. Studies addressed the impacts of SBS on human wellbeing

Author (s)	Country	Type of Building	Identified Symptoms associated with SBS

{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Magnavita</Author><Year>2015</Year><RecNum>49</RecNum><Prefix>Magnavita`, </Prefix><DisplayText>(Magnavita, 2015)</DisplayText><record><rec-number>49</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473867158">49</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Magnavita, N</author></authors></contributors><titles><title>Work-related symptoms in indoor environments: a puzzling problem for the occupational physician</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>185-196</pages><volume>88</volume><number>2</number><dates><year>2015</year></dates><urls></urls></reco	Italy	Companies	Anxiety, depression, environmental discomfort and job strain

rd></Cite></EndNote> **}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Jafari</Author><Year>2015</Year><RecNum>50</RecNum><Prefix>Jafari`, et al.`, </Prefix><DisplayText>(Jafari, et al., 2015)</DisplayText><record><rec-number>50</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473957736">50</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jafari, M. J., Khajevandi, A. A., Najarkola, S. A. M., Yekaninejad, M. S., Pourhoseingholi, M. A., Omidi, L., & Kalantary, S </author></authors></contributors><titles><title>Association of sick building syndrome with indoor air parameters</title><secondary-title>Tanaffos</secondary-title></titles><periodical><full-title>Tanaffos</full-title></periodical><pages>55</pages><volume> 14</volume><number>1</number><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote> **}**	Iran	Office buildings	Malaise, headache, throat dryness, cough, sputum, wheezing, skin dryness and eye pain

{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Zhang</Author><Year>2014</Year><RecNum>51</RecNum><Prefix>Zhang`, et al.`, </Prefix><DisplayText>(Zhang, et al., 2014)</DisplayText><record><rec-number>51</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473960091">51</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Zhang, X., Li, F., Zhang, L., Zhao, Z., & Norback, D</author></authors></contributors><titles><title>A Longitudinal Study of Sick Building Syndrome (SBS) among Pupils in Relation to SO 2, NO 2, O 3 and PM 10 in Schools in China</title><secondary-title>PloS one</secondary-title></titles><periodical><full-title>PloS one</full-title></periodical><pages>e112933</pages><volume>9</volume><number>11</number><dates><year>2014</year></dates><urls></urls></record></Cite></EndNote>}	China	Schools	Skin symptoms, mucosal symptoms
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Shan</Author><Year>2016</Year><Re	Singapore	Schools	Head and eye related issues

cNum>1</RecNum><Prefix>Shan`, et al.`, </Prefix><DisplayText>(Shan, et al., 2016)</DisplayText><record><rec-number>1</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624526">1</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Shan, X., Zhou, J., Chang, V. W. C., & Yang, E. H. </author></authors></contributors><titles><title>Comparing mixing and displacement ventilation in tutorial rooms: Students' thermal comfort, sick building syndromes, and short-term performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>128-137</pages><volume>102</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2016</Year><RecNum>6</RecNum><Prefix>Norbäck`, et al.`,	Malaysia	Schools	Ocular, rhinitis, throat symptoms, headache and tiredness, dermal symptoms.

</Prefix><DisplayText>(Norbäck, et al., 2016)</DisplayText><record><rec-number>6</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469640899">6</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., Hashim, J. H., Markowicz, P., Cai, G. H., Hashim, Z., Ali, F., & Larsson, L</author></authors></contributors><titles><title>Endotoxin, ergosterol, muramic acid and fungal DNA in dust from schools in Johor Bahru, Malaysia- Associations with rhinitis and sick building syndrome (SBS) in junior high school students</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>95-103</pages><volume>545</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><Rec	Malaysia	University	Dermal, mucosal and general symptoms

Num>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Amin</Author><	Malaysia	University	Dry skin, runny nose, dry eyes, blocked/ stuffy nose, tiredness and flu-like symptoms

Year>2015</Year><RecNum>4</RecNum><Prefix>Amin`, et al.`, </Prefix><DisplayText>(Amin, et al., 2015)</DisplayText><record><rec-number>4</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624956">4</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Amin, N. D. M., Akasah, Z. A., & Razzaly, W.</author></authors></contributors><titles><title>Architectural Evaluation of Thermal Comfort: Sick Building Syndrome Symptoms in Engineering Education Laboratories</title><secondary-title>Procedia-Social and Behavioral Sciences</secondary-title></titles><periodical><full-title>Procedia-Social and Behavioral Sciences</full-title></periodical><pages>19-28</pages><volume>204</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote> **}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sun</Author><Year>2013</Year><RecNum>52</RecNum><Prefix>Sun`, et al.`, </Prefix><DisplayText>(Sun, et al.,	China	Dormitory	General symptoms of sick building, mucosal or skin problems and nose irritation

2013)</DisplayText><record><rec-number>52</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474012954">52</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sun, Y., Zhang, Y., Bao, L., Fan, Z., Wang, D., & Sundell, J</author></authors></contributors><titles><title>Effects of gender and dormitory environment on sick building syndrome symptoms among college students in Tianjin, China</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>134-139</pages><volume>68</volume><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote> **}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sahlberg</Author><Year>2013</Year><RecNum>53</RecNum><Prefix>Sahlberg`, et al.`, </Prefix><DisplayText>(Sahlberg, et al., 2013)</DisplayText><record><rec-number>53</rec-	Sweden/Estonia/ Iceland	Residential Building	General signs of sick building (i.e. mucosal symptoms)

number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474015222">53</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sahlberg, B., Gunnbjörnsdottir, M., Soon, A., Jogi, R., Gislason, T., Wieslander, G., ... & Norback, D</author></authors></contributors><titles><title>Airborne molds and bacteria, microbial volatile organic compounds (MVOC), plasticizers and formaldehyde in dwellings in three North European cities in relation to sick building syndrome (SBS)</title><secondary-title>Science of the total environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>433-440</pages><volume>444</volume><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>**}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Takigawa</Author><Year>2010</Year><RecNum>54</RecNum><Prefix>Takigawa`, et al.`,	Japan	Residential Building	Optical, nasal, and gular symptoms

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>(Takigawa, et al.,
2010)</DisplayText><
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K., Nakayama, K.,
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R</author></authors>
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<title>Relationship
between indoor
chemical
concentrations and
subjective symptoms
associated with sick
building syndrome in
newly built houses in
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{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Tsai</Author><Year>2012</Year><RecNum>55</RecNum><Prefix>Tsai`, et al.`, </Prefix><DisplayText>(Tsai, et al., 2012)</DisplayText><record><rec-number>55</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474043287">55</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Tsai, D. H., Lin, J. S., & Chan, C. C</author></authors></contributors><titles><title>Office workers' sick building syndrome and indoor carbon dioxide concentrations</title><secondary-title>Journal of occupational and environmental hygiene</secondary-title></titles><periodical><full-title>Journal of occupational and environmental hygiene</full-title></periodical><pages>345-351</pages><volume>9</volume><number>5</number><dates><year>2012</year></dates><urls></urls></record></Cite></EndNote>}	Taiwan	Office building	Eye irritation and upper respiratory symptoms
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lukcso</Author><Year>2016</Year><	USA	Office building	Asthma and allergic disease

RecNum>56</RecNum><Prefix>Lukcso`, et al.`, </Prefix><DisplayText>(Lukcso, et al., 2016)</DisplayText><record><rec-number>56</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474043780">56</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lukcso, D., Guidotti, T. L., Franklin, D. E., & Burt, A</author></authors></contributors><titles><title>Indoor environmental and air quality characteristics, building-related health symptoms, and worker productivity in a federal government building complex</title><secondary-title>Archives of environmental & occupational health</secondary-title></titles><periodical><full-title>Archives of environmental & occupational health</full-title></periodical><pages>85-101</pages><volume>71</volume><number>2</number><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote> **}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Au	Croatia	Office buildings	Fatigue, sore and dry eyes, and headache

thor>Gomzi</Author><Year>2007</Year><RecNum>57</RecNum><Prefix>Gomzi`, et al.`, </Prefix><DisplayText>(Gomzi, et al., 2007)</DisplayText><record><rec-number>57</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474044547">57</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gomzi, M., Bobic, J., Radosevic-Vidacek, B., Macan, J., Varnai, V. M., Milkovic-Kraus, S., & Kanceljak-Macan, B</author></authors></contributors><titles><title>Sick building syndrome: psychological, somatic, and environmental determinants</title><secondary-title>Archives of environmental & occupational health</secondary-title></titles><periodical><full-title>Archives of environmental & occupational health</full-title></periodical><pages>147-155</pages><volume>62</volume><number>3</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote> **}**			
{ ADDIN EN.CITE <EndNote><Cite	Sweden	Office buildings	Headache, tiredness, nausea, and sensation of a cold

ExcludeAuth="1"><Author>Runeson-Broberg</Author><Year>2013</Year><RecNum>48</RecNum><Prefix>Runeson-Broberg & Norbäck`, </Prefix><DisplayText>(Runeson-Broberg & Norbäck, 2013)</DisplayText><record><rec-number>48</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473846678">48</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Runeson-Broberg, R., & Norbäck, D</author></authors></contributors><titles><title> Sick building syndrome (SBS) and sick house syndrome (SHS) in relation to psychosocial stress at work in the Swedish workforce</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages> 915-922</pages><volume>86</volume><number>8</number><dates><year>2013</year></dat

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rd></Cite></EndNote>
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2.2 SBS Contributors

According to WHO, up to 30% of new and remodeled buildings worldwide were recognized to be potential carriers of SBS { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Wong</Author><Year>2009</Year><RecNum>86</RecNum><Prefix>Wong`, et al.`, </Prefix><DisplayText>(Boubekri, 2008; Wong, et al., 2009)</DisplayText><record><rec-number>86</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1475252326">86</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Wong, S. K., Lai, L. W. C., Ho, D. C. W., Chau, K. W., Lam, C. L. K., & Ng, C. H. F</author></authors></contributors><titles><title>Sick building syndrome and perceived indoor environmental quality: A survey of apartment buildings in Hong Kong</title><secondary-title>Habitat International</secondary-title></titles><periodical><full-title>Habitat International</full-title></periodical><pages>463-471</pages><volume>33</volume><number>4</number><dates><year>2009</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Boubekri</Author><Year>2008</Year><RecNum>155</RecNum><Prefix>Boubekri`, </Prefix><record><rec-number>155</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485951660">155</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Boubekri, M</author></authors></contributors><titles><title>Daylighting, architecture and health</title><secondary-title>Routledge</secondary-title></titles><periodical><full-title>Routledge</full-title></periodical><dates><year>2008</year></dates><urls></urls></record></Cite></EndNote>}. Since then, there have been many cases of SBS, predominantly in sealed office buildings. Although poor indoor environmental quality (IEQ) is often blamed for causing SBS, it is empirically challenging to substantiate or single out the main source(s) responsible for stimulating the appearance of a particular symptom. Reviewing the recent research investigations about SBS in buildings, the study draws attention to the major contributors of SBS as highlighted below:

- *Physical contributors;* These factors are associated with the physical attributes of buildings that can stimulate the appearance of SBS signs. These contributors can significantly affect the health status, well-being and comfort. In fact, the provision of physical comfort in a workplace is essential in enhancing the occupants' performances through encouraging a healthier and more productive workplace **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**.

- *Temperature;* Deviation from the thermal comfort threshold for buildings' indoor environment may result in occurrence of SBS { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Humphreys</Author><Year>2015</Year><RecNum>21</RecNum><Prefix>Humphreys`, et al.`,</Prefix><DisplayText>(Humphreys, et al.,2015)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1470731093">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Humphreys, M., Nicol, F., Roaf, S., & Sykes, O</author></authors></contributors><titles><title>Standards for Thermal Comfort: Indoor Air Temperature Standards for the 21st Century</title><secondary-title>Routledge</secondary-title></titles><periodical><full-title>Routledge</full-title></periodical><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>}, while subsequently affecting the performance rates of individuals **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Chua</Author><Year>2016</Year><RecNum>22</RecNum><Prefix>Chua`, et al.`, </Prefix><DisplayText>(Chua, et al., 2016)</DisplayText><record><rec-number>22</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1470733428">22</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Chua, S. J. L., Ali, A. S., & Lim, M. E. L</author></authors></contributors><titles><title>Physical Environment Comfort Impacts on Office Employee's Performance</title><secondary-title>In MATEC Web of Conferences. EDP Sciences</secondary-title></titles><periodical><full-title>In MATEC Web of Conferences. EDP Sciences</full-

title></periodical><pages>00124</pages><volume>66</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** found a strong correlation existing between room temperature, lighting and relative humidity in one hand and health-related issues in the other. These caused difficulties in concentration and eventually affected the employees' productivity. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Seppanen</Author><Year>2006</Year><RecNum>23</RecNum><Prefix>Seppanen`, et al.`, </Prefix><DisplayText>(Seppanen, et al., 2006)</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1470735496">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Seppanen, O., Fisk, W. J., & Lei, Q. H</author></authors></contributors><titles><title>Effect of temperature on task performance in office environment</title><secondary-title>Lawrence Berkeley National Laboratory</secondary-title></titles><periodical><full-title>Lawrence Berkeley National Laboratory</full-title></periodical><dates><year>2006</year></dates><urls></urls></record></Cite></EndNote>**}** identified a direct link between workers' performances and temperature. It was shown that the performance increased with temperature up to 21-22ºC and decreased with temperature above 23-24ºC. In a review of a 24 research paper on the effect of thermal comfort on productivity, **{** ADDIN EN.CITE <EndNote><Cite><Author>Wargorcki</Author><Year>(2006)</Year><RecNum>203</RecNum><DisplayText>(Wargorcki, (2006))</DisplayText><record><rec-number>203</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509181677">203</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Wargorcki, P., Seppänen, O., Andersson, J., Boerstra, A., Clements-Croome, D., Fitzner, K., Hanssen, SO</author></authors></contributors><titles><title>REHVA Guidebook: Indoor Climate and Productivity In Offices. REHVA, Brussels</title></titles><dates><year>(2006)</year></dates><urls></urls></record></Cite></EndNote>**}** found a 10% reduction in performance at both 30°C and 15C compared with a baseline between 21°C and 23°C. Similarly, **{** ADDIN EN.CITE <EndNote><Cite><Author>Vimalanathan</Author><Year>(2014)</Year><RecNum>204</RecNum><DisplayText>(Vimalanathan, (2014))</DisplayText><record><rec-number>204</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509181848">204</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Vimalanathan, K., & Babu, T. R</author></authors></contributors><titles><title>The effect of indoor office environment on the work performance, health and well-being of office workers</title><secondary-title>Journal of Environmental Health Science and Engineering</secondary-title></titles><periodical><full-title>Journal of Environmental Health Science and Engineering</full-title></periodical><pages>113</pages><volume>12</volume><number>1</number><dates><year>(2014)</year></dates><urls></urls></record></Cite></EndNote>**}** conducted a neurobehavioral test experiment to explore the effect of indoor environment on workers performance. They concluded that an optimum level indoor room temperature on 21°C have improved the work performance, health and productivity of office workers.

- *Humidity;* The mechanism by which heat affects human performance is basically dependent upon interactions of a wide array of variables such as temperature, radiation, wind, and humidity, though it is often treated as a sole product of temperature **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Davis</Author><Year>2016</Year><RecNum>26</RecNum><Prefix>Davis`, et al.`, </Prefix><DisplayText>(Davis, et al., 2016)</DisplayText><record><rec-number>26</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1472378269">26</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davis, R. E., McGregor, G. R., & Enfield, K. B. </author></authors></contributors><titles><title>Humidity: a review and primer on atmospheric moisture and human health</title><secondary-title>Environmental research</secondary-title></titles><periodical><full-title>Environmental research</full-title></periodical><pages>106-116</pages><volume>144</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**. Among these factors, the importance of humidity received a significant attention due to its direct link to human health. Although there is no agreement on what constitutes the ideal range of relative humidity, environments with temperature above 32ºC and relative humidity above 60% are considered as hot and humid environment { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Shi</Author><Year>2013</Year><RecNum>27</RecNum><Prefix>Shi`, et al.`, </Prefix><DisplayText>(Shi, et al., 2013)</DisplayText><record><rec-number>27</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1472378427">27</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Shi, X., Zhu, N., & Zheng, G</author></authors></contributors><titles><title>The combined effect of temperature, relative humidity and work intensity on human strain in hot and humid environments</title><secondary-title>Building and environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>72-80</pages><volume>69</volume><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>}.The existence of humidity can potentially provide a hospitable environment for microscopic organisms such as mildews and molds to be grown up indoor and pose a serious danger upon the health status of residents { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Davis</Author><Year>2016</Year><RecNum>26</RecNum><Prefix>Davis`, et al.`, </Prefix><DisplayText>(Davis, et al., 2016)</DisplayText><record><rec-number>26</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1472378269">26</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Davis, R. E., McGregor, G. R., & Enfield, K. B. </author></authors></contributors><titles><title>Humidity: a review and primer on atmospheric moisture and human health</title><secondary-title>Environmental research</secondary-title></titles><periodical><full-title>Environmental research</full-title></periodical><pages>106-116</pages><volume>144</volume><dates><year>2016</year></dates><urls></urls></record></Cite> </EndNote>}. Additionally, humidity exposure can cause muscle cramps, fainting, heat stroke, and even exacerbate the underlying medical conditions, such as lung or heart disease { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Zheng</Author><Year>2012</Year><RecNum>30</RecNum><Prefix>Zheng`, et al.`, </Prefix><DisplayText>(Zheng, et al., 2012)</DisplayText><record><rec-number>30</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1472379803">30</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Zheng, G., Zhu, N., Tian, Z., Chen, Y., & Sun, B</author></authors></contributors><titles><title>Application of a trapezoidal fuzzy AHP method for work safety evaluation and early warning rating of hot and humid environments</title><secondary-title>Safety Science</secondary-title></titles><periodical><full-title>Safety Science</full-title></periodical><pages>228-239</pages><volume>50</volume><number>2</number><dates><year>2012</year></dates><urls></urls></record></Cite></EndNote>}. { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Wang</Author><Year>2013</Year><RecNum>156</RecNum><Prefix>Wang`, et al.`, </Prefix><DisplayText>(Wang, et al., 2013)</DisplayText><record><rec-number>156</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485955983">156</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Wang, J., Li, B., Yang, Q., Yu, W., Wang, H., Norback, D., & Sundell, J	</author></authors></contributors><titles><title>Odors and sensations of humidity and dryness in relation to sick building syndrome and home environment in Chongqing, China</title><secondary-title>PloS one</secondary-title></titles><periodical><full-title>PloS one</full-title></periodical><pages>e72385</pages><volume>8</volume><number>8</number><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>} investigated the prevalent perceptions of odors and sensations of air humidity and SBS symptoms in domestic environments through questionnaire distributed among 4530 parents of kindergarten children in China. The findings confirmed the significance of humid air's role in symptomizing general signs as well as mucosal and skin sicknesses in children.

