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Creating awareness on the negative impact of dampness on the health of occupants: A case for inhabitants living in damp buildings in Ghana

Kofi Agyekum [1], Burcu Salgin [2*], Anthony Kwame Danso [1]

[1] *Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana*
[2] *Department of Architecture, Faculty of Architecture, Erciyes University, Kayseri, Turkey*

Abstract

Epidemiological studies conducted in many parts of the world have shown that there are health issues associated with living in damp buildings. Dampness is a key building defect in Ghana. Despite the findings from such studies, very little is known about the threats posed by dampness to the health of occupants in Ghana. As a result, people are still living in damp affected buildings, and this should create a major cause for concern. This study sought to conduct an extensive literature search on the negative health impact of dampness as a means of creating awareness among building occupants. A four-stage methodology which included: identifying; searching and collecting; classifying, and analyzing the relevant literature material was used. The review clearly showed that being exposed to damp conditions could trigger a number of respiratory tract infections, allergic infections, dermatological infections, as well as mental illnesses. This study should enlighten the general public on the dangers posed by living in damp affected buildings. By so doing, basic mechanisms could be put in place to control the problem, and this could minimize its contribution to respiratory-related issues in Ghana. Public health researchers and practitioners should put the necessary measures in place to create awareness of the problem to the general public.

Keywords: Damp; Health; Ghana; Tropical Buildings; Ghana

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* Corresponding author. *E-mail address:* bsalgin@gmail.com

1. Introduction

The building envelope separates living environment from the outdoor environment. It protects occupants from the elements and shields them from environmental influences. Human beings have created indoor environments to ensure their comfortability (Al horr et al., 2016). The health of human beings should be placed first when assessing the overall comfort of the built environment (Al horr et al., 2016). The characteristics of the environment associated with housing, community and neighbourhood can affect the physical, mental and social health of humans (Agyekum et al., 2017; Udofia et al., 2014; Egan et al., 2010). Adequate housing is expected to provide shelter from climatic conditions, security, environmental nuisances, etc. (Agyekum et al., 2017; Udofia et al., 2014; Lawrence, 2006). However, as a key determinant of health, housing is well recognized by the World Health Organization as having a key impact on people's physical, mental and overall well-being (Bonnefoy, 2007). Literature have shown that poor housing has contributed to indoor air quality problems, resulting in adverse health conditions (Agyekum et al., 2017; Udofia et al., 2014; Kreiger and Higgins, 2002). According to Al horr et al. (2016), the built environment should not lead to any adverse health effects on the health of occupants. However, if this should happen, then it should become a matter of concern to all stakeholders. Indoor air quality is an important issue for occupational and public health (Agyekum et al., 2017; Al horr et al., 2016; Maxim, 2013). There are several building defects that can affect the indoor air quality. One of such is the presence of excessive moisture which leads to dampness (Agyekum et al., 2017).

Moisture is a major problem that affects both olden and modern types of buildings (Sandrolini and Franzoni, 2006). It is a key agent of building deterioration, and has been an issue of great concern to building professionals worldwide (Dacquisto et al., 2004). Excessive moisture present in a building can damage the structure and cause infestations, which can pollute the indoor air and affect the health of the occupants. The presence of moisture in buildings is most commonly caused by pipe leakages, waste or overflows, rain water splashback on walls of buildings, rain water penetration capillary rise of water from the ground into buildings, etc. According to The Islington Health and Care Scrutiny Committee, IHCSC, (2015), normal everyday living may produce significant amount of moisture in buildings. Cooking, laundry, washing, and human and animal respiration may also contribute to the presence of moisture in buildings.

Moisture that should not be present in a building is known as dampness (Burkinshaw and Parrett, 2003). A building is said to have a dampness problem when the materials in that building become sufficiently wet leading to material damage or visible mould growth (Burkinshaw and Parrett, 2003). Damp is also the presence of unwanted moisture diffused through the air, condensed on a surface or within the solid substance of a building, typically with detrimental or unpleasant effect (IHCSC, 2015). Three major conditions should be present for moisture to occur in buildings. There should be: a source of moisture available; a means or route for the moisture to travel; and a driving force to enhance the moisture movement (Straube, 2007; Straube and Schumacher, 2007; Straube, 2002). Eliminate anyone of these conditions and moisture will varnish.