- *Ventilation;* The current ventilation standards and guidelines { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>ASHRAE</Author><Year>2009</Year><RecNum>31</RecNum><Prefix> ASHRAE`, </Prefix><DisplayText>(ASHRAE, 2007; ASHRAE, 2009)</DisplayText><record><rec-number>31</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473137631">31</key></foreign-keys><ref-type name="Journal Article">17</ref-

type><contributors><authors><author>ASHRAE</author></authors></contributors><titles><title>Indoor Air Quality Guide (ISBN 978-1-933742-59-5)</title></titles><dates><year>2009</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>ASHRAE</Author><Year>2007</Year><RecNum>32</RecNum><Prefix>ASHRAE`, </Prefix><record><rec-number>32</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473137699">32</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>ASHRAE</author></authors></contributors><titles><title>ASHRAE Standard 62.1e2007, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA, USA: ASHRAE; 2007</title></titles><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}** recommend a minimum ventilation rate of 8 litre/Second per person in order to extract the bio effluents (odors) **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bakó-Biró</Author><Year>2012</Year><RecNum>34</RecNum><Prefix>Bakó-Biró`, et al.`, </Prefix><DisplayText>(Bakó-Biró, et al., 2012)</DisplayText><record><rec-number>34</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473137818">34</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bakó-Biró, Z., Clements-Croome, D. J., Kochhar, N., Awbi, H. B., & Williams, M. J</author></authors></contributors><titles><title>Ventilation rates in schools and pupils' performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>215-223</pages><volume>48</volume><dates><year>2012</year></dates><urls></urls></record></Cite></EndNote>**}**. Poor ventilation can potentially trigger the emergence of SBS symptoms such as lowering the productivity rate, nose and throat irritation, headaches, fatigue, asthma, rhinitis and increased susceptibility to colds and flu **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. Actions have been proposed to include adequate outdoor ventilation, control of moisture, and avoidance of indoor exposures to pollutants such as microbiological particles, allergens and chemical substances which are considered likely to have adverse effects. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bakó-Biró</Author><Year>2012</Year><RecNum>34</RecNum><Prefix>Bakó-Biró`, et al.`, </Prefix><DisplayText>(Bakó-Biró, et al., 2012)</DisplayText><record><rec-number>34</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473137818">34</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bakó-Biró, Z., Clements-Croome, D. J., Kochhar, N., Awbi, H. B., & Williams, M. J</author></authors></contributors><titles><title>Ventilation rates in schools and pupils' performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>215-223</pages><volume>48</volume><dates><year>2012</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the effects of classroom ventilation on pupils' performance in 8 primary schools in England by monitoring a number of parameters such as CO_2 for three weeks in two selected classrooms. The results indicated that low ventilation rates in classrooms significantly reduce pupils' attention and vigilance, and negatively affect memory and concentration. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sundell</Author><Year>2011</Year><RecNum>158</RecNum><Prefix>Sundell`, et al.`, </Prefix><DisplayText>(Sundell, et al., 2011)</DisplayText><record><rec-number>158</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485974360">158</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sundell, J., Levin, H., Nazaroff, W. W., Cain, W. S., Fisk, W. J., Grimsrud, D. T., ... & Samet, J. M</author></authors></contributors><titles><title>Ventilation rates and health: multidisciplinary review of the scientific literature</title><secondary-title>Indoor air</secondary-title></titles><periodical><full-title>Indoor Air</full-title></periodical><pages>191-204</pages><volume>21</volume><number>3</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}** stated that higher ventilation rates in offices, up to about 25 l/s per person, are associated with reduced prevalence of SBS symptoms, whereas the state of having lower ventilation rates contributes to causing symptoms such as inflammation, respiratory infections, asthma symptoms and short-term sick leave. Additionally, sufficient use of natural ventilation (NV) systems can be also considered as a promising strategy to tackle the SBS. Ideally, the air movement induced by buoyancy is capable of transporting heat and pollutants away from the occupied zone, promoting stratification, creating a warmed

mixed layer in the upper part of the room. Studies also reported promising results for improving the health status of occupants where DV system was installed **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Cheong</Author><Year>2006</Year><RecNum>179</RecNum><Prefix>Cheong`, et al.`, </Prefix><DisplayText>(Cheong, et al., 2006; Shan, et al., 2016)</DisplayText><record><rec-number>179</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490782880">179</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Cheong, K. W. D., Yu, W. J., Tham, K. W., Sekhar, S. C., & Kosonen, R</author></authors></contributors><titles><title>A study of perceived air quality and sick building syndrome in a field environment chamber served by displacement ventilation system in the tropics</title><secondary-title> Building and environment</secondary-title></titles><pages>1530-1539</pages><volume>41</volume><number>11</number><dates><year>2006</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Shan</Author><Year>2016</Year><RecNum>1</RecNum><Prefix>Shan`, et al.`, </Prefix><record><rec-number>1</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624526">1</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Shan, X., Zhou, J., Chang, V. W. C., & Yang, E. H. </author></authors></contributors><titles><title>Comparing mixing and displacement ventilation in tutorial rooms: Students' thermal comfort, sick building syndromes, and short-term performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>128-137</pages><volume>102</volume><dates><year>2016</year></dates><urls></urls></record></Cite>
</EndNote>**}**. However, the usage of this system is involved in certain limitation. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Mateus</Author><Year>2016</Year><RecNum>178</RecNum><Prefix>Mateus`, et al.`, </Prefix><DisplayText>(Mateus, et al., 2016)</DisplayText><record><rec-number>178</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490782616">178</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Mateus, N. M., Simões, G. N., Lúcio, C., & da Graça, G. C</author></authors></contributors><titles><title>Comparison of measured and simulated performance of natural displacement ventilation systems for classrooms</title><secondary-title>Energy and Buildings</secondary-title></titles><periodical><full-title>Energy and Buildings</full-title></periodical><pages>185-196</pages><volume>133</volume><dates><year>2016</year></dates><urls></urls></record></Cite>
</EndNote>**}** stated that DV systems require a height difference between inflow and outflow in order for the buoyancy forces to be effective, in which is difficult to achieve without using chimneys. For single story buildings chimneys can be placed in the roof, any other configurations require internal voids or individual chimneys that may be difficult to integrate in the target building.

- *Illuminance level;* The poor quality of light can directly influence human health by affecting the occupants' visual comforts. First, light influences the suprachiasmatic nucleus (SCN), a region in the hypothalamus that controls circadian rhythms, through the eye and the retinohypothalamic tract. Second, light inhibits the secretion of melatonin and result in disrupting of sleep pattern. Third, light is found to have alerting effects through indirect projections on the ascending arousal system, which in turn, facilitates thalamic and cortical connections **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. In addition, the poor status of lighting may potentially result in increasing the possibility for occurring the hazardous events, lowering occupants' performances, and having a negative effects on the occupants' eyes **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Glen</Author><Year>2016</Year><RecNum>121</RecNum><Prefix>Glen`, et al.`, </Prefix><DisplayText>(Glen, et al., 2016)</DisplayText><record><rec-number>121</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480236597">121</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Glen, F. C., Smith, N. D., Jones, L., & Crabb, D. P</author></authors></contributors><titles><title>'I didn't see that coming': simulated visual fields and driving hazard perception test performance</title><secondary-title>Clinical and Experimental Optometry</secondary-title></titles><periodical><full-title>Clinical and Experimental Optometry</full-title></periodical><pages>469-

475</pages><volume>99</volume><number>5</number><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**. The importance of indoor illuminance was highlighted by **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Hwang</Author><Year>2010</Year><RecNum>159</RecNum><Prefix>Hwang & Kim`, </Prefix><DisplayText>(Hwang & Kim, 2010)</DisplayText><record><rec-number>159</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486013729">159</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Hwang, T., & Kim, J. T</author></authors></contributors><titles><title>Effects of indoor lighting on occupants' visual comfort and eye health in a green building</title><secondary-title>Indoor and Built Environment</secondary-title></titles><periodical><full-title>Indoor and Built Environment</full-title></periodical><volume>1420326X10392017</volume><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}**'s research, where they investigated the effects of indoor lighting on occupants' visual comfort and eye health amongst 2744 workers in Korea. The findings indicated that daylight can potentially improve the occupants' psychological health and productivity. Illumination level at 1000lux were found to improve productivity, performance and occupant's health in office buildings (**{** ADDIN EN.CITE <EndNote><Cite><Author>Vimalanathan</Author><Year>(2014)</Year><RecNum>204</RecNum><DisplayText>(Vimalanathan, (2014))</DisplayText><record><rec-number>204</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509181848">204</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Vimalanathan, K., & Babu, T. R</author></authors></contributors><titles><title>The effect of indoor office environment on the work performance, health and well-being of office workers</title><secondary-title>Journal of Environmental Health Science and Engineering</secondary-title></titles><periodical><full-title>Journal of Environmental Health Science and Engineering</full-title></periodical><pages>113</pages><volume>12</volume><number>1</number><dates><year>(2014)</year></dates><urls></urls></record></Cite></EndNote>**}**.

- *Noise;* Noise is a pervasive and influential source of stress with great potentials to distract occupants engaged in undertaking a particular performance **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Takki</Author><Year>2011</Year><RecNum>191</RecNum><Prefix>Takki`, et al.`, </Prefix><DisplayText>(Takki, et al., 2011)</DisplayText><record><rec-number>191</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491149177">191</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Takki, T., Villberg, K., Hongisto, V., Kosonen, R., & Korpi, A</author></authors></contributors><titles><title>A Continuous and Proactive Process to Enhance Well-being Indoors. In Sick Building Syndrome</title><secondary-title>353-370</secondary-title></titles><periodical><full-title>353-370</full-title></periodical><pages>Springer Berlin Heidelberg</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**.

  Noise effects are generally categorized into two broad groups; auditory (noise-induced hearing loss) and non-auditory (behavioral and physiological effects) **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Basner</Author><Year>2014</Year><RecNum>38</RecNum><Prefix>Basner`, et al.`, </Prefix><DisplayText>(Basner, et al., 2014; Seidman & Standring, 2010)</DisplayText><record><rec-number>38</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473707412">38</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S</author></authors></contributors><titles><title>Auditory and non-auditory effects of noise on health</title><secondary-title>The Lancet</secondary-title></titles><periodical><full-title>The Lancet</full-title></periodical><pages>1325-1332</pages><volume>383</volume><number>9925</number><dates><year>2014</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Seidman</Author><Year>2010</Year><RecNum>39</RecNum><Prefix>Seidman & Standring`, </Prefix><record><rec-number>39</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473707499">39</key></foreign-keys><ref-type name="Journal Article">17</ref-

type><contributors><authors><author>Seidman, M. D., & Standring, R. T</author></authors></contributors><titles><title>Noise and quality of life</title><secondary-title>International journal of environmental research and public health</secondary-title></titles><periodical><full-title>International journal of environmental research and public health</full-title></periodical><pages>3730-3738</pages><volume>7</volume><number>10</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}**. It is more likely that low frequency noise (20-100 Hz) which is found in buildings with industrial machines or ventilation machinery may cause health problems **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bluyssen</Author><Year>2011</Year><RecNum>40</RecNum><Prefix>Bluyssen`, et al.`, </Prefix><DisplayText>(Bluyssen, et al., 2011)</DisplayText><record><rec-number>40</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473707631">40</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bluyssen, P. M., Aries, M., & van Dommelen, P</author></authors></contributors><titles><title>Comfort of workers in office buildings: The European HOPE project</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>280-288</pages><volume>46</volume><number>1</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. Noise exposure during night can lead to serious health effects on long-term, such as behavioral problems and cardio vascular effects **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bluyssen</Author><Year>2011</Year><RecNum>40</RecNum><Prefix>Bluyssen`, et al.`, </Prefix><DisplayText>(Bluyssen, et al., 2011)</DisplayText><record><rec-number>40</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473707631">40</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bluyssen, P. M., Aries, M., & van Dommelen, P</author></authors></contributors><titles><title>Comfort of workers in office buildings: The European HOPE project</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>280-288</pages><volume>46</volume><number>1</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. Moreover, it may affect the occupants' hearing abilities, increased systolic blood pressure and chronic headaches **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Wong</Author><Year>2009</Year><RecNum>86</RecNum><Prefix>Wong`, et al.`, </Prefix><DisplayText>(Wong, et al., 2009)</DisplayText><record><rec-number>86</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1475252326">86</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Wong, S. K., Lai, L. W. C., Ho, D. C. W., Chau, K. W., Lam, C. L. K., & Ng, C. H. F</author></authors></contributors><titles><title>Sick building syndrome and perceived indoor environmental quality: A survey of apartment buildings in Hong Kong</title><secondary-title>Habitat International</secondary-title></titles><periodical><full-title>Habitat International</full-title></periodical><pages>463-471</pages><volume>33</volume><number>4</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** studied the relationship between human health and environmental quality through investigating the prevalence of SBS among 748 households and their evaluation of IEQ in Hong Kong. It was shown that nasal discomfort was the most common home-related SBS symptom despite the absence of any central ventilation system in apartment buildings. Furthermore, noise rather than ventilation, was the major IEQ problem perceived by residents.

- *Air quality;* The quality of indoor air can be affected by various factors, such as inappropriate selection of indoor materials or HVAC systems (based on their excessive CO_2 concentrations).This can provide a hospitable environment for growing airborne bacteria and fungi, and subsequently, results in increasing the possibility for respiratory diseases, namely asthma **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bonetta</Author><Year>2010</Year><RecNum>41</RecNum><Prefix>Bonetta`, et al.`, </Prefix><DisplayText>(Bonetta, et al., 2010)</DisplayText><record><rec-number>41</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473708955">41</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bonetta, S., Bonetta, S., Mosso, S., Sampò, S., & Carraro, E</author></authors></contributors><titles><title>Assessment of microbiological indoor air quality in an Italian office building equipped with an HVAC system</title><secondary-title>Environmental monitoring and assessment</secondary-title></titles><periodical><full-title>Environmental monitoring and assessment</full-title></periodical><pages>473-483</pages><volume>161</volume><number>1-4</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}**. Poor quality of indoor air can directly influence the residents' health and their performances **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Pegas</Author><Year>2011</Year><RecNum>42</RecNum><Prefix>Pegas`, et al.`, </Prefix><DisplayText>(Pegas, et al., 2011)</DisplayText><record><rec-number>42</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473709077">42</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Pegas, P. N., Alves, C. A., Evtyugina, M. G., Nunes, T., Cerqueira, M., Franchi, M., ... & Freitas, M. C</author></authors></contributors><titles><title>Indoor air quality in elementary schools of Lisbon in spring</title><secondary-title>Environmental Geochemistry and Health</secondary-title></titles><periodical><full-title>Environmental Geochemistry and Health</full-title></periodical><pages>455-468</pages><volume>33</volume><number>5</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>de Magalhães Rios</Author><Year>2009</Year><RecNum>161</RecNum><Prefix>de Magalhães Rios`, et al.`, </Prefix><DisplayText>(de Magalhães Rios, et al., 2009)</DisplayText><record><rec-number>161</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486033934">161</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>de Magalhães Rios, J. L., Boechat, J. L., Gioda, A., dos Santos, C. Y., de Aquino Neto, F. R., & e Silva, J. R. L</author></authors></contributors><titles><title>Symptoms prevalence among office workers of a sealed versus a non-sealed building: associations to indoor air quality</title><secondary-title>Environment international</secondary-title></titles><periodical><full-title>Environment International</full-title></periodical><pages>1136-1141</pages><volume>35</volume><number>8</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the association between the prevalence of work-related symptoms and the indoor air quality by comparing a sealed office building with a naturally ventilated building. It was concluded that symptoms such as eye dryness, runny nose, dry throat and lethargy were more prevalent in the sealed building. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Gupta</Author><Year>2007</Year><RecNum>175</RecNum><Prefix>Gupta`, et al.`, </Prefix><DisplayText>(Gupta, et al., 2007)</DisplayText><record><rec-number>175</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490640422">175</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gupta, S., Khare, M., & Goyal, R</author></authors></contributors><titles><title>Sick building syndrome—A case study in a multistory centrally air-conditioned building in the Delhi City</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>2797-2809</pages><volume>42</volume><number>8</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the impacts of indoor air quality(IAQ) on the prevalence of SBS symptoms among the office employees in New Delhi, India. Quantitative analysis of IAQ was conducted by monitoring the indoor concentrations of four pollutants, namely, nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), suspended particulate matter (SPM) and carbon monoxide (CO). It was found that the prevailing symptoms were headache (51%), lethargy (50%), and dryness in body mucous (33%). The results indicating a direct relation between the average SBS score and CO_2 concentration was found, i.e., the average SBS score increased with CO_2 concentration and vice versa. Additionally, CO_2 and RH were positively associated with new onset of mucosal, general and school-related symptoms. This was generally supported by **{** ADDIN EN.CITE <EndNote><Cite><Author>Satish</Author><Year>(2012)</Year><RecNum>205</RecNum><DisplayText>(Satish, (2012))</DisplayText><record><rec-number>205</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22"

timestamp="1509182351">205</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Satish, U., Mendell, M. J., Shekhar, K., Hotchi, T., Sullivan, D., Streufert, S., & Fisk, W. J</author></authors></contributors><titles><title>Is CO2 an indoor pollutant? Direct effects of low-to-moderate CO2 concentrations on human decision-making performance</title><secondary-title>Environmental health perspectives</secondary-title></titles><periodical><full-title>Environmental Health Perspectives</full-title></periodical><pages>1671</pages><volume>120</volume><number>12</number><dates><year>(2012)</year></dates><urls></urls></record></Cite></EndNote>**}** who conducted lab-based study using simulated decision-making. The results suggested that CO_2having a significant detrimental impact at 1000 parts per million (ppm) compared to 600ppm, despite 1000ppm being widely considered acceptable.