The home environment has changed considerably worldwide due to altered building technologies, new building components and strong demands for energy conservation (Emenius et al., 2004). As these changes are taking place, the amount of moisture that are generated in the buildings should be controlled as well. Uncontrolled moisture in buildings can lead to a number of issues. According to Harriman et al. (2000), indoor moisture originates from many sources. These sources include vapour diffusion through building envelopes, water rising into walls from the ground, and penetration of precipitation. Oreszczyn and Pretliove (1999) also suggested that indoor activities such as cooking, showering and cleaning can introduce moisture into buildings. Building design and operational issues such as plumbing leakages and uncontrolled airflows may also introduce moisture into buildings (Glass and TenWolde, 2009). All these occurrences may result in structural damages, degradation of materials, health issues, and changes to microbial communities (Dedesko and Siegel, 2015).

ASHRAE (2012) reported that in many parts of the world, moisture damage and microbial growth have caused billions of dollars in the cost of repair and interruption of building operations. An increase in the moisture level within a building creates unsatisfactory indoor environments (ASHRAE, 2012). According to Thrasher et al. (2012), indoor dampness and fungal contamination have been shown in qualitative reviews to be associated with a variety of respiratory health effects, including infections, sinusitis, and otitis media. Despite this and many related studies on the health impact of damp on occupants, many people today are happily living in damp affected buildings without the realization of the health issues they are exposed to (Maxim, 2013). According to Maxim (2013), excessive moisture which accumulate in building structures through condensation, rain penetration, capillary rise of water, etc. have the potential to promote mould growth. These moulds may release different compounds and particles into the air, which when inhaled, may create health problems (Agyekum et al., 2017).

Quite a number epidemiological studies have shown linkages between dampness and adverse health effects (Agyekum et al., 2017). The effects range from irritation of mucous membranes, respiratory symptoms and infections, to chronic diseases like asthma and allergy (Agyekum et al., 2017). Other studies have also reported on general symptoms such as fever, fatigue, headaches and depressions (Agyekum et al., 2017). Despite these findings, it is still unknown how the dampness leads to the appearance of these symptoms (Udofia et al., 2014). Studies that investigate the relationship between housing and health have been conducted in many developed countries, however, in Africa, much is not known (Agyekum et al., 2017; Udofia et al., 2014; Asamoah et al., 2012; Govender et al., 2011; Arku et al., 2011; Baiden et al., 2010; Ahianba et al., 2008). This study is therefore conducted to review extensive literature on the negative health impacts associated with living in damp buildings in order to create awareness among inhabitants in Ghana living in buildings with similar conditions.

The paper is in four sections. Section 1 begins with a brief background on the health impacts of damp buildings. Section 2 describes in detail the methods used to conduct the study. Section 3 highlights on some key issues concerning studies conducted in other countries on the subject matter, narrows down to damp housing situations in Ghana and further throws some light on the prevalence of health problems associated with damp housing in Ghana, and section 4 draws conclusion on the issue under investigation.

2. Research methodology

The objective of this study was to conduct an extensive review of literature on the health impacts associated with living in damp buildings in order to create awareness among inhabitants in Ghana living in buildings with similar conditions.

This study adopted a similar methodology used by Al horr et al. (2016) to conduct their study. It involved a four-stage approach which included: identifying, searching and collecting, classifying and analyzing the relevant literature material.

2.1. Stage 1: Identification of the keywords

Stage 1 involved the identification of the main keywords. Because the focus of the study was to critically review literature on the health impacts associated with living in damp buildings, the keywords used for the search included: moisture in buildings; dampness in buildings; health impact of dampness in buildings; dampness and occupants.

2.2. Stage 2: Searching and collecting relevant literature

After the identification of the relevant keywords, Stage 2 involved using the keywords to search for and to collect the relevant literature. As the most common and popular search engine, the Google scholar engine was used to search for these keywords. After retrieving and collecting the articles from google scholar, the bibliographies of the collected articles were thoroughly searched to identify any other articles that were relevant but missed in the first search results.

2.3. Stage 3: Classification of relevant literature

Stage 3 was based on the classification of the relevant literature materials. The classifications were based on three sub-criteria as follows:

a. Year of publication: Since a number of studies had been conducted earlier on, the authors were interested in current studies (that is studies that spanned a little over a decade). As a result, studies that had been conducted between the years 2000 to 2016 were considered in this study.

b. Reputation of journal: studies published in good quality and more reputable journals in the area of the subject matter were considered. Key amongst such journals were Indoor Air; Indoor and Built Environment; Ghana Medical Journal; International Journal of Tuberc Lung Disorders; African Health Sciences; BMC Public Health Journal; Microbiome; European Journal of Allergy and Clinical Immunology; Occup Environ Med; European Respiratory Journal; Pediatrics; Environmental Health; Acta Paediatrics; Environmental Health Perspectives; and Thorax. This is not to say that there are no other journals which are as equally important as these ones. However, based on the focus of the study and the key words used in the search these were the top journals within the areas that were obtained.

c. Papers cited 50 or more times: The articles selected and considered for this study were those which had been cited 50 or more times per google scholar citations, and which were relevant to the study. Authors

considered such articles because they were deemed to contain information that were of interest to the international community, hence the need to cite such articles. However, where the need arose, articles which were relevant but with citations below 50 were also considered. Such papers included Mudarri, 2016; Al horr et al., 2016; Wang et al., 2013; and Ayanbimpe et al., 2010. The citations to these papers were recorded as at 28th May, 2017.

2.4. Stage 4: Analysing the relevant literature materials

Stage 4 involved analysis of the relevant literature materials that were downloaded. Based on the analysis of the papers, they were divided in four sub-categories. The sub-categories included: studies related to respiratory symptoms; studies related to allergic symptoms; studies related to dermatological symptoms; and studies related to mental symptoms or mental wellbeing of occupants. The structure of the rest of the paper is therefore centred around these four sub-categories. After these sub-sections have been presented, the paper discusses major issues concerning the prevalence of health problems associated with damp housing in Ghana. The paper further looks at the way forward with regards to the health impacts of damp housing conditions in Ghana.

3. Findings and discussion

3.1. Negative impact of damp on the health of occupants: A review of related literature

Various studies worldwide have identified moisture-related problems in buildings as a health-risk exposure (Wang et al., 2013). Such studies have also confirmed the fact that living or working in such building conditions could create respiratory or allergic health effects to occupants (Wang et al., 2013). This section reviews and summarizes the findings from various studies conducted on the impact of dampness on the health of people.

A study was conducted by Norbäck et al. (2000) to examine whether there existed any relationship between the symptoms of asthma and dampness within indoor environment in hospitals in Sweden. Indoor air pollutants were measured, together with the determination of dampness in concrete floors, and allergens in settled dust. The study revealed that occupants of two of the buildings that showed signs of dampness showed symptoms of asthma. The study further diagnosed the asthmatic symptoms to be associated with the higher relative humidity in the upper floor construction, and the presence of ammonia in the floors.

An interdisciplinary review was carried out by Bornehag et al. (2001) to assess the relationships between the exposure of occupants to dampness in buildings and their health effects. After the review, it was revealed that the presence of dampness in the buildings studied increased the risk of health effects in the airways. Several health effects were identified to include cough, wheeze and asthma. The study further identified positive relationships between dampness and other symptoms such as tiredness, headache and airway infections. After the study, the authors concluded that the evidence for a causal association between

dampness and health effects was strong. They however stated that the mechanisms that were involved in such actions were unknown (Bornehag et al., 2001).

Kilpeläinen et al. (2001) also conducted a study on 10, 667 Finnish first year university students with the aim of examining the associations between dampness in the homes and other respiratory tract infections diagnosed by physicians. The infections included asthma, allergic rhinitis, allergic conjunctivitis, atopic dermatitis, common colds and bacteria respiratory infections. The dampness categories studied included visible mould, damp stains and water damages. After the survey, 15% of the respondents reported on the presence of visible mould, damp stains, or water damages. The researchers further developed multivariate models, which later revealed that there existed a positive association between home dampness and those respiratory tract infections studied. The researchers confidently concluded that there exists a risk of both upper and lower respiratory tract infections in damp homes.

Maritta et al. (2002) conducted a study to examine the impact of indoor dampness on the development of asthma in adults, both at work and in the house. The researchers methodically enlisted all new cases of asthma between 1997 and 2000 in the Pirkanmaa Hospital district, South of Finland. The study revealed that the occupants who were at the risk of developing asthma were those exposed to the presence of visible mould or mould odour in buildings. About 31.5% of those exposed to the mould at the work place had developed asthma. The researchers further concluded in their study that indoor mould problems that result from dampness contribute significantly to occupational health hazard.