- *Electromagnetic radiation (ER);* The electromagnetic spectrum refers to a group of distinct forms of energies emanating from multiple sources with various frequencies (Genuis, 2008). The high frequencies are gamma rays, X-rays and ultraviolet light; the lower frequencies of the spectrum include microwaves; medium frequencies include radio waves and light wave emission that provide the possibility to perceive the vision and the light and infrared energy which allows perceiving the heat (Genuis, 2008). Ionizing radiation is a term to describe the human exposure to the sources of energy with high frequencies which results in causing serious health issues (Christensen, et al. 2014; Azzam, et al. 2012). This phenomenon may intrigue the risk of malignancy or cell death by altering the atomic composition of cell structures, breaking the chemical bonds and inducing free radical formation (Genuis, 2008; Azzam, et al. 2012). Fife (2017) mentioned that '*electromagnetic energy surrounds and penetrates our homes, our work environment and every place-in-between*'. In this regards, Zamanian and Hardiman (2005) stated that human beings are constantly exposed to low levels of ionizing radiation from natural sources such as sunlight, radioactive materials on the earth's surface, radioactive gases leaking from the earth, cosmic rays from outer space entering the earth's atmosphere through the ionosphere and natural radioactivity.

  The natural radioactivity has been around since the beginning of universe due to the found radioelement in the earth's crust. The radionuclides of ^{226}Ra, ^{232}Th and ^{40}K can be almost found in all types of rocks, granite, sand, cement and gypsum, from which majority of building materials are produced (Mavi and Akkurt, 2010). As such, materials obtained from the earth's crust contain traces of ^{238}U and ^{232}Th (Bavarnegin, et al. 2013). In the ^{238}U series, ^{226}Ra decays to radon (^{222}Rn), which is a radioactive gas with a half-life of 3.82 days (Bavarnegin, et al. 2013; Lu, et al. 2012; Baykara, et al. 2011). Prolonged exposure of occupants to the indoor radon causes pathological effects and functional respiratory alterations, by which consequently lead to serious risks of developing lung cancer (Bavarnegin, et al. 2013; Saad, et al. 2014). The severity of this risk depends on the concentration of radon indoors, the duration of exposure, and the degree of ventilation in the houses (Saad, et al. 2014). To this extent, the significance of addressing the exposure of human beings originating from the building materials has been underlined by several initiatives. For instance, the article 75 of the Euratom basic safety standards (EU-BSS) (Council directive 2013/59/Euratom) stipulated that, '*the reference level applying to indoor external exposure to gamma radiation emitted by building materials, in addition to outdoor external exposure, shall be 1 MilliSievert (mSv) per year*' (European Council, 2014). EU-BSS is expected to be transposed to national law by EU Member States before February 2018, aiming to establish a basic standard adoptable by the EU members to protect the public against the exposure of ionising radiation (Croymans, et al. 2018; Schroeyers, et al. 2018). Studies have widely addressed the issue associated with the emission of natural radioactivity from building materials (Mavi and Akkurt, 2010; Chen, et al. 2010; Saad, et al. 2014; Bavarnegin, et al. 2013; Lu, et al. 2012; Ravisankar, et al. 2012). In one attempt, Mavi and Akkurt (2010) measured the radioactivity of commonly-used building materials, namely brick, cement, limestone, ytong, limra, gypsum, ceramic tile and gravel existing in Ispartacity of Turkey. They conclusively stated that the levels of natural radioactivity in these materials were below the acceptable limits. Saad, et al. (2014) also assessed the rates of radon exhalation concerned with 37 samples of different building materials which were being utilized for the purposes of construction and decoration in Libyan market. The results identified two materials, Indian granite and Italian marble, with high values of radon concentration, in which have been recommended to be substituted by alternatives.

- *Biological contributors;* IAQ can be affected by development of moulds, fungi and mites inside the buildings and endanger the occupants' wellbeing and health status. Several contributors can be mentioned with the association to the growth of biological factors inside the buildings namely, building's structural failure, poor air ventilation or improper maintenance of building **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Johansson</Author><Year>2013</Year><RecNum>45</RecNum><Prefix>Johansson

`, et al.`, </Prefix><DisplayText>(Johansson, et al., 2013; Vereecken & Roels, 2012)</DisplayText><record><rec-number>45</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473798553">45</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Johansson, P., Svensson, T., & Ekstrand-Tobin, A</author></authors></contributors><titles><title>Validation of critical moisture conditions for mould growth on building materials</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>201-209</pages><volume>62</volume><dates><year>2013</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Vereecken</Author><Year>2012</Year><RecNum>46</RecNum><Prefix>Vereecken & Roels`, </Prefix><record><rec-number>46</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473798775">46</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Vereecken, E., & Roels, S</author></authors></contributors><titles><title>Review of mould prediction models and their influence on mould risk evaluation</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>296-310</pages><volume>51</volume><dates><year>2012</year></dates><urls></urls></record></Cite></EndNote>**}**. Consistent exposure of residents with these infected environments can result in occurring health-related issues such as respiratory and allergic diseases **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Singh</Author><Year>2005</Year><RecNum>43</RecNum><Prefix>Singh`, </Prefix><DisplayText>(Singh, 2005; Singh, et al., 2010)</DisplayText><record><rec-number>43</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473798181">43</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Singh, J</author></authors></contributors><titles><title>Toxic moulds and indoor air quality</title><secondary-title>Indoor and Built Environment</secondary-title></titles><periodical><full-title>Indoor and Built Environment</full-title></periodical><pages>229-234</pages><volume>14</volume><number>3-4</number><dates><year>2005</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Singh</Author><Year>2010</Year><RecNum>44</RecNum><Prefix>Singh`, et al.`, </Prefix><record><rec-number>44</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473798287">44</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Singh, J., Yu, C. W. F., & Kim, J. T</author></authors></contributors><titles><title>Building pathology, investigation of sick buildings—toxic moulds</title><secondary-title>Indoor and Built Environment</secondary-title></titles><periodical><full-title>Indoor and Built Environment</full-title></periodical><pages>40-47</pages><volume>19</volume><number>1</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sun</Author><Year>2013</Year><RecNum>52</RecNum><Prefix>Sun`, et al.`, </Prefix><DisplayText>(Sun, et al., 2013)</DisplayText><record><rec-number>52</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474012954">52</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sun, Y., Zhang, Y., Bao, L., Fan, Z., Wang, D., & Sundell, J</author></authors></contributors><titles><title>Effects of gender and dormitory environment on sick building syndrome symptoms among college students in Tianjin, China</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>134-139</pages><volume>68</volume><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>**}** carried out a research to investigate the dorm environment and college students' health in Tianjin, China. They found that local moldy odor was a significant risk factor for nose irritation. Since 2004, the development of quantitative polymerase chain reaction (QPCR) analysis of molds (US. Patent 6,387,652) has dramatically improved fungal speciation and quantification, resulting in a highly standardized process for describing the indoor fungal population **{** ADDIN EN.CITE <EndNote><Cite><Author>EPA</Author><Year>2004</Year><RecNum>172</RecNum><DisplayText>(EPA, 2004; Vesper & Vesper, 2004)</DisplayText><record><rec-number>172</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490635260">172</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>EPA</author></authors></contributors><titles><title>United States

Environmental Protection Agency (EPA). EPA Science Inventory. 21th century mold analysis in food. Available on: https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=75868. Accessed: 26/03/2017</title></titles><dates><year>2004</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Vesper</Author><Year>2004</Year><RecNum>173</RecNum><Prefix>Vesper & Vesper`, </Prefix><record><rec-number>173</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490635519">173</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Vesper, S. J., & Vesper, M. J</author></authors></contributors><titles><title>Possible role of fungal hemolysins in sick building syndrome</title><secondary-title>Advances in applied microbiology</secondary-title></titles><periodical><full-title>Advances in applied microbiology</full-title></periodical><pages>191-213</pages><volume>55</volume><dates><year>2004</year></dates><urls></urls></record></Cite></EndNote>**}**. Recently, studies are focused on identifying the significance of biological attributes, namely fungi that can potentially contribute to SBS. In one attempt, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Boechat</Author><Year>2011</Year><RecNum>171</RecNum><Prefix>Boechat`, et al. </Prefix><DisplayText>(Boechat, et al. 2011)</DisplayText><record><rec-number>171</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490629573">171</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Boechat, J. L., Rios, J. L., Ramos, M. C., Luiz, R. R., Neto, F. A., & e Silva, J. L</author></authors></contributors><titles><title>Sick Building Syndrome (SBS) Among Office Workers and Exposure to Indoor Fungal Allergens in Rio de Janeiro, Brazil</title><secondary-title>Journal of Allergy and Clinical Immunology</secondary-title></titles><periodical><full-title>Journal of Allergy and Clinical Immunology</full-title></periodical><pages>AB178</pages><volume>127</volume><number>2</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the prevalence of SBS in workers of two buildings and its relationship with fungal exposure in the workplace in Rio de Janeiro, Brazil. Based on the medical examination and a score-based questionnaire, they evaluated the SBS diagnosis of 160 full-time workers of a sealed building, and 164 employers from a naturally ventilated building. The results indicated that the prevalence of SBS in the sealed building and non-sealed buildings were 44.8% and 48.6%, respectively. They stated that, fungi exposure was the unique significant risk factor for SBS in the non-sealed building, whilst no significant exposure to fungi in the indoor environment of the sealed building was found. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Polizzi</Author><Year>2011</Year><RecNum>180</RecNum><Prefix>Polizzi`, et al.`, </Prefix><DisplayText>(Polizzi, et al., 2011)</DisplayText><record><rec-number>180</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490785374">180</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Polizzi, V., Adams, A., Picco, A. M., Adriaens, E., Lenoir, J., Van Peteghem, C., ... & De Kimpe, N</author></authors></contributors><titles><title>Influence of environmental conditions on production of volatiles by Trichoderma atroviride in relation with the sick building syndrome</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>945-954</pages><volume>46</volume><number>4</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}** also announced that the *6-pentyl-2-pyrone* produced by *T. atroviride*, a mold present in damp dwellings, can result in the appearance of SBS symptoms. The *6-pentyl-2-pyrone* is a compound emitted on common building materials that could give irritation and damage to mucosal membranes.

- *Chemical contributors:* Certain chemical substances and dust could lead to developing SBS. For example, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sahlberg</Author><Year>2013</Year><RecNum>53</RecNum><Prefix>Sahlberg`, et al.`, </Prefix><DisplayText>(Sahlberg, et al., 2013)</DisplayText><record><rec-number>53</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474015222">53</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sahlberg, B., Gunnbjörnsdottir, M., Soon, A., Jogi, R., Gislason, T., Wieslander, G., ... & Norback, D</author></authors></contributors><titles><title>Airborne molds and bacteria, microbial volatile organic compounds (MVOC), plasticizers and formaldehyde in dwellings in three North European cities in relation to sick building syndrome (SBS)</title><secondary-title>Science of the total environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>433-

440</pages><volume>444</volume><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>**}** examined the association between volatile organic compounds (VOCs) of possible microbial origin (MVOCs), and airborne levels of bacteria, molds, formaldehyde, and two plasticizers in dwellings with the prevalence of SBS. This study was conducted with participation of 159 adults selected from three cities in Sweden, Iceland and Estonia. The conclusion confirmed the existence of a positive association between MVOCs, formaldehyde and the plasticizer texanol with appearance of symptoms of sick buildings, namely mucosal symptoms. On the other hand, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Takigawa</Author><Year>2010</Year><RecNum>54</RecNum><Prefix>Takigawa`, et al.`, </Prefix><DisplayText>(Takigawa, et al., 2010)</DisplayText><record><rec-number>54</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474041872">54</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Takigawa, T., Wang, B. L., Saijo, Y., Morimoto, K., Nakayama, K., Tanaka, M., ... & Kishi, R</author></authors></contributors><titles><title>Relationship between indoor chemical concentrations and subjective symptoms associated with sick building syndrome in newly built houses in Japan</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>225-235</pages><volume>83</volume><number>2</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the possible relationship between chemical substances and SBS symptoms of residents living in newly constructed houses in Japan. The results demonstrated the positive association between existence of VOCs and aldehydes with optical, nasal, and gular symptoms. They concluded that chemicals detected in Japanese newly built houses tend to increase the risk of subjective symptoms in residents suffering from SBS. In another study **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Sahlberg</Author><Year>2009</Year><RecNum>168</RecNum><Prefix>Sahlberg`, et al.`, </Prefix><DisplayText>(Sahlberg, et al., 2009)</DisplayText><record><rec-number>168</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486712626">168</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sahlberg, B., Mi, Y. H., & Norbäck, D</author></authors></contributors><titles><title>Indoor environment in dwellings, asthma, allergies, and sick building syndrome in the Swedish population: a longitudinal cohort study from 1989 to 1997</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>1211-1218</pages><volume>82</volume><number>10</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the changes of SBS and different types of indoor exposures at home for the period of 8 years. They concluded that indoor painting is one of the major to SBS. In addition, the presence of fine dust was found to be associated with SBS **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2016</Year><RecNum>6</RecNum><Prefix>Norbäck`, et al.`, </Prefix><DisplayText>(Norbäck, et al., 2016)</DisplayText><record><rec-number>6</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469640899">6</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., Hashim, J. H., Markowicz, P., Cai, G. H., Hashim, Z., Ali, F., & Larsson, L</author></authors></contributors><titles><title>Endotoxin, ergosterol, muramic acid and fungal DNA in dust from schools in Johor Bahru, Malaysia-Associations with rhinitis and sick building syndrome (SBS) in junior high school students</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>95-

103</pages><volume>545</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** studied the appearance of SBS among 462 students at secondary schools in Johor Bahru, Malaysia. The results confirmed a positive association between the existence of fine dust in the classroom and appearing of some symptoms of sick buildings i.e. ocular symptoms and rhinitis. Furthermore, there were positive associations between C14 3-OH and rhinitis and between C18 3-OH and dermal symptoms.

- *Psychosocial contributors*: SBS can pose serious threats on occupants' psychosocial status through subjecting them with anxiety, depression, environmental discomfort, job strain and reducing the occupants' performances. One of the psychosocial factors that is believed to be effective in the development of SBS is monotonous work environment. Monotonous work refers to the state that the employees are obligated to constantly repeating activities or tasks **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Gül</Author><Year>2011</Year><RecNum>188</RecNum><Prefix>Gül`, </Prefix><DisplayText>(Gül, 2011)</DisplayText><record><rec-number>188</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491058525">188</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gül, H</author></authors></contributors><titles><title>Sick Building Syndrome from the Perspective of Occupational and Public Health. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg</full-title></periodical><pages>89-104</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. This can result in degrading the productivity rate of employees as they may become mentally disengaged with their tasks. Additionally, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Crawford</Author><Year>1996</Year><RecNum>167</RecNum><Prefix>Crawford & Bolas`, </Prefix><DisplayText>(Crawford & Bolas, 1996)</DisplayText><record><rec-number>167</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486195696">167</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Crawford, J. O., & Bolas, S. M</author></authors></contributors><titles><title>Sick building syndrome, work factors and occupational stress</title><secondary-title>Scandinavian journal of work, environment & health</secondary-title></titles><periodical><full-title>Scandinavian journal of work, environment & health</full-title></periodical><pages>243-250</pages><dates><year>1996</year></dates><urls></urls></record></Cite></EndNote>**}** underlined the role of occupational stress to be closely correlated with appearance of SBS symptoms. Nevertheless, it should be argued that despite the significant impact of psychosocial contributor, the number of existing studies with focus on examining its impacts is relatively limited.

- *Individual contributors*: Personal characteristics of individual's might amplify the effect of SBSs on occupants. To explain, gender, genetic tendency to develop allergy, smoking status and psychological state were found to be associated with SBS **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. In one study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the associations between SBS symptoms, selected personal factors, office characteristics and indoor office exposures among office workers from a university in Malaysia. It was concluded that a combination of allergy to cat or house dust mites is a risk factor for SBS. On the other hand, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Zhang</Author><Year>2011</Year><RecNum>58</RecNum><Prefix>Zhang`, et al.`, </Prefix><DisplayText>(Zhang, et al., 2011)</DisplayText><record><rec-number>58</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474181393">58</key></foreign-keys><ref-type name="Journal Article">17</ref-

type><contributors><authors><author>Zhang, X., Zhao, Z., Nordquist, T., & Norback, D</author></authors></contributors><titles><title>The prevalence and incidence of sick building syndrome in Chinese pupils in relation to the school environment: a two-year follow-up study</title><secondary-title>Indoor air</secondary-title></titles><periodical><full-title>Indoor Air</full-title></periodical><pages>462-471</pages><volume>21</volume><number>6</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}** conducted a two-year study investigating changes of SBS symptoms in Chinese pupils pertained to the parental asthma/allergy, own atopy, classroom temperature, relative and absolute humidity, crowdedness, IAQ (i.e. CO_2, NO_2, and SO_2). It was found that parental asthma/allergy and atopy were correlated with incidence of SBS.

The attributes causing SBS will not be limited to the mentioned contributors, other factors such as 'building materials', 'poor sanitation', 'availability of ozone, organic solvents and formaldehyde in the atmosphere', 'office equipment, furnishings and other materials and products located or used in the building with potentials to produce fumes or contact dermatitis', 'air borne chemical fumes or gasses from any components in the building' and 'vermin (i.e., mice, rats and cockroaches) infestation' can also play a significant role towards the unhealthy status of a building **{** ADDIN EN.CITE <EndNote><Cite><Author>Jansz</Author><Year>2011</Year><RecNum>187</RecNum><DisplayText>(Jansz, 2011b)</DisplayText><record><rec-number>187</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491056316">187</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jansz, J</author></authors></contributors><titles><title>Theories and knowledge about sick building syndrome. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg</full-title></periodical><pages>25-58</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. In a study, Lee, et al. (2001) employed a test chamber to characterize the rate of pollutants introduced from certain office equipment, namely fax machines, laser printers, ink-jet printers, scanners and photocopying machines. They measured the concentrations of VOCs, total VOC (TVOC), ozone, respirable particles (PM10) and temperature associated with the usage of these equipment. The results indicated that the highest emission rates of VOCs compounds were toluene, ethylbenzene, m,p-xylene, and styrene. Also, the emissions of ozone and VOC produced through the laser printers were significantly higher than ink-jet printers. In another study, Kowalska, et al. (2015) analyzed the indoor emissions of volatile halogenated organic compounds (VHOCs) produced through office printers and copiers by taking samples in laboratory conditions during the operation of these appliances. The tests of VHOCs were performed by dint of utilizing a simulated environment (test chamber). The results showed that, the operation of these devices can significantly lead to producing VOCs in typical office indoor air. Furthermore, the chlorinated organic compounds were the only determinants found amongst the examined VHOCs, which may possibly contribute to carcinogenic.

Table 3 summarizes the major effects of each contributor on the occupants' well-being. It can be conclusively mentioned that attributes pertained to the physical features of buildings may have a more determinative influence in stimulating the emergence of SBS' symptoms. The negative impacts of physical contributors on occupants' health during the operational phase of building can be initially neutralized through considering health-related design principles during the building's design phase. The building's orientation **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Abanda</Author><Year>2016</Year><RecNum>128</RecNum><Prefix>Abanda & Byers`, </Prefix><DisplayText>(Abanda & Byers, 2016; Mangkuto, et al., 2016)</DisplayText><record><rec-number>128</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480272307">128</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Abanda, F. H., & Byers, L</author></authors></contributors><titles><title>An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling)</title><secondary-title>Energy</secondary-title></titles><periodical><full-title>Energy</full-title></periodical><pages>517-527</pages><volume>97</volume><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Mangkuto</Author><Year>2016</Year><RecNum>129</RecNum><Prefix>Mangkuto`, et al.`, </Prefix><record><rec-number>129</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480272735">129</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Mangkuto, R. A., Rohmah, M., & Asri, A. D</author></authors></contributors><titles><title>Design optimisation for window size, orientation, and wall reflectance with regard to various daylight metrics and lighting energy demand: A case study of buildings in the tropics</title><secondary-title>Applied Energy</secondary-title></titles><periodical><full-title>Applied Energy</full-title></periodical><pages>211-219</pages><volume>164</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**, felicitous selection of building materials in accordance with local climate **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Mirrahimi</Author><Year>2016</Year><RecNum>130</RecNum><Prefix>Mirrahimi`, et al.`, </Prefix><DisplayText>(Mirrahimi, et al., 2016)</DisplayText><record><rec-number>130</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480273441">130</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Mirrahimi, S., Mohamed, M. F., Haw, L. C., Ibrahim, N. L. N., Yusoff, W. F. M., & Aflaki, A</author></authors></contributors><titles><title>The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate</title><secondary-title>Renewable and Sustainable Energy Reviews</secondary-title></titles><periodical><full-title>Renewable and Sustainable Energy Reviews</full-title></periodical><pages>1508-1519</pages><volume>53</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**, application of passive techniques in building envelope such as passive walls **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Omrany</Author><Year>2016</Year><RecNum>131</RecNum><Prefix>Omrany`, et al.`, </Prefix><DisplayText>(Bellos, et al., 2016; Omrany, et al., 2016)</DisplayText><record><rec-number>131</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480273599">131</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Omrany, H., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Raahemifar, K., & Tookey, J</author></authors></contributors><titles><title>Application of passive wall systems for improving the energy effciency in buildings: A comprehensive review</title><secondary-title>Renewable and Sustainable Energy Reviews</secondary-title></titles><periodical><full-title>Renewable and Sustainable Energy Reviews</full-title></periodical><pages>1252-1269</pages><volume>62</volume><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Bellos</Author><Year>2016</Year><RecNum>132</RecNum><Prefix>Bellos`, et al.`, </Prefix><record><rec-number>132</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480273679">132</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bellos, E., Tzivanidis, C., Zisopoulou, E., Mitsopoulos, G., & Antonopoulos, K. A</author></authors></contributors><titles><title>An innovative Trombe wall as a passive heating system for a building in Athens—A comparison with the conventional Trombe wall and the insulated wall</title><secondary-title>Energy and Buildings</secondary-title></titles><periodical><full-title>Energy and Buildings</full-title></periodical><pages>754-769</pages><volume>133</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** are some primitive measures that can be taken during the design phase in order to preclude the occurrence of physical contributors.

Table 3. SBS Contributors

Contributor			Effects
Physical	*Temperature*	Deviation from the thermal comfort threshold (hot or cold). 21°C is recommended for better performance and health.	Distraction, Lowering the rate of productivity
	Humidity	Temperature above 32ºC and relative humidity above 60%	Growing mildews and molds, muscle cramps, fainting, heat stroke, exacerbation of medical conditions
	Ventilation	Poor ventilation, less than of 8 Litter/Second per person ventilation rate	Lowering the rate of productivity, nose and throat irritation, headaches, fatigue, asthma, rhinitis and a susceptibility to colds and flu
	Illuminance level	Poor quality of light, poor illumination levels. 1000lux is suggested for better performance and health.	Disruption of sleep pattern, lowering the rate of productivity, increased possibility for occurring hazardous events
	Noise	low frequency noise (20-100 Hz), Noise exposure during night,	Distractions, affecting occupants' performances, behavioral problems and cardio vascular effects,

			hearing issues, headaches, increasing blood pressure
	Air quality	Poor quality of indoor air, CO_2, SO_2, O_3,PM_{10}	Respiratory diseases, lowering the rate of productivity, tiredness, decision-making
	Electromagnetic radiation (ER)	Protracted exposure to the building materials emitting	Respiratory diseases and lung cancer
Biological		Moulds, fungi and mites, *6-pentyl-2-pyrone*	respiratory and allergic diseases, mucosal and skin problems, nose irritation
Chemical		Building materials, MVOCs, formaldehyde, plasticizer texanol, fine dust, C14 3-OH, C18 3-OH C02 concentrations	Mucosal, optical, nasal, gular, ocular and rhinitis symptoms, respiratory issues
Psychosocial		Monotonous work environment, occupational stress	Anxiety, depression, environmental discomfort, job strain and reduction in performances
Individual		Gender, genetic tendency to develop allergy, atopy, parental asthma/allergy, smoking status and psychological state	Individual with these characteristics are more likely to experience different types of SBSs.

The occurrence of SBS can be recognized in various environments such as office spaces **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**, residential environments **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**, schools **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**, universities **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Ahmad</Author><Year>2015</Year><RecNum>11</RecNum><Prefix>Ahmad & Hassim.`, </Prefix><DisplayText>(Ahmad & Hassim., 2015)</DisplayText><record><rec-number>11</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469865053">11</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ahmad, N., & Hassim, M. H. </author></authors></contributors><titles><title>Assessment of indoor air quality level and sick building syndrome according to the ages of buildings in Universiti Teknologi Malaysia</title><secondary-title>Jurnal Teknologi</secondary-title></titles><periodical><full-title>Jurnal Teknologi</full-title></periodical><volume>76</volume><number>1</number><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}** or hospitals **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. The core symptoms of SBS may concern with the health status of occupants, either physically or mentally. These symptoms can potentially incur many negative effects on the occupants. Majority of these negative effects are interrelated, in which the occurrence of one effect may trigger the emergence of another (Vural and Balanlı, 2011; Abdul-Wahab, 2011).

2.2.1 Symptomatology

Recent studies **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}** suggested several symptoms for SBS, affecting different parts of human body ranging from headache, fatigue and irritation in upper respiratory tract to nose, throat, eyes, and dermal abnormalities. These signs can be categorized into eight main groups (See Table 4):

Table 4. SBS symptoms

Category	**Symptoms**	**Description**
Respiratory	Allergic Rhinitis (repetitive sneezing and a runny nose),Sinus congestion, Influenza like symptoms, Dry Cough, Throat irritation, Wheezing when breathing, Shortness of breath, Sensation of having dry mucus membranes, Hoarseness of the voice due to inflammation of the throat and larynx, Sensitivity to odors, Increased incidences of building related asthma attacks, Asthma	It refers to the symptoms that concern the respiratory system of patients **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Choi</Author><Year>2017</Year><RecNum>150</RecNum><Prefix>Choi`, et al.`, </Prefix><DisplayText>(Choi, et al., 2017; Norbäck, et al., 2017)</DisplayText><record><rec-number>150</rec-number><foreign-

keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485888896">150</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Choi, H., Schmidbauer, N., & Bornehag, C. G</author></authors></contributors><titles><title>Volatile organic compounds of possible microbial origin and their risks on childhood asthma and allergies within damp homes</title><secondary-title>Environment International</secondary-title></titles><periodical><full-title>Environment International</full-title></periodical><pages>143-151</pages><volume>98</volume><dates><year>2017</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2017</Year><RecNum>149</RecNum><Prefix>Norbäck`, et al.`, </Prefix><record><rec-number>149</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1485888800">149</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., Hashim, J. H., Hashim, Z., Cai, G. H., Sooria, V., Ismail, S. A., & Wieslander, G</author></authors></contributors><titles><title>Respiratory symptoms and fractional exhaled nitric oxide (FeNO) among students in Penang, Malaysia in relation to signs of dampness at school and fungal DNA in school dust</title><secondary-title>Science of The Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>148-154</pages><volume>577</volume><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>**}**.

Nasal	Runny nose, Sneezing, Blocked nose, Nose bleeding	One of the most frequent symptoms that inhabitants of sick buildings suffer is the nasal irritation with rhinorrhea and nasal obstruction. This symptom which is

		usually considered as ‘nasal stuffiness’ may appear alongside the other factors **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**.
Ocular	Eye dryness, Itching of the eyes, Watering of the eyes, Gritty eyes, Eye Burning, Visual disturbances, Light sensitivity, Swollen eyelids	It refers to the presence of issues related to the dryness and irritation of mucous membrane of eye and swollen eyelids **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**.
Oropharyngeal	Dryness and irritation of the throat, Dry sore throat	It refers to the presence of dryness and irritation of the throat **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**.
Cutaneous	Skin rashes, Itchy skin, Dry skin, Erythema (Redness or inflammation due to congestion in, and dilation of, the superficial capillaries of the skin.), Irritation and dryness of the lips, Seborrheic dermatitis, Periorbital eczema, Rosacca, Uritcaria, Itching folliculitis	This is related to the appearance of dryness and irritation of skin, which occasionally associated with rashes exposed on the skin surfaces **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Maoz-Segal</Author><Year>2015</Year><RecNum>16</RecNum><Prefix>Maoz-Segal`, et al.`, </Prefix><DisplayText>(Lu, et al., 2016; Maoz-Segal, et al., 2015)</DisplayText><record><rec-number>16</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469958717">16</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Maoz-Segal, R., Agmon-Levin, N., Israeli, E., & Shoenfeld, Y. </author></authors></contributors><titles><title>The sick building syndrome as a part of'ASIA'(autoimmune/auto-inflammatory syndrome induced by adjuvants)</title><secondary-title>Harefuah</secondary-title></titles><pages>129-32</pages><volume>154</volume><number>2</number><dates><year>2015</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Lu</Author><Year>2016</Year><RecNum>2</RecNum><Prefix>Lu`, et al.`, </Prefix><record><rec-number>2</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624654">2</key></foreign-keys><ref-type name="Journal

		Article">17</ref-type><contributors><authors><author>Lu, C., Deng, Q., Li, Y., Sundell, J., & Norbäck, D. </author></authors></contributors><titles><title>Outdoor air pollution, meteorological conditions and indoor factors in dwellings in relation to sick building syndrome (SBS) among adults in China</title><secondary-title>Science of The Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>186-196</pages><volume>560</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**.
Lethargy	Lethargy, Difficulty in concentrating, Mental fatigue, General fatigue, Unable to think clearly, Drowsy	It refers to the emergence of symptoms that cause the occupants feel laziness **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>de Magalhães Rios</Author><Year>2009</Year><RecNum>161</RecNum><Prefix>de Magalhães Rios`, et al.`, </Prefix><DisplayText>(de Magalhães Rios, et al., 2009; Gupta, 2007)</DisplayText><record><rec-number>161</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486033934">161</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>de Magalhães Rios, J. L., Boechat, J. L., Gioda, A., dos Santos, C. Y., de Aquino Neto, F. R., & e Silva, J. R. L</author></authors></contributors><titles><title>Symptoms prevalence among office workers of a sealed versus a non-sealed building: associations to indoor air quality</title><secondary-title>Environment international</secondary-title></titles><periodical><full-title>Environment International</full-title></periodical><pages>1136-1141</pages><volume>35</volume><number>8</number><dates><year>2009</year></dates><urls></urls></record></Cite><Cite><Author>Gupta</Author><Year>2007</Year><RecNum>175<

		/RecNum><record><rec-number>175</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490640422">175</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gupta, S., Khare, M., & Goyal, R</author></authors></contributors><titles><title>Sick building syndrome—A case study in a multistory centrally air-conditioned building in the Delhi City</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>2797-2809</pages><volume>42</volume><number>8</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}**.
Cognitive	Functional headache that affect a person's performance, but which fail to reveal evidence of physiological or structural abnormalities, Migraine headache, Tension headache, Sinus headache due to swelling of the mucus membranes, Mental confusion	It refers to the manifestation of illness that concern the occupants' concentration **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**.
General	Nausea, Dizziness, Unspecified hypersensitivity reactions, deteriorating the pre-existing illnesses i.e., asthma, sinusitis or eczema.	It refers to the general symptoms such as nausea, unspecified hypersensitivity reactions, exacerbation of pre-existing illnesses such as asthma, sinusitis or eczema.

2.2.2 Psychological well-being and satisfaction

Sick buildings can induce the appearance of psychological symptoms such as stress, anxiety and aggression in occupants **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Kamaruzzaman</Author><Year>2011</Year><RecNum>47</RecNum><Prefix>Kamaruzzaman & Sabrani`, </Prefix><DisplayText>(Kamaruzzaman & Sabrani, 2011; Runeson-Broberg & Norbäck, 2013)</DisplayText><record><rec-number>47</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473846591">47</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Kamaruzzaman, SN., & Sabrani, NA</author></authors></contributors><titles><title>The effect of indoor air quality (IAQ) towards occupants' psychological performance in office buildings</title><secondary-title>Jurnal Rekabentuk dan Binaan</secondary-title></titles><periodical><full-title>Jurnal Rekabentuk dan Binaan</full-title></periodical><pages>49-61</pages><volume>4</volume><dates><year>2011</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Runeson-Broberg</Author><Year>2013</Year><RecNum>48</RecNum><Prefix>Runeson-Broberg & Norbäck`, </Prefix><record><rec-number>48</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1473846678">48</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Runeson-Broberg, R., & Norbäck, D</author></authors></contributors><titles><title> Sick building syndrome (SBS) and sick house syndrome (SHS) in relation to psychosocial stress at work in the Swedish workforce</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages> 915-922</pages><volume>86</volume><number>8</number><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>**}**. These psychological disorders may further result in increasing people' susceptibilities toward other environmental factors, lowering workers' performances and increase absenteeism **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Rydstedt</Author><Year>2016</Year><RecNum>126</RecNum><Prefix>Rydstedt`, </Prefix><DisplayText>(Realyvásquez, et al., 2016; Rydstedt, 2016)</DisplayText><record><rec-number>126</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480239505">126</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Rydstedt, L. W</author></authors></contributors><titles><title>Psychosocial job strain as a mediator between physical working conditions and symptoms associated with sick building syndrome</title><secondary-title>Human Affairs</secondary-title></titles><periodical><full-title>Human Affairs</full-title></periodical><pages>440-449</pages><volume>26</volume><number>4</number><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Realyvásquez</Author><Year>2016</Year><RecNum>127</RecNum><Prefix>Realyvásquez`, et al.`, </Prefix><record><rec-number>127</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480239599">127</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Realyvásquez, A., Maldonado-Macías, A. A., García-Alcaraz, J., Cortés-Robles, G., & Blanco-Fernández, J</author></authors></contributors><titles><title>Structural Model for the Effects of Environmental Elements on the Psychological Characteristics and Performance of the Employees of Manufacturing Systems</title><secondary-title>International journal of environmental research and public health</secondary-title></titles><periodical><full-title>International journal of environmental research and public health</full-title></periodical><pages>104</pages><volume>13</volume><number>1</number><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**. These negative psychological effects of being in sick buildings can further result in subsequent issues for occupants such as increasing the possibility for occurring the hazardous events in workplace. Likewise, SBS can also influence occupants' satisfaction. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Gavhed</Author><Year>2007</Year><RecNum>160</RecNum><Prefix>Gavhed & Toomingas`, </Prefix><DisplayText>(Gavhed & Toomingas, 2007)</DisplayText><record><rec-number>160</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486015393">160</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Gavhed, D., & Toomingas, A</author></authors></contributors><titles><title>Observed physical working conditions in a sample of call centres in Sweden and their relations to directives, recommendations and operators' comfort and symptoms</title><secondary-title>International Journal of Industrial Ergonomics</secondary-title></titles><periodical><full-title>International Journal of Industrial Ergonomics</full-title></periodical><pages>790-800</pages><volume>37</volume><number>9</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}** counted poor illumination levels, besides indoor climate, the air quality, the ambient noise level, as the major contributors leading to dissatisfaction among Swedish employees. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Newsham</Author><Year>2009</Year><RecNum>166</RecNum><Prefix>Newsham`, et al.`, </Prefix><DisplayText>(Newsham, et al., 2009)</DisplayText><record><rec-number>166</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486194480">166</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Newsham, G., Brand, J., Donnelly, C., Veitch, J., Aries, M., & Charles, K</author></authors></contributors><titles><title>Linking indoor environment conditions to job satisfaction: a field study</title><secondary-title>Building Research & Information</secondary-title></titles><periodical><full-title>Building Research & Information</full-title></periodical><pages>129-147</pages><volume>37</volume><number>2</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** studied the effects of physical measurements such as thermal, lighting, and acoustic variables, furniture dimensions, and an assessment of potential exterior view on the employees' performances at an open-plan office building in Michigan, US. Results highlighted the significant role of window access at the desk in satisfaction with lighting, particularly through its effect on satisfaction with outside view.