A cross-sectional study was conducted by Bholah and Subratty (2003) to examine the existence of dampness related respiratory symptoms among workers in 25 buildings in Mauritius. The study revealed that health-related issues such as unusual tiredness (lethargy), forgetfulness, headache, excessive mental fatigue, nervousness, irritated and tired/strained eyes and sneezing were the major complaints of the workers. The study concluded that those health-related issues were common among the workers because dampness had existed in the buildings for a longer period of time without any intervention methods. The researchers therefore suggested that stakeholders involved should be made aware of the problem, and key intervention methods put in place to control the situation.

Park et al. (2004) used a semi-quantitative mould exposure index to determine if 13 college building-related respiratory symptoms among young employees had any relationship with environmental exposure to mould and dampness in buildings. The researchers obtained data on respiratory tract symptoms, and their associations with time spent in specific rooms affected by dampness using self-administered questionnaires. The findings from the study showed that those who dwelled in buildings affected by moulds showed the potential of contracting building-related respiratory symptoms.

Emenius et al. (2004) examined the relationship between indoor exposures and the home environment, and the potential of these associations to cause recurrent wheezing in infants in Denmark. A birth cohort that comprised of 4,089 children was followed. The study found that recurrent wheezing in infants was closely associated with a number of indicators of dampness. The study concluded that exposing infants to damp indoor environments has the potential to cause recurrent wheezing.

In 2005, Simoni et al. conducted a study to examine the relationship between dampness exposure and respiratory disorders in children and adolescents in Italy. A questionnaire survey on indoor exposures and respiratory tract infections was conducted on 20,016 children (with mean age of 7 years) and 13,266 adolescents (with mean age of 13 years). The findings from the study showed that asthma, eczema, rhino conjunctivitis, among others was related to early exposure to damp buildings both in children and adolescents. However, the associations seemed more evident in the children than in the adolescents. The researchers concluded that the respiratory disorders were as a result of the exposure to dampness, especially in early life.

Pekkanen et al. (2007) conducted a population-based incident case-control study to examine the association between moisture damage and childhood asthma in Finland. New cases of asthma aged 12-84 months were recruited and matched for year of birth, sex and living area with two randomly selected population controls. The findings revealed that risk of asthma increased with severity of moisture damage and presence of visible mould in the main living quarters. The study concluded that moisture damage and mould growth in the main living quarters were associated with the development of asthma in early childhood.

In another study by Karvonen et al. (2009), the impact of objectively observed moisture damage and visible mould in the homes on early-life respiratory morbidity and atopic sensitization in a birth cohort was evaluated. Building Engineers carried out building inspections in the homes of 396 children. Questionnaire surveys were used to obtain information on the children from birth to the age of 18 months. The findings from the study revealed that Doctor-diagnosed wheezing was associated with severe moisture problems in the kitchen and visible mould in the living and bedroom areas. In achieving this result, the researchers concluded that their study supports previous observations which revealed that moisture mould problems in the kitchen and in the main living areas increase the risk for wheezing in early childhood.

Fisk et al. (2010) also conducted a study to determine the associations between dampness in homes and respiratory (both upper and lower) tract infections. Their study found that there exist serious relationships between home affected dampness and the respiratory tract infections developed by occupants.

In South Africa, Ayanbimpe et al. (2010) evaluated the level of fungal contamination of indoor air and the health-related experiences of residents, in the Jos Metropolis. The findings from the study revealed that the indoor air quality of residential dwellings in Jos is poor because of dampness that introduced the growth of fungi into their homes which affected their health as well.

Tischer et al. (2011) examined the relationship between dampness exposure and its associated allergic disorders amongst children from eight European birth cohorts. Data was obtained and analysed from 31,742 children from eight European birth cohorts. The findings from the study revealed that children who were exposed to mould resulting from dampness within their first two years were at the risk of developing asthma.

In China, Wang et al. (2013) conducted a study to examine the associations between dampness in dwellings and the development of asthma and other allergies among children in Chongqing. A questionnaire survey was conducted on 5,299 children on the said issue under investigation. The findings from the study revealed that all the various buildings surveyed exhibited symptoms of one form of dampness or the other.

Wheezing, cough at night, rhinitis, eczema, asthma, amongst others were reported amongst the health effects associated with the damp buildings.