2.2.3 Productivity and Associated Costs

The negative effects of sick buildings can be also regarded in terms of costs imposing upon occupants. These expenses may appear in various forms, namely absence from work, lower productivity, remedial expenses, or increasing the building energy consumption **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Fisk</Author><Year>2012</Year><RecNum>18</RecNum><Prefix>Fisk`, et al.`, </Prefix><DisplayText>(Fisk, et al., 2011; Fisk, et al., 2012)</DisplayText><record><rec-number>18</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1470648707">18</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Fisk, W. J., Black, D., & Brunner, G. </author></authors></contributors><titles><title>Changing ventilation rates in US offices: Implications for health, work performance, energy, and associated economics</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>368-372</pages><volume>47</volume><dates><year>2012</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Fisk</Author><Year>2011</Year><RecNum>19</RecNum><Prefix>Fisk`, et al.`, </Prefix><record><rec-number>19</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1470649279">19</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Fisk, W. J., Black, D., & Brunner, G. </author></authors></contributors><titles><title>Benefits and costs of improved IEQ in US offices</title><secondary-title>Indoor Air</secondary-title></titles><periodical><full-title>Indoor Air</full-title></periodical><pages>357-367</pages><volume>21</volume><number>5</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**.The Carnegie Mellon's E-bids project found that natural ventilation or mixed-mode conditioning could achieve 0.8 - 1.3% savings on health costs, 3 - 18% productivity gains, and 47 - 79% in HVAC energy savings (**{** ADDIN EN.CITE <EndNote><Cite><RecNum>206</RecNum><DisplayText>("World Green Building Council. (2004). Health, wellbeing and productivity in offices,")</DisplayText><record><rec-number>206</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509183148">206</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors></contributors><titles><title>World Green Building Council. (2004). Health, wellbeing and productivity in offices</title><secondary-title>The next chapter for green building. Accessed via: http://www.jll.com/Research/Health_Wellbeing_Productivity.pdf?1a56c1ad-7be7-4d6d-8f32-74bb6e72fa3f. Last accessed: 10 October 2017</secondary-title></titles><periodical><full-title>The next chapter for green building. Accessed via: http://www.jll.com/Research/Health_Wellbeing_Productivity.pdf?1a56c1ad-7be7-4d6d-8f32-74bb6e72fa3f. Last accessed: 10 October 2017</full-title></periodical><dates></dates><urls></urls></record></Cite></EndNote>**}**In another study, **{** ADDIN EN.CITE <EndNote><Cite><Author>Bekö</Author><Year>(2008)</Year><RecNum>208</RecNum><DisplayText>(Bekö, (2008))</DisplayText><record><rec-number>208</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509185700">208</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bekö, G., Clausen, G., & Weschler, C. J</author></authors></contributors><titles><title>Is the use of particle air filtration justified? Costs and benefits of filtration with regard to health effects, building cleaning and occupant productivity</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>1647-1657</pages><volume>43</volume><number>10</number><dates><year>(2008)</year></dates><urls></urls></record></Cite></EndNote>**}** suggests that financial benefits resulting from improved occupant health and productivity from more efficient air filter upgrades, may exceed the incremental costs of the new filters by a factor of twenty. In fact, the cost of SBS was point out earlier by WHO in their influential 1986 report **{** ADDIN EN.CITE <EndNote><Cite><Author>WHO</Author><Year>(1986)</Year><RecNum>207</RecNum><DisplayText>(WHO, (1986))</DisplayText><record><rec-number>207</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509185186">207</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>WHO</author></authors></contributors><titles><title>Indoor Air Quality Research- EURO Reports and Studies </title><secondary-title>WHO Regional Office for Europe, Copenhagen</secondary-title></titles><periodical><full-title>WHO Regional Office for Europe, Copenhagen</full-title></periodical><volume>No. 103</volume><dates><year>(1986)</year></dates><urls></urls></record></Cite></EndNote>**}** in which they stated, '*energy-efficient but sick buildings often cost society far more than it gains by energy savings*', they further added, ‘*The added cost to society of the increased sensory irritation, the increased discomfort and the fear of more serious, persistent health effects among the occupants is likely to exceed any of the gains that can be made on the margins of energy savings*’.

Lowering the productivity rates of occupants’ performances is a crucial adverse effect of SBS. This is particularly relevant to those occupants who are continuously exposed to sick environments (i.e. employees or pupils) **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. The predominant exposure of SBSs can potentially compel the occupants to have lower performance compared to their usual productivity **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}** and schools **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**.

Sick buildings can affect occupants’ performances through different ways. Decreasing the quality of indoor environments is one of the key issues contributing to discomfort conditions of occupants. In a study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Singh</Author><Year>2010</Year><RecNum>60</RecNum><Prefix>Singh`, et al.`, </Prefix><DisplayText>(Singh, et al., 2010)</DisplayText><record><rec-number>60</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474320042">60</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Singh, A., Syal, M., Grady, S. C., & Korkmaz, S</author></authors></contributors><titles><title>Effects of green buildings on employee health and productivity</title><secondary-title>American journal of public health</secondary-title></titles><periodical><full-title>American journal of public health</full-title></periodical><pages>1665-1668</pages><volume>100</volume><number>9</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the effects of improved IEQ on perceived health and productivity in occupants in office buildings. The results demonstrated that improved IEQ contributed to the reductions of absenteeism and work hours affected by asthma, respiratory allergies, depression, and stress and to self-reported improvements in productivity. They also mentioned that green buildings may positively be considered as an effective strategy for enhancing the public health. In this line, Baird et al (2012) compared the performance of sustainable buildings versus conventional buildings from users' viewpoint. Their analysis concluded that sustainable buildings not only provide generally higher level of operation but as well, they result in an increased level of users' satisfaction.

In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Ahmadi</Author><Year>2015</Year><RecNum>61</RecNum><Prefix>Ahmadi`, et al.`, </Prefix><DisplayText>(Ahmadi, et al., 2015)</DisplayText><record><rec-number>61</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474550387">61</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ahmadi, M., Golbabaei, F., Behzadi, M</author></authors></contributors><titles><title>The effect of sick building syndrome (SBS) on the productivity of administrative staff</title><secondary-title>International Journal of Occupational Hygiene</secondary-title></titles><periodical><full-title>International Journal of Occupational Hygiene</full-title></periodical><pages>210-219</pages><volume>6</volume><number>4</number><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the effect of SBS on the productivity of 105 staff working in an office building through distribution of questionnaire survey. The findings showed that the mental SBS symptoms such as irritability, depression, mental fatigue can have a negative impact on productivity. Similarly, findings of **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lan</Author><Year>2011</Year><RecNum>62</RecNum><Prefix>Lan`, et al.`, </Prefix><DisplayText>(Lan, et al., 2011)</DisplayText><record><rec-number>62</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474551007">62</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lan, L., Wargocki, P., Wyon, D. P., & Lian, Z</author></authors></contributors><titles><title>Effects of thermal discomfort in an office on perceived air quality, SBS symptoms, physiological responses, and human performance</title><secondary-title>Indoor Air</secondary-title></titles><periodical><full-title>Indoor Air</full-title></periodical><pages>376-390</pages><volume>21</volume><number>5</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**’s investigation confirmed the negative effects of SBS symptoms on people’s productivity rates. They studied the impacts of thermal discomfort on health and occupants’ performance in an office to elucidate the physiological mechanisms involved. The results revealed that productivity of performing tasks decreased once residents detected signs of SBS (high temperature). Also, Wargorcki et al (2006) argued that staff performance in office environments is highly correlated with indoor temperature levels. On the other hand, Karakolis and Callaghan (2014) examined the recent studies focusing on the influence of sit-stand office workstations. Among the existing 14 studies, they identified that six of these studies show lower level of discomfort upon use of sit-stand office workstations while eight studies presented an increase in staff productivity. Also, Etemadinezhad, et al (2017) explored the existence of SBS and its impacts on bank staff in Iran and their findings indicated that the satisfaction level of staff is significantly correlated with the prevalence of SBS.

Apart from the IAQ and thermal concerns, improper properties of buildings envelope, such as wall can be also counted as a factor causing discomfort for occupants. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Mak</Author><Year>2011</Year><RecNum>67</RecNum><Prefix>Mak & Lui`, </Prefix><DisplayText>(Mak & Lui, 2011)</DisplayText><record><rec-number>67</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474798270">67</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Mak, C. M., & Lui, Y. P	</author></authors></contributors><titles><title>The effect of sound on office productivity</title><secondary-title>Building Services Engineering Research and Technology</secondary-title></titles><periodical><full-title>Building Services Engineering Research and Technology</full-title></periodical><volume>0143624411412253</volume><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}** reported the results of a questionnaire survey conducted to investigate the impacts of sound on office productivity and assessing the relationship between changes in office productivity and noise sources. They also studied the effects of five environmental and office design factors, namely temperature, air quality, office layout, sound and lighting on people's productivities. The outcomes yielded that among the factors examined, sound and temperature were the principal factors affecting office productivity. In another effort, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>De Been</Author><Year>2014</Year><RecNum>68</RecNum><Prefix>De Been & Beijer`, </Prefix><DisplayText>(De Been & Beijer, 2014)</DisplayText><record><rec-number>68</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474799029">68</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>De Been, I., & Beijer, M</author></authors></contributors><titles><title>The influence of office type on satisfaction and perceived productivity support</title><secondary-title>Journal of Facilities Management</secondary-title></titles><periodical><full-title>Journal of Facilities Management</full-title></periodical><pages>142-157</pages><volume>12</volume><number>2</number><dates><year>2014</year></dates><urls></urls></record></Cite></EndNote>**}** studied the effects of office types on satisfaction with the office environment and productivity support in Netherlands. They surveyed the contribution of three types of office buildings, individual and shared room offices, Combi offices and flex offices, on employees' productivities. The results demonstrated the significance of office types on productivities of employees, as people felt more comfortable to be working in the individual and shared room offices. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Shan</Author><Year>2016</Year><RecNum>1</RecNum><Prefix>Shan`, et al.`, </Prefix><DisplayText>(Shan, et al., 2016)</DisplayText><record><rec-number>1</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624526">1</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Shan, X., Zhou, J., Chang, V. W. C., & Yang, E. H. </author></authors></contributors><titles><title>Comparing mixing and displacement ventilation in tutorial rooms: Students' thermal comfort, sick building syndromes, and short-term performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>128-137</pages><volume>102</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** studied the effects of utilizing mixing and displacement ventilation on human subjects' thermal comfort, SBS, and short-term performance. The experimental results indicated that higher CO_2 concentration contributed to causing SBS related to head, while both higher CO_2 concentration and lower relative humidity (RH) associated to SBS related to eyes. Consequently, they concluded that SBS resulted from high CO_2 concentration and low RH could lead to decrease in short-term performance. Furthermore, according to a study in the UK, over 80% of office staff express being in an indoor space with high temperature does now allow them to easily concentrate; approximately 60% believe in such hot indoor environment, they need 25% more time to complete their given tasks and lastly, 78% think their office environment partially kills their creativity for completing their job (USDAW, 2006).

In summary, SBS can negatively affect occupants' performances and productivity due to a number of factors, which can be conclusively summarized as the unsatisfactory IAQ; the existence of unacceptable level of humidity, $CO_{2,}$ and temperature in indoor environment; building layout; sound and lighting status. However, the list of factors leading to undermining the occupants' productivity can be further expanded to include more determinants such as psychological or social parameters. Figure 1 provides a comprehensive summary of the factors that contributes to SBS and their negative effects on occupants as per the reviewed studies

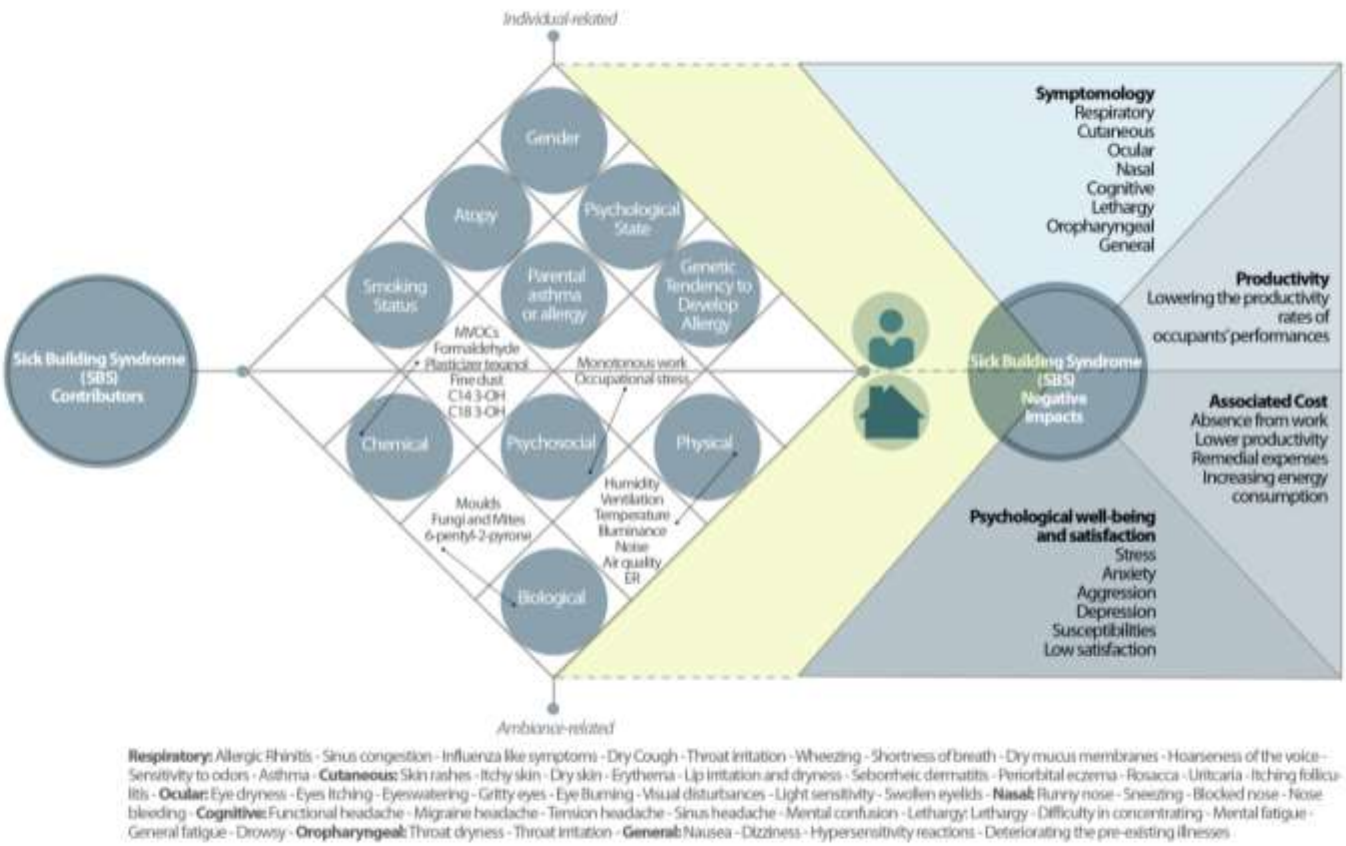

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Figure 1. An overview of SBS contributors and their negative impact on occupants

3. Review of studies mitigating SBS

This section reviews recent studies conducted with the aim of addressing issues germane to SBS. The outcome of this section helps developing practical guidelines through discussing the recent strategies examined in the literature.

In order to address the issues related to SBS, improvement of ventilation systems has been a key strategy **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. In an effort, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Shan</Author><Year>2016</Year><RecNum>1</RecNum><Prefix>Shan`, et al.`, </Prefix><DisplayText>(Shan, et al., 2016)</DisplayText><record><rec-number>1</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624526">1</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Shan, X., Zhou, J., Chang, V. W. C., & Yang, E. H. </author></authors></contributors><titles><title>Comparing mixing and displacement ventilation in tutorial rooms: Students' thermal comfort, sick building syndromes, and short-term performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>128-137</pages><volume>102</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** suggested that proper design of ventilation system, besides efficient room layout including thoughtful arrangement of seating can be helpful to defuse the symptoms of SBS in tutorial rooms. These proposed strategies could be promising in facilitating the air circulation throughout the building layout and result in enhancement of IAQ. These measures can be further coupled by application of frequent cleaning and improvement of indoor hygiene status, as recommended by **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2016</Year><RecNum>6</RecNum><Prefix>Norbäck`, et al.`, </Prefix><DisplayText>(Norbäck, et al., 2016; Zhang, et al., 2011)</DisplayText><record><rec-number>6</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469640899">6</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., Hashim, J. H., Markowicz, P., Cai, G. H., Hashim, Z., Ali, F., & Larsson, L</author></authors></contributors><titles><title>Endotoxin, ergosterol, muramic acid and fungal DNA in dust from schools in Johor Bahru, Malaysia-Associations with rhinitis and sick building syndrome (SBS) in junior high school students</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>95-103</pages><volume>545</volume><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Zhang</Author><Year>2011</Year><RecNum>64</RecNum><Prefix>Zhang`, et al.`, </Prefix><record><rec-number>64</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474691509">64</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Zhang, X., Zhao, Z., Nordquist, T., Larsson, L., Sebastian, A., & Norback, D</author></authors></contributors><titles><title>A longitudinal study of sick building syndrome among pupils in relation to microbial components in dust in schools in China</title><secondary-title>Science of the total environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>5253-5259</pages><volume>409</volume><number>24</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}** to bolster the efficiency of preventative measures to tackle SBS. However, mere reliance upon employment of active ventilation systems for increasing the IAQ may associate with the increase of building energy usage. This can further trigger the emergence of new concerns, namely environmental issues. As such, there is a demand from professional engineers for application of an optimized ventilation system which can maintain the internal air temperature at a comfortable range, while meeting the concerns toward energy consumption and environmental issues. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Jaber</Author><Year>2017</Year><RecNum>162</RecNum><Prefix>Jaber & Ezzat`, </Prefix><DisplayText>(Jaber & Ezzat, 2017)</DisplayText><record><rec-number>162</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486185850">162</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jaber, S., & Ezzat, A. W</author></authors></contributors><titles><title>Investigation of energy recovery with exhaust air evaporative cooling in ventilation system</title><secondary-title>Energy and Buildings</secondary-title></titles><periodical><full-title>Energy and Buildings</full-title></periodical><pages>439–448</pages><volume>139</volume><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>**}** proposed a model of Energy Recovery with Exhaust air Evaporative Cooling (EREEC) in ventilation to theoretically and experimentally test the thermal performance in Mediterranean climate. The experimental results indicated a superior saving due to the application of EREEC. The inlet temperature was reduced by 2.2°C at ambient temperature of 24.4 °C and by 7.5°C at highest ambient temperature of 35.7 °C. Additionally, simulation results showed that the base cooling load can be reduced up to 13.38%. Moreover, the payback period of EREEC from annual energy saving occurred is around 8 years.

{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}** explored using a thermostat in the air-conditioning system in order to control room temperature, plus performing frequent house cleaning to reduce house dust mites allergens in the tropical office environments. The use of thermostat enables the ventilation system to be activated once the indoor temperature reaches a certain point. Therefore, it avoids the ventilation system to be constantly operational and result in saving up energy. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Amin</Author><Year>2015</Year><RecNum>4</RecNum><Prefix>Amin`, et al.`, </Prefix><DisplayText>(Amin, et al., 2015)</DisplayText><record><rec-number>4</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624956">4</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Amin, N. D. M., Akasah, Z. A., & Razzaly, W.</author></authors></contributors><titles><title>Architectural Evaluation of Thermal Comfort: Sick Building Syndrome Symptoms in Engineering Education Laboratories</title><secondary-title>Procedia-Social and Behavioral Sciences</secondary-title></titles><periodical><full-title>Procedia-Social and Behavioral Sciences</full-title></periodical><pages>19-28</pages><volume>204</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}** stated that poor application of ventilation system may lead to SBS symptoms and affect students' health. As a result, they recommended the use of proper functioning control system to maintain a comfortable indoor environment for occupants.

{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lu</Author><Year>2016</Year><RecNum>2</RecNum><Prefix>Lu`, et al.`, </Prefix><DisplayText>(Lu, et al., 2016)</DisplayText><record><rec-number>2</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624654">2</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lu, C., Deng, Q., Li, Y., Sundell, J., & Norbäck, D. </author></authors></contributors><titles><title>Outdoor air pollution, meteorological conditions and indoor factors in dwellings in relation to sick building syndrome (SBS) among adults in China</title><secondary-title>Science of The Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>186-196</pages><volume>560</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** expressed that reduction of household mold/dampness, control air pollution emissions from home renovations, and improving building ventilation through frequent opening windows and use of an exhaust fan in bathroom can be efficacious in order to deal with SBS symptoms. Additionally, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2008</Year><RecNum>63</RecNum><Prefix>Norbäck & Nordström`, </Prefix><DisplayText>(Norbäck & Nordström, 2008)</DisplayText><record><rec-number>63</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474618630">63</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., & Nordström, K</author></authors></contributors><titles><title>Sick building syndrome in relation to air exchange rate, CO2, room temperature and relative air humidity in university computer classrooms: an experimental study</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>21-30</pages><volume>82</volume><number>1</number><dates><year>2008</year></dates><urls></urls></record></Cite></EndNote>**}** explored a number of strategies to deal with SBS, namely careful control of classrooms' temperature through air conditioning, utilization of sun shield to control the incoming sun radiations and use of sufficiently high ventilation flow in the classrooms. Furthermore, application of ventilation was also introduced as an effective measure to control indoor air pollution caused by Volatile Organic Compound (VOCs) emissions **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Kim</Author><Year>2008</Year><RecNum>165</RecNum><Prefix>Kim`, et al.`, </Prefix><DisplayText>(Kim, et al., 2008)</DisplayText><record><rec-number>165</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486190924">165</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Kim, S. S., Kang, D. H., Choi, D. H., Yeo, M. S., & Kim, K. W</author></authors></contributors><titles><title>Comparison of strategies to improve indoor air quality at the pre-occupancy stage in new apartment buildings</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages> 320-

328</pages><volume>43</volume><number>3</number><dates><year>2008</year></dates><urls></urls></record></Cite></EndNote>**}**. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Takigawa</Author><Year>2009</Year><RecNum>163</RecNum><Prefix>Takigawa`, et al.`, </Prefix><DisplayText>(Takigawa, et al., 2009)</DisplayText><record><rec-number>163</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1486187004">163</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Takigawa, T., Wang, B. L., Sakano, N., Wang, D. H., Ogino, K., & Kishi, R</author></authors></contributors><titles><title>A longitudinal study of environmental risk factors for subjective symptoms associated with sick building syndrome in new dwellings</title><secondary-title>Science of the total environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>5223-5228</pages><volume>407</volume><number>19</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** also introduced the existence of chemicals (i.e. indoor aldehydes, VOCs, airborne fungi, and dust mite allergens) as the major contributors to SBS. They suggested the consideration of preventive strategy designed to mitigate the exposure to indoor chemicals as a solution to counter the occurrence of SBS in newly built houses. Minimizing the interior building products to exterior, decrease the moisture accumulation during construction and striking the balance HVAC systems to control thermal comfort and humidity were among the recommendations given by **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Crook</Author><Year>2010</Year><RecNum>59</RecNum><Prefix>Crook & Burton`, </Prefix><DisplayText>(Crook & Burton, 2010)</DisplayText><record><rec-number>59</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474181973">59</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Crook, B., & Burton, N. C</author></authors></contributors><titles><title>Indoor moulds, sick building syndrome and building related illness</title><secondary-title>Fungal Biology Reviews</secondary-title></titles><periodical><full-title>Fungal Biology Reviews</full-title></periodical><pages>106-113</pages><volume>24</volume><number>3</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}** to reduce the possibility for indoor development of mold. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Assimakopoulos</Author><Year>2004</Year><RecNum>176</RecNum><Prefix>Assimakopoulos & Helmis`, </Prefix><DisplayText>(Assimakopoulos & Helmis, 2004)</DisplayText><record><rec-number>176</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490642942">176</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Assimakopoulos, V. D., & Helmis, C. G</author></authors></contributors><titles><title>On the study of a sick building: the case of Athens Air Traffic Control Tower</title><secondary-title>Energy and Buildings</secondary-title></titles><periodical><full-title>Energy and Buildings</full-title></periodical><pages>15-22</pages><volume>36</volume><number>1</number><dates><year>2004</year></dates><urls></urls></record></Cite></EndNote>**}** also found the existence of SBS symptoms among the employees working at the air traffic control tower in Athens. They suggested a number of measures to eliminate the symptoms and improve the poor IAQ, in which was identified as the principle contributor in occurring SBS. i) restriction of smoking in indoor spaces, ii) checking all HVAC systems, replacement of the air filters and cleaning all screens of the outdoor air intakes of the systems, iii) cleaning, checking and regulating inlet and outlet openings (diffusers) of the HVAC systems inside the various rooms of building to deliver maximum air supply iv) cleaning the plenum, floor, carpet and all equipment and furniture, v) opening the building's windows and doors to supplement the room ventilation, vi) cleaning the outdoor areas around the building, which are close to the air intakes of the HVAC systems. Notwithstanding the promising results achieved to improve the occupants' well beings, these conducted studies paid no or considerably limited attention to the energy performance of buildings. Building sector has already performed a considerable role in consuming a large portion of global energy **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Omrany</Author><Year>2016</Year><RecNum>131</RecNum><Prefix>Omrany`, et al.`, </Prefix><DisplayText>(Omrany, et al., 2016)</DisplayText><record><rec-number>131</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480273599">131</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Omrany, H., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Raahemifar, K., & Tookey, J</author></authors></contributors><titles><title>Application of passive wall systems for improving the energy effciency in buildings: A comprehensive review</title><secondary-title>Renewable and

Sustainable Energy Reviews</secondary-title></titles><periodical><full-title>Renewable and Sustainable Energy Reviews</full-title></periodical><pages>1252-1269</pages><volume>62</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**, therefore, from a critical perspective, the demand for enhancement of occupants' wellbeing should be addressed by exploring strategies that not only lead to the development of healthy environments for the occupants but also consider the concerns toward global energy crisis. As reviewed earlier, WHO (1986) pointed out that SBS is likely to cost the society more than the saving that could be achieved by applying energy-effect measures in buildings. This includes not only the monetary value but also people's confidence on the effectiveness of health and building authorities.

Apart from the reviewed strategies, several studies have been carried out to assist the improvement of IAQ and addressing SBS concerns. One of these measures is the use of green building for enhancing the health status of occupants **{** ADDIN EN.CITE **{** ADDIN EN.CITE.DATA **}}**. To answer the question whether green building can have a really better impact on occupants, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Thatcher</Author><Year>2016</Year><RecNum>135</RecNum><Prefix>Thatcher & Milner`, </Prefix><DisplayText>(Thatcher & Milner, 2016)</DisplayText><record><rec-number>135</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480355003">135</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Thatcher, A., & Milner, K</author></authors></contributors><titles><title>Is a green building really better for building occupants? A longitudinal evaluation</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>194-206</pages><volume>108</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** conducted a longitudinal study to empirically investigate three green buildings through using a pre-test, post-test design, and repeated measures design with a contrast group for two of the buildings. The statistical analyses established significant improvements in perceived air quality across all three buildings, significant improvements in self-report productivity in two of the buildings and a significant improvement in physical wellbeing in one building. In another study, **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>MacNaughton</Author><Year>2016</Year><RecNum>65</RecNum><Prefix>MacNaughton`, et al.`, </Prefix><DisplayText>(MacNaughton, et al., 2016)</DisplayText><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474694918">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>MacNaughton, P., Spengler, J., Vallarino, J., Santanam, S., Satish, U., & Allen, J</author></authors></contributors><titles><title>Environmental perceptions and health before and after relocation to a green building</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>138-144</pages><volume>104</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}** investigated the influence of green building on improving the health status through recording and monitoring the IEQ, self-reported health, and heart rates of participants dwelling in two green and conventional buildings. The findings indicated that participants consistently reported fewer symptoms during the green building conditions. It is also claimed that green buildings can have a direct impact on decision-making process of residents. **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>MacNaughton</Author><Year>2017</Year><RecNum>170</RecNum><Prefix>MacNaughton`, et al.`, </Prefix><DisplayText>(MacNaughton, et al., 2017)</DisplayText><record><rec-number>170</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490627434">170</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>MacNaughton, P., Satish, U., Laurent, J. G. C., Flanigan, S., Vallarino, J., Coull, B., ... & Allen, J. G</author></authors></contributors><titles><title>The impact of working in a green certified building on cognitive function and health</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>178-186</pages><volume>114</volume><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>**}** conducted a cognitive function test among 109 participants from ten high performing buildings (i.e. buildings surpassing the ASHRAE Standard 62.1-2010 ventilation requirement and with low total volatile organic compound concentrations) in five U.S. cities. The findings revealed that workers in green certified buildings scored 26.4% higher on cognitive function tests, controlling for annual earnings, job category and level of schooling, and had 30% fewer sick building symptoms than those in non-certified buildings. Although it is still arguable that the utilization of green building may not necessarily guarantee the deliverance of desirable IAQ { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Steinemann</Author><Year>2016</Year><RecNum>139</RecNum><Prefix>Steinemann`, et al.`, </Prefix><DisplayText>(Steinemann, et al., 2016)</DisplayText><record><rec-number>139</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480443913">139</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Steinemann, A., Wargocki, P., & Rismanchi, B</author></authors></contributors><titles><title>Ten questions concerning green buildings and indoor air quality</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><volume>In Press</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>}, but with the reference to the promising performance of green buildings in saving energy { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Pérez</Author><Year>2017</Year><RecNum>137</RecNum><Prefix>Pérez`, et al.`, </Prefix><DisplayText>(Foustalieraki, et al., 2017; Pérez, et al., 2017)</DisplayText><record><rec-number>137</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480439613">137</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Pérez, G., Coma, J., Sol, S., & Cabeza, L. F</author></authors></contributors><titles><title>Green facade for energy savings in buildings: The influence of leaf area index and facade orientation on the shadow effect</title><secondary-title>Applied Energy</secondary-title></titles><periodical><full-title>Applied Energy</full-title></periodical><pages>424-437</pages><volume>187</volume><dates><year>2017</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Foustalieraki</Author><Year>2017</Year><RecNum>138</RecNum><Prefix>Foustalieraki`, et al.`, </Prefix><record><rec-number>138</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480443021">138</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Foustalieraki, M., Assimakopoulos, M. N., Santamouris, M., & Pangalou, H</author></authors></contributors><titles><title>Energy performance of a medium scale green roof system installed on a commercial building using numerical and experimental data recorded during the cold period of the year</title><secondary-title>Energy and Buildings</secondary-title></titles><periodical><full-title>Energy and Buildings</full-title></periodical><pages>33-38</pages><volume>135</volume><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>}, and the results indicating promising achievements in enhancement of IAQ and occupants' well beings, further exploration of green buildings deems practical and operative.

From another side, Ghashghaei et al. (2017) examined the impacts of cool colours in indoor environments on the sensation of elderlies in high-rise condominiums in Malaysia. They realized that cool colours can significantly alter the levels of blood pressure, heart beat rate and skin temperature. Their analysis concluded that use of particular cool colours can result in relaxation feeling. Moving on, from a psychological point of view, a visual and/or physical access to nature is likely to improve people's wellbeing in buildings. While this notion has been around since at least 1976 (Ludlow, 1976), it is recently known as Biophilic design (Cramer and Browning, 2008){ ADDIN EN.CITE <EndNote><Cite><Author>Kellert</Author><Year>(2012)</Year><RecNum>209</RecNum><DisplayText>(Kellert, (2012))</DisplayText><record><rec-number>209</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509186483">209</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Kellert, R</author></authors></contributors><titles><title>Birthright: People and Nature in the Modern World</title><secondary-title>Yale University Press</secondary-title></titles><periodical><full-title>Yale University Press</full-title></periodical><dates><year>(2012)</year></dates><urls></urls></record></Cite></EndNote>}. The term Biophilia might be first used in this context by the socio-biologist Edward Wilson to describe his connection to nature (Wilson, 1984). It was later assumed that humankind's connection to nature is innate and hence our physiological responses to experiencing being in nature is genetically programed (Kellert and Wilson, 1993). This hypothesis has been widely tested at different levels and in different contexts. Evidences that support the positive impact of nature on people's physiological wellbeing are not scarce ({ HYPERLINK \l "_ENREF_76" \o "Kellert, (2012) #209" } and scientifically tested (Ryan et. al., 2014). Examples include improved mental health (Ulrich, 1979; Tyrväinen et al., 2014), reduced stress (Berman et al., 2008; Matsunaga et al., 2011), increased well-being (Ulrich et al., 1991; Ikei et al., 2014), attention restoration (Kaplan, 1995; Raanaas et al. 2011) and faster healing rates (Ulrich, 1984; Park and Mattson, 2008).Providing a window with a view to a pleasing nature scene or indoor planning allows the eye to adjust and re-focus, which reduces fatigue, headaches resulting in better health, less frustration, and better overall performance in work places { ADDIN EN.CITE <EndNote><Cite><Author>Kaplan</Author><Year>(1992)</Year><RecNum>210</RecNum><DisplayText>(Kaplan, (1992); Van, (2001))</DisplayText><record><rec-number>210</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509186839">210</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Kaplan, R</author></authors></contributors><titles><title>The psychological benefits of nearby nature. In Role of horticulture in human well-being and social development: A national symposium</title><secondary-title>Arlington, Va.: Timber Press</secondary-title></titles><periodical><full-title>Arlington, Va.: Timber Press</full-title></periodical><pages>125-133</pages><dates><year>(1992)</year></dates><urls></urls></record></Cite><Cite><Author>Van</Author><Year>(2001)</Year><RecNum>211</RecNum><record><rec-number>211</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509187087">211</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Van, D.A., & Bergs, J</author></authors></contributors><titles><title>Study on Plants and Productivity. Leiden, Bloemenbureau Holland</title></titles><dates><year>(2001)</year></dates><urls></urls></record></Cite></EndNote>}. In the healthcare sector, a recent substantial report found that providing patients with views of nature could save the US healthcare authorities up to $93 million/year { ADDIN EN.CITE <EndNote><Cite><Author>Browning</Author><Year>(2012)</Year><RecNum>212</RecNum><DisplayText>(Browning, (2012))</DisplayText><record><rec-number>212</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509187271">212</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Browning, B</author></authors></contributors><titles><title>The Economics of Biophilia: Why designing with nature in mind makes sense</title><secondary-title>Available: http://202020vision.com.au/media/1024/the-economics-of-biophilia_terrapin-bright-green-2012e.pdf. Last accessed 14October 2017</secondary-title></titles><periodical><full-title>Available: http://202020vision.com.au/media/1024/the-economics-of-biophilia_terrapin-bright-green-2012e.pdf. Last accessed 14October 2017</full-title></periodical><dates><year>(2012)</year></dates><urls></urls></record></Cite></EndNote>}. In fact, research has shown a reasonable awareness of the importance of providing view to nature in hospital among designers. For example, { ADDIN EN.CITE <EndNote><Cite><Author>Alalouch</Author><Year>(2015)</Year><RecNum>213</RecNum><DisplayText>(C. Alalouch, Aspinall, P., & Smith, H, (2015))</DisplayText><record><rec-number>213</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509187491">213</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Alalouch, C., Aspinall, P., & Smith, H</author></authors></contributors><titles><title>Architects' priorities for hospital-ward design criteria: Application of choice-based conjoint analysis in architectural research</title><secondary-title>Journal of Architectural and Planning Research</secondary-title></titles><periodical><full-title>Journal of Architectural and Planning Research</full-title></periodical><pages>1-22</pages><volume>32</volume><number>1</number><dates><year>(2015)</year></dates><urls></urls></record></Cite></EndNote>} conducted a Conjoint Analysis study to explore priorities of a group of UK-based architect's when designing a hospital; and found that "creating a view to outside" lies at their top priority when design a hospital ward. Nevertheless, views to nature could be provided by creating atriums, courtyards, communal sky gardens with real trees and plants, or roof gardens { ADDIN EN.CITE <EndNote><Cite><RecNum>206</RecNum><DisplayText>("World Green Building Council. (2004). Health, wellbeing and productivity in offices,")</DisplayText><record><rec-number>206</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509183148">206</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors></contributors><titles><title>World Green Building Council. (2004). Health, wellbeing and productivity in offices</title><secondary-title>The next chapter for green building. Accessed via: http://www.jll.com/Research/Health_Wellbeing_Productivity.pdf?1a56c1ad-7be7-4d6d-8f32-74bb6e72fa3f. Last accessed: 10 October 2017</secondary-title></titles><periodical><full-title>The next chapter for green building. Accessed via: http://www.jll.com/Research/Health_Wellbeing_Productivity.pdf?1a56c1ad-7be7-4d6d-8f32-74bb6e72fa3f. Last accessed: 10 October 2017</full-title></periodical><dates></dates><urls></urls></record></Cite></EndNote>} On the other hand, Largo-Wight et al (2011) presented that in working environments, there is a significant negative correlation between nature contact and stress as well as nature contact and health-related complaints. More recently, another study indicated that in office spaces that are exposed to natural daylight and vegetation, staff are 15% more creative and 6% more productive (Human spaces report, 2015).

Biophilic design is not limited to providing visual/physical access to nature. Söderlund and Newman (2017) categorized the key elements of biophilic design into three categories based on the works of Cramer and Browning (2008) and Ryan, et al (2014).

1) '*Nature in the space*'; incorporating plants, water, animals and movement into the built environment.
2) '*Natural analogues*'; suggesting patterns/materials that evoke the nature.
3) '*Nature of the space*'; referring to different spatial configurations and associated physiological/psychological responses they engender such as prospect, refuge, mystery and risk/peril.

These studies (Cramer and Browning, 2008; Ryan et. al. 2014) support the proposition that biophilic design is likely to mitigate the effect of SBS, improve the overall wellbeing of the occupants, and contribute positively to their satisfactions, productivity and performances.

In conclusion, a number of strategies and methodologies are put forward and suggested in the relative literature in order to tackle the issues concerned with SBS. Table 5 provides a comprehensive summary of these strategies, whereas Figure 2 separates these strategies according to their effectiveness and ease of implementation in existing buildings as assessed in literature.

Table 5. Strategies to tackle the SBS

Author (s)	**Proposed Strategy to tackle SBS**	**Building type**
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Shan</Author><Year>2016</Year><RecNum>1</RecNum><Prefix>Shan`, et al.`, </Prefix><DisplayText>(Shan, et al., 2016)</DisplayText><record><rec-number>1</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624526">1</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Shan, X., Zhou, J., Chang, V. W. C., & Yang, E. H. </author></authors></contributors><titles><title>Comparing mixing and displacement ventilation in tutorial rooms: Students' thermal comfort, sick building syndromes, and short-term performance</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>128-137</pages><volume>102</volume><dates><year>2016</year></da	Proper design of ventilation system and careful arrangement of room layout	University

tes><urls></urls></record></Cite></EndNote>**}**		
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2016</Year><RecNum>6</RecNum><Prefix>Norbäck`, et al.`, </Prefix><DisplayText>(Norbäck, et al., 2016)</DisplayText><record><rec-number>6</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469640899">6</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., Hashim, J. H., Markowicz, P., Cai, G. H., Hashim, Z., Ali, F., & Larsson, L</author></authors></contributors><titles><title>Endotoxin, ergosterol, muramic acid and fungal DNA in dust from schools in Johor Bahru, Malaysia- Associations with rhinitis and sick building syndrome (SBS) in junior high school students</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>95-103</pages><volume>545</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**	Improvement of cleaning in schools	Schools
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lim</Author><Year>2015</Year><RecNum>3</RecNum><Prefix>Lim`, et al.`, </Prefix><DisplayText>(Lim, et al., 2015)</DisplayText><record><rec-number>3</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kx	Improvement of ventilation system, and frequent cleaning	Office environment, University

xe2pdszvt22" timestamp="1469624878">3</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lim, F. L., Hashim, Z., Said, S. M., Than, L. T. L., Hashim, J. H., & Norbäck, D.</author></authors></contributors><titles><title>Sick building syndrome (SBS) among office workers in a Malaysian university—Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment</title><secondary-title>Science of the Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>353-361</pages><volume>536</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}**		
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Amin</Author><Year>2015</Year><RecNum>4</RecNum><Prefix>Amin`, et al.`, </Prefix><DisplayText>(Amin, et al., 2015)</DisplayText><record><rec-number>4</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624956">4</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Amin, N. D. M., Akasah, Z. A., & Razzaly, W.</author></authors></contributors><titles><title>Architectural Evaluation of Thermal Comfort: Sick Building Syndrome Symptoms in Engineering Education Laboratories</title><secondary-title>Procedia-Social and Behavioral Sciences</secondary-title></titles><periodical><full-	Use of functioning control system to control the indoor air temperature	Laboratory

title>Procedia-Social and Behavioral Sciences</full-title></periodical><pages>19-28</pages><volume>204</volume><dates><year>2015</year></dates><urls></urls></record></Cite></EndNote>**}**		
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Lu</Author><Year>2016</Year><RecNum>2</RecNum><Prefix>Lu`, et al.`, </Prefix><DisplayText>(Lu, et al., 2016)</DisplayText><record><rec-number>2</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1469624654">2</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Lu, C., Deng, Q., Li, Y., Sundell, J., & Norbäck, D. </author></authors></contributors><titles><title>Outdoor air pollution, meteorological conditions and indoor factors in dwellings in relation to sick building syndrome (SBS) among adults in China</title><secondary-title>Science of The Total Environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>186-196</pages><volume>560</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**	Reduction of mold/dampness, control air pollution emissions from home renovations, and enhancement of building ventilation	Home
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Norbäck</Author><Year>2008</Year><RecNum>63</RecNum><Prefix>Norbäck & Nordström`, </Prefix><DisplayText>(Norbäck & Nordström, 2008)</DisplayText><record><rec-number>63</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kx	Regulation of indoor temperature, Sun shield, use of sufficient ventilation system	Classroom

xe2pdszvt22" timestamp="1474618630">63</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Norbäck, D., & Nordström, K</author></authors></contributors><titles><title>Sick building syndrome in relation to air exchange rate, CO2, room temperature and relative air humidity in university computer classrooms: an experimental study</title><secondary-title>International archives of occupational and environmental health</secondary-title></titles><periodical><full-title>International archives of occupational and environmental health</full-title></periodical><pages>21-30</pages><volume>82</volume><number>1</number><dates><year>2008</year></dates><urls></urls></record></Cite></EndNote>**}**		
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Zhang</Author><Year>2011</Year><RecNum>64</RecNum><Prefix>Zhang`, et al.`, </Prefix><DisplayText>(Zhang, et al., 2011)</DisplayText><record><rec-number>64</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474691509">64</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Zhang, X., Zhao, Z., Nordquist, T., Larsson, L., Sebastian, A., & Norback, D</author></authors></contributors><titles><title>A longitudinal study of sick building syndrome among pupils in relation to microbial components in dust in schools in China</title><secondary-title>Science of the total	Frequent cleaning and improving hygiene	School

environment</secondary-title></titles><periodical><full-title>Science of The Total Environment</full-title></periodical><pages>5253-5259</pages><volume>409</volume><number>24</number><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**			
{ ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>MacNaughton</Author><Year>2016</Year><RecNum>65</RecNum><Prefix>MacNaughton`, et al.`, </Prefix><DisplayText>(MacNaughton, et al., 2016)</DisplayText><record><rec-number>65</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474694918">65</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>MacNaughton, P., Spengler, J., Vallarino, J., Santanam, S., Satish, U., & Allen, J</author></authors></contributors><titles><title>Environmental perceptions and health before and after relocation to a green building</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>138-144</pages><volume>104</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>MacNaughton</Author><Year>2017</Year><RecNum>170</RecNum><Prefix>MacNaughton`, et al.`, </Prefix><DisplayText>(MacNaug	Green building		Office building, Residential building

hton, et al., 2017; Singh, et al., 2010)</DisplayText><record><rec-number>170</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1490627434">170</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>MacNaughton, P., Satish, U., Laurent, J. G. C., Flanigan, S., Vallarino, J., Coull, B., ... & Allen, J. G</author></authors></contributors><titles><title>The impact of working in a green certified building on cognitive function and health</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>178-186</pages><volume>114</volume><dates><year>2017</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Singh</Author><Year>2010</Year><RecNum>60</RecNum><Prefix>Singh`, et al.`, </Prefix><record><rec-number>60</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474320042">60</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Singh, A., Syal, M., Grady, S. C., & Korkmaz, S</author></authors></contributors><titles><title>Effects of green buildings on employee health and productivity</title><secondary-title>American journal of public health</secondary-

title></titles><periodical><full-title>American journal of public health</full-title></periodical><pages>1665-1668</pages><volume>100</volume><number>9</number><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**} {** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Miller</Author><Year>2009</Year><RecNum>133</RecNum><Prefix>Miller`, et al.`, </Prefix><DisplayText>(Miller, et al., 2009)</DisplayText><record><rec-number>133</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480353939">133</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Miller, N., Pogue, D., Gough, Q., & Davis, S</author></authors></contributors><titles><title>Green buildings and productivity</title><secondary-title>Journal of Sustainable Real Estate</secondary-title></titles><periodical><full-title>Journal of Sustainable Real Estate</full-title></periodical><pages>65-89</pages><volume>1</volume><number>1</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>**}** ; **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Thatcher</Author><Year>2016</Year><RecNum>135</RecNum><Prefix>Thatcher & Milner`, </Prefix><DisplayText>(Thatcher & Milner, 2016)</DisplayText><record><rec-number>135</rec-

number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1480355003">135</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Thatcher, A., & Milner, K</author></authors></contributors><titles><title>Is a green building really better for building occupants? A longitudinal evaluation</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>194-206</pages><volume>108</volume><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote>**}**		
{ ADDIN EN.CITE <EndNote><Cite><Author>Kaplan</Author><Year>(1992)</Year><RecNum>210</RecNum><DisplayText>(Kaplan, (1992); Van, (2001))</DisplayText><record><rec-number>210</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509186839">210</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Kaplan, R</author></authors></contributors><titles><title>The psychological benefits of nearby nature. In Role of horticulture in human well-being and social development: A national symposium</title><secondary-title>Arlington, Va.: Timber Press</secondary-title></titles><periodical><full-title>Arlington, Va.: Timber Press</full-title></periodical><pages>125-133</pages><dates><year>(1992)	Biophilic design (view/access to nature); indoor plants; nature patterns, colors, and materials; spatial configurations that are provided by nature.	Prison building, Elderly house, Office building

</year></dates><urls></urls></record></Cite><Cite><Author>Van</Author><Year>(2001)</Year><RecNum>211</RecNum><record><rec-number>211</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1509187087">211</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Van, D.A., & Bergs, J</author></authors></contributors><titles><title>Study on Plants and Productivity. Leiden, Bloemenbureau Holland</title></titles><dates><year>(2001)</year></dates><urls></urls></record></Cite></EndNote>**}** Söderlund and Newman, 2017; Ghashghaei, et al, 2017)

Accordingly, the most prevalent measure claimed to address the SBS symptoms is associated with application of proper ventilation systems in buildings. These reviewed strategies can be generally classified into two major groups; first group refers to those measures that do not require major considerations such as physical modification in buildings structure in order to rectify the SBS symptoms such as frequent cleaning procedures or maintaining the hygiene in buildings. Second group refers to those measures that require considering the physical alterations such as usage of greeneries in building or improvement of mechanical ventilation systems. Apart from these measures, it is believed that SBS can be categorized as a pollution-related illness **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Imai</Author><Year>2011</Year><RecNum>189</RecNum><Prefix>Imai & Imai`, </Prefix><DisplayText>(Imai & Imai, 2011)</DisplayText><record><rec-number>189</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1491060977">189</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Imai, N., & Imai, Y</author></authors></contributors><titles><title>Psychosocial Factors that Aggravate the Symptoms of Sick Building Syndrome and a Cure for Them. In Sick Building Syndrome</title><secondary-title>Springer Berlin Heidelberg</secondary-title></titles><periodical><full-title>Springer Berlin Heidelberg</full-title></periodical><pages>105-111</pages><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>**}**. Therefore, national governments must also attempt to solve these problems by making building regulations that prevent the use of toxic materials in living environments and/or providing financial support for SBS patients to take radical measures to solve their problems. Yet, there is a dearth of attempts performed to address the SBS related issues with consideration of all potential strategies altogether.

Figure 2.A matrix separates SBS mitigation strategies found in the reviewed studies by their impact and ease of application in existing buildings

Based on the review of recent studies (Abdul-Wahab, 2011; Vural and Balanlı, 2011; Clements-Croome, 2018), it can be deduced that in order to effectively tackle SBS and achieve a healthy indoor environment, the following key attributes should be taken into account:

- *Fresh and clean air and proper (natural) ventilation while maintaining indoor air quality (i.e. cross ventilation provides the most ventilation)*
- *Thermally comfortable environment (i.e. acceptable level of temperature, humidity, PMV)*
- *Adequate acoustic level and minimized level of external noise*
- *Acceptable level of CO_2 and minimized level of indoor pollutants (i.e. NO_2)*
- *Control moisture levels (i.e. too much moisture can increase growth of bacteria, and mould)*
- *Sufficient daylight and no glare (i.e. window sizes should be carefully considered and be fit for purpose)*
- *Solar gain control (i.e. Too much glass can lead to internal overheating).*
- *Acceptable material usage with no issues of toxicity, microbe, dampness, mold, and similar challenges*
- *External views, and determines the window height required for views*
- *Appropriate landscape allocation and possibly nature contact*
- *Proper colour use relevant to the function of spaces*
- *Proper segregation of spaces for sense of privacy once required*
- *Efficient plan layout and furniture arrangement to promote flexibility and collaboration*
- *Ergonomic indoor layout*
- *Adequate use of digital technology once required*

4. Future Directions of Buildings from SBS Perspective

Well-being, embracing health and comfort, is a critical parameter for determining the quality of life of an occupant. In late 1980s and during the 1990s, WHO concept of health, became significant for identifying the concept of a ‘healthy building’ in terms of building performances (*i.e., IAQ, thermal comfort, lighting quality and acoustics*) **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Bluyssen</Author><Year>2010</Year><RecNum>66</RecNum><Prefix>Bluyssen`, </Prefix><DisplayText>(Bluyssen, 2010)</DisplayText><record><rec-number>66</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474724844">66</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Bluyssen, P.M</author></authors></contributors><titles><title>Towards new methods and ways to create healthy and comfortable buildings</title><secondary-title>Building and Environment</secondary-title></titles><periodical><full-title>Building and Environment</full-title></periodical><pages>808–818</pages><volume>45</volume><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>**}**. A healthy building is defined as ‘*built environment that encourages positive well-being of human beings*’ **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Mohtashami</Author><Year>2016</Year><RecNum>69</RecNum><Prefix>Mohtashami`, et al.`, </Prefix><DisplayText>(Ho, et al., 2004; Mohtashami, et al., 2016)</DisplayText><record><rec-number>69</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474802070">69</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Mohtashami, N., Mahdavinejad, M., & Bemanian, M</author></authors></contributors><titles><title>Contribution of City Prosperity to Decisions on Healthy Building Design: A case study of Tehran</title><secondary-title> Frontiers of Architectural Research</secondary-title></titles><pages>319-331</pages><volume>5</volume><number>3</number><dates><year>2016</year></dates><urls></urls></record></Cite><Cite ExcludeAuth="1"><Author>Ho</Author><Year>2004</Year><RecNum>70</RecNum><Prefix>Ho`, et al.`, </Prefix><record><rec-number>70</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474802994">70</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ho, D. C., Leung, H. F., Wong, S. K., Cheung, A. K. C., Lau, S. S. Y., Wong, W. S., ... & Chau, K. W</author></authors></contributors><titles><title>Assessing the health and hygiene performance of apartment buildings</title><secondary-title>Facilities</secondary-title></titles><periodical><full-title>Facilities</full-title></periodical><pages>58-69</pages><volume>22</volume><number>3/4</number><dates><year>2004</year></dates><urls></urls></record></Cite></EndNote>**}**. Moreover, a broader definition is proposed by **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Levin</Author><Year>1995</Year><RecNum>71</RecNum><Prefix>Levin`, </Prefix><DisplayText>(Levin, 1995)</DisplayText><record><rec-number>71</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474806363">71</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Levin, H</author></authors></contributors><titles><title>Building ecology: an architect’s perspective on healthy buildings</title><secondary-title>Proceedings of the Fourth International Conference on Healthy Buildings</secondary-title></titles><periodical><full-title>Proceedings of the Fourth International Conference on Healthy Buildings</full-title></periodical><volume>Avaliable on: http://www.buildingecology.net/index_files/publications/DesignandConstructionofHealthyandSustainableBuildings.pdf</volume><dates><year>1995</year></dates><urls></urls></record></Cite></EndNote>**}**, considering the impacts of buildings on both occupants and surrounding environments. Levin defined healthy building as ‘*a building that adversely affects neither the health of its occupants nor the larger environment’*. From a more generic outlook, a healthy building is free of hazardous materials (e.g. lead and asbestos) and capable of fostering health and comfort of the occupants during its entire building life cycle, while supporting social needs and enhancing productivity. While Levin aspiration calls for ‘treads lightly on the earth’, this brings in other dimensions– such as the total amounts of materials used in the construction and operation of a building *and* the environmental impact of the mining/production/transportation to site and subsequent disposal of waste. In short, this would require lifecycle analysis of the wider environmental impact of buildings. This reveals the ‘health’ and ‘well-being’ approaches as being flawed because they are entirely species-centric and lacking regard for other flora and fauna.

This study critically argues that there is a gradual shift from the current predominant focus on ‘sustainable and intelligent design’ to ‘healthy design’ as a fundamental basis of future buildings. This healthy design vision should not only be observed at building-scale level as its urban and city-scale image allows effectively contributing to the eventual goals of smart and intelligent cities.

Do current standards go far enough? A healthy building recognizes the human health needs, and responds to the occupants’ comfort requirement as the top priority. But beside these tangible benefits, there is a need to consistently draw attention to its potentials for intangible output ranging from stress reduction to mental calmness and happiness. Likewise, a healthy building should be ready and capable to respond to future needs, adaptable to ‘new drivers’ such as climate change, and responsive to the changes towards a multifunctional and diverse society, the increasing individualization and the ever-changing needs and preferences of occupants (See Figure 3).

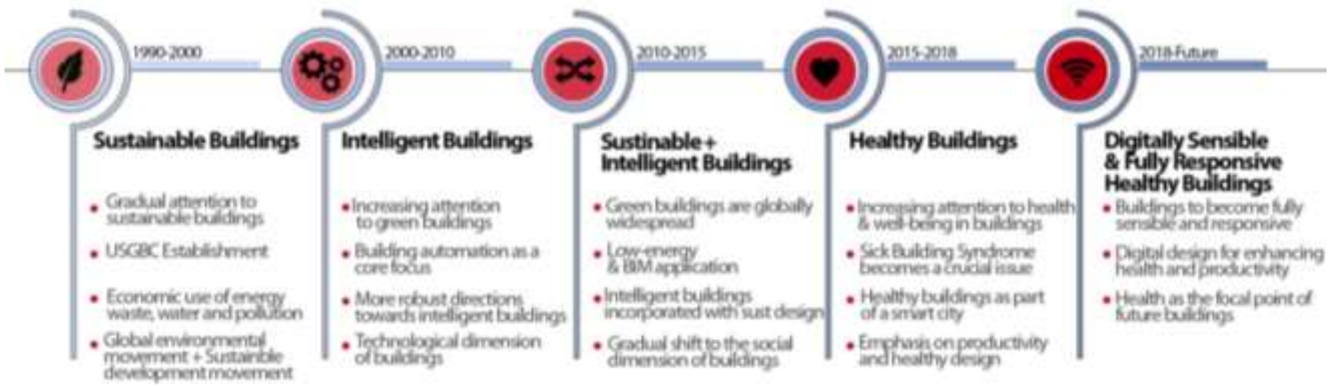

Figure 3. The role of SBS: Evolution of building design and development from sustainable, intelligent and healthy design perspectives

In principle, healthy buildings should be developed based on successful fulfillment of various technical requirements such as being in line with proper design and construction principles of buildings and their satisfactory performance with view to providing sufficient IAQ, visual comfort, daylight and natural ventilation without compromising the occupants’ health and satisfaction **{** ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Loftness</Author><Year>2007</Year><RecNum>72</RecNum><Prefix>Loftness`, et al.`, </Prefix><DisplayText>(Loftness, et al., 2007)</DisplayText><record><rec-number>72</rec-number><foreign-keys><key app="EN" db-id="z2wa9ws2tvf000ex5pfps95kxxe2pdszvt22" timestamp="1474952982">72</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Loftness, V., Hakkinen, B., Adan, O., & Nevalainen, A</author></authors></contributors><titles><title>Elements that contribute to healthy building design</title><secondary-title>Environmental Health Perspectives</secondary-title></titles><periodical><full-title>Environmental Health Perspectives</full-title></periodical><pages>965</pages><volume>115</volume><number>6</number><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote>**}**. However, Rees (1999) would argue that this focus solely on occupants (building end users) – and not on ‘*distant elsewhere*’ is a continual failing of the design and construction industries which ‘*draw on resources and dump their garbage all over the world*’. This ecological reality underscores the urgency of `healthier factors’ in the building industry.

Overall, the result of reviewed studies reveals the significant impact of buildings’ health-related parameters not only on occupants but in many different ways, take into account the health and well-being of those involved in producing the materials or constructing buildings or servicing their operation. This can be deemed as a convincing reason to justify more rigorous consideration of both objective and subjective healthy principles during the design, construction and operational phases of buildings towards tackling SBS (See Figures 4).The following paragraphs discuss the major principles to be taken into account towards future healthy buildings.

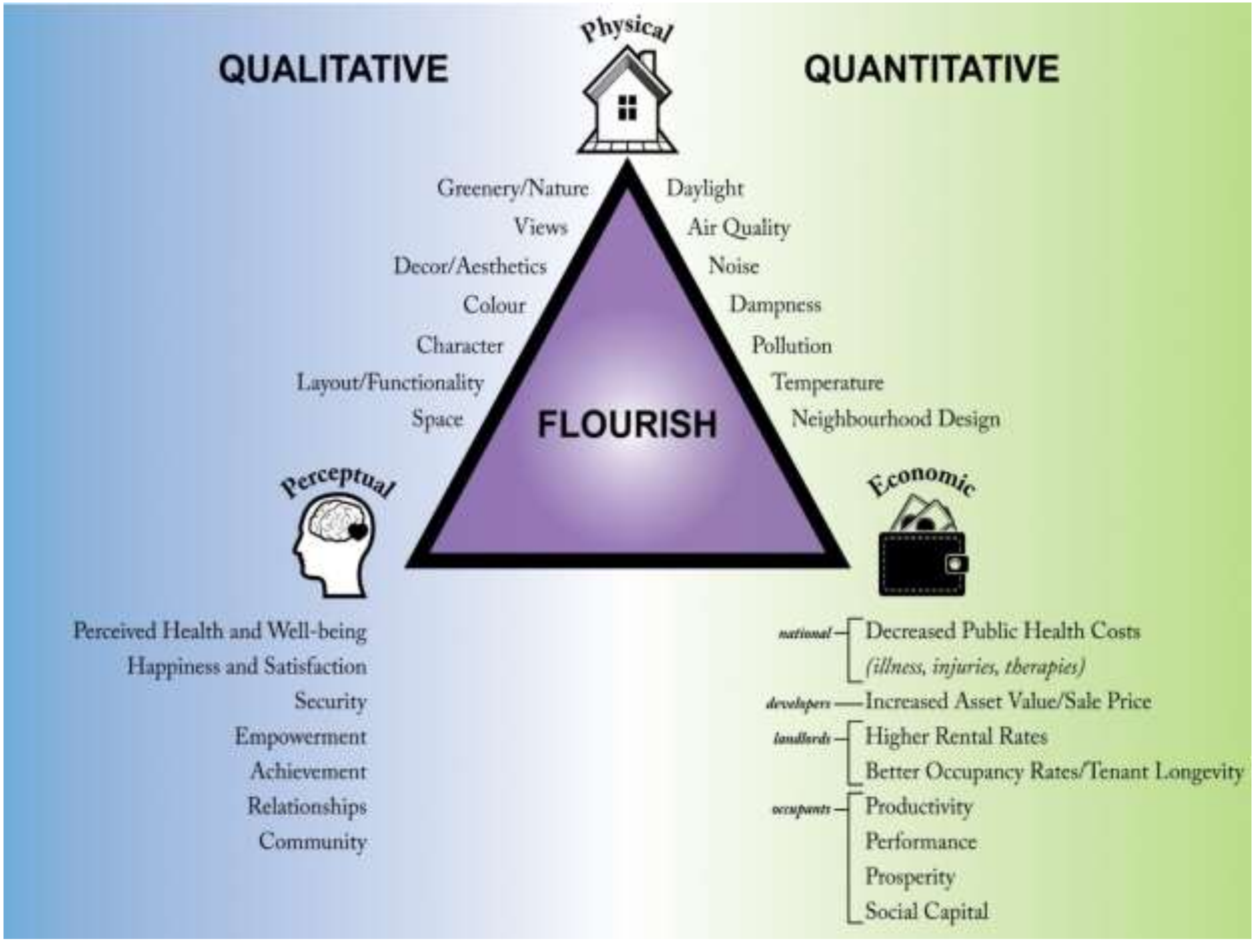

Figure 4. Flourish Model for healthy buildings, source: Clements-Croome 2018

5. Conclusions

The exposure of occupants to unhealthy indoor environments can potentially trigger the emergence of SBS symptoms. This paper attempted to advocate the crucial role of healthy buildings, based on their significant impacts on occupants' health and well-being, through exploring the negative effects of sick buildings. The review critically showed that sick buildings are likely to endanger the occupants' health status while negatively affecting the level of productivity. On the contrary, the concept of healthy building has been discussed through highlighting its major promising principles including the maintenance of IAQ and thermal control, maximizing the use of daylight, providing a workplace in compliance with the occupants' ergonomics and creating opportunities for occupants to access nature. Additionally, this study redefines the concept of healthy building through including the importance of energy management in its scope, besides its capability to procure flourishing environments and assuring the occupants' health (Clements-Croome 2018).

This study has identified physical, biological, chemical, psychosocial and individual parameters as the major contributors to SBS. These factors facilitate the emergence of SBS symptoms, in which they result in bringing several negative effects for occupants. The analysis categorized these effects into four major groups. The first one is the symptomatology that refers to nasal, ocular, oropharyngeal, cutaneous and general manifestations. The second one is the psychological effect of SBS such as stress and anxiety; as well as the impact of SBS on occupants' satisfaction. The third effect refers to the costs associated with occurrence of SBS such as the absence from work, lower productivity, remedial expenses, or increasing the building energy consumption. The fourth effect refers to compromising the productivity of occupants in sick buildings. Although the reviewed points cover majority of negative effects attributed to the SBS, but these effects can go beyond that, namely social effects of SBS. Therefore, future studies will be required to address new aspects of SBS.

Reviewing recent studies has revealed that the physical features of buildings can be influential in appearing SBS symptoms. The adverse effects of physical contributors on occupants' health during the operational phase of building can be initially neutralized through practicing a careful architecture during the building's design phase. It can be stated that the accurate consideration of building's orientation, felicitous selection of building materials in accordance with local climate, application of passive techniques in building envelope such as passive walls can be efficacious in avoidance of occurring the physical contributors. These design principles may potentially facilitate the air circulation throughout the building, manage recipient of a sufficient amount of solar radiations and providing a required measure of illuminance for occupants. The control of physical contributors can be further promising in minimization of biological and psychosocial contributors.

It should be stressed that healthy buildings are beyond SBS and embrace many other interrelated aspects such as stress, physical mental, musculoskeletal impacts, social well-being and others health-related attributes (Clements-Croome, 2018). Indeed, healthy building is a better conceptualization than what we have today but requires consistent in-depth exploration to unleash new potentials. This study identifies a number of strategies to improve the issues concerned with SBS namely; proper design of ventilation systems, careful arrangement of room layouts, sanitizing frequency, reduction of mold/dampness, installation of external devices on openings such as sun shades, development of green buildings and providing visual/physical access to nature. Despite the stand-alone influences of the abovementioned factors, further investigations to address their interrelated effects are essential. Lastly, from the professional practice perspective, while the main focus of this research was on the identification of SBS indicators and their impacts, highlighting the current needs to pave the way for healthier buildings, it is vital to continue this debate regarding the role of professionals and professionalism in this context. Without a doubt, more in-depth explorations should be carried out to dictate the role of architects, engineers, and building technology experts towards creating healthier indoor environments.

Building for health and wellbeing is presented in this paper as a moving target where there is neither a 'state to be reached' nor a 'one-size-fits-all' solution. This implies creating a secure sense of long term vitality, with sustainable thinking influencing all aspects of development, from the built form to financial, technological, economic and social policies and delivery mechanism. Healthy/ well-being approach does not happen as an outcome in a 'predetermined way'. It requires to be carefully discussed, openly debated and even centrally planned. The concept will need to be translated into real and tangible design solutions if the built environments are to avoid serious problems and costs in the future (Trained, 2011). This may move the design for health and well-being debate away from 'best practice' and towards 'next practice', focusing on innovation in the design of housing, workplaces, schools, public spaces and transport (Trained, 2011).

Meeting the objectives and apprehensions described above confront professional bodies and individuals with a major challenge on how to become more responsible for healthier places. Unlike the deterministic conventional physical-led approach to green/sustainable building design, many contemporary thinkers emphasize the inter-relationship between people's lives and their environment and advocate taking a more strategic and holistic approach. Therefore, any search concerning healthier places must consider the built environment as a complex system. Thus, multi-level, multi-sectorial policymaking challenges along this way must be coordinately addressed to materialize desired healthier outcomes. Realizing this goal may require investigations on a 'new professionalism' which must span all across the built environment, planning, engineering and design professions based on their interconnectivity and collective responsibilities, including fully appraising desired healthier outcomes (Cooper, 2009; Hill and Lorenz, 2011). Indeed, such approach is a necessity if our health, wellbeing and quality of life are to be enhanced, and thus GHG emissions to be seriously mitigated. Roberts (2009) argued that placing emphasis on applying (subject-specific) specialist skills can result in the full or partial exclusion of wider generic competences (Roberts 2009): over dependence on discipline skills may be redressed by expanding professionals' knowledge and skills toward the social and cognitive competences required for sharing experience and insights. Achieving this would require paying detailed attention to understanding the patterns of relationships between the wish-list of desires voiced by academics in this paper in order to provide clues for understanding how effective outcomes emerge. Successful building design process would thus require explicitly managing for integration and harmonisation across disciplines and phases, as well as between and among team members and local stakeholders from a wide range of disciplines and constituencies - including the interface of private and public exchange. This would be needed to ensure the effective capture and integration of both explicit/professional and tacit/lay forms of knowledge into more deliberative forms of practice (Cooper, 2009).

To sum up, the following research-based future actions are recommended for further exploring the SBS impacts, enhancing the capacity of healthy buildings and contributing to the overall well-being and health status of inhabitants:

- To present a more holistic and inclusive definition of healthy buildings with no limit to SBS but moving beyond the current boundaries
- To expand the technical studies on the evaluation of buildings from health perspective (soft and hard issues) to demonstrate the most crucial obstacles and future direction
- To move beyond sustainable buildings and interconnect the sustainable design principles to healthy design attributes
- To similarly explore the weaknesses, challenges and drawbacks of healthy design rather than predominantly concentrating on its benefits
- To clarify the role of industry professionals for promoting healthy buildings during the implementation and application phases based on an explicit understanding of SBS impacts and other health-related parameters
- To increase the public awareness regarding the impacts of buildings on health and well-being
- To develop incentivized programs and policies to encourage the professionals as well as building owners to move towards the proliferation of healthy buildings
- To strike an urban-scale vision towards the possible impacts and potentials of SBS versus healthy buildings at city level

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1. **{** ADDIN EN.REFLIST **}**