Mudarri (2016) also conducted a study to estimate the cost of diseases associated with dampness and mould. The researcher used available 'cost of illness' and 'willingness to pay' (WTP) for the estimates. The framework for hospitalization was used to highlight the sensitivity of results to alternative assumptions and methods. The dampness related health issues considered in the study included allergic rhinitis, acute bronchitis and asthma. The study revealed that the total annual cost to society attributable to dampness and mould is estimated to be $3.7 billion for allergic rhinitis, $1.9 billion for acute bronchitis, $15.1 billion for asthma morbidity and $1.7 billion for asthma mortality.

The review has clearly shown that being exposed to damp conditions could trigger a number of diseases. These include upper and lower respiratory tract infections, as well as skin diseases. Among the diseases prevalent and found to be associated with dampness are asthma, wheeze, allergic rhinitis, atopic dermatitis, headache, eczema, bronchitis, cough at night, etc.

Table 1 shows a summary of the various studies on major health issues associated with living in damp buildings. As stated in Section 2.4, studies presented in Table 1 have been grouped under the four sub-categories to include studies related to respiratory symptoms; studies related to allergic symptoms; studies related to dermatological symptoms; and studies related to mental symptoms or mental wellbeing of occupants.

3.2. Discussion of the key findings in relation to the situation of dampness in Ghanaian residential buildings

The literature reviewed clearly suggests the fact that living in damp buildings may expose occupants to health risks. Studies on dampness has not received serious attention in Africa, especially in Ghana. Until 2012 where issues of dampness gained attention among researchers in Ghana, the problem was still prevalent.

A critical look at Section 3.1 suggests that mould growth was key amongst the various symptoms that cause the health-related diseases among the occupants. Mould is a type of fungus that is found both in the inside and outside air (Minnesota Department of Health, MDH, n.d). However, they will only grow once they have favourable conditions in place. Thus, for moulds to occur, there should be a suitable temperature available, there should also be a food source (nutrient) and finally, there should be moisture present.

According to the MDH (n.d.), health effects that result from the exposure to mould may vary from one person to the other. Common among such effects are coughing, runny nose, wheezing, sore throat, among others.

Table 1 clearly shows that for over a decade now, studies concerning the health impact associated with mould that result from dampness has gained popularity. All countries worldwide are participating in active studies concerning the problem to remedy some basic illnesses that can kill people as a result of dampness. Studies conducted in Ghana concerning the problem of dampness have shown its prevalence among many residential and public buildings (Agyekum et al., 2013). Though not much is known about the health

conditions of occupants living within such buildings, the presence of mould, fungus, dust mite, etc. associated with dampness and which cause health related issues have been identified.

Table 1. Summary of health issues associated with living in damp buildings (Source: Agyekum et al., 2017)

Moisture-Related Possible Health Problem / Study that Mentioned the Health Problem	Respiratory Symptoms								Allergic Symptoms			Derma. Symptoms			Mental Symptoms				
	Asthma	Bronchitis	Cough	Wheeze	Sneeze	Common colds	Airway infections	Bacteria respiratory infections	Allergic rhinitis	Allergic conjunctivitis	Irritated eyes	Atopic dermatitis	Eczema	Fungal presence	Headache	Mental fatigue	Nervousness	Forgetfulness	Tiredness
Norbäck et al. (2000)	X																		
Bornehag et al. (2001)	X		X	X			X								X				X
Kilpeläinen et al. (2001)	X					X		X	X	X		X							
Maritta et al. (2002)																			
Bholah & Subratty (2003)					X						X				X	X	X	X	X
Park et al. (2004)	X	X	X	X	X	X	X	X											
Emenius et al. (2004)				X															
Simoni et al. (2005)	X			X					X	X			X						
Pekkanen et al. (2007)	X																		
Karvonen et al. (2009)				X															
Fisk et al. (2010)		X						X											
Ayanbimpe et al. (2010)														X					
Tischer et al. (2011)	X								X										
Wang et al. (2013)	X		X	X					X				X						
Mudarri (2016)	X	X							X										

In a survey conducted to determine the most severe symptoms associated with damp buildings in Ghana, it was revealed that mould growth was one of the key symptoms identified with damp affected buildings (Agyekum et al., 2013). The presence of mould in buildings and the associated impact on the health of occupants who come in contact with them has been debated for many years. Some of its related health impacts is what has been discussed in Section 3.1 of this paper.

In Africa, not much is known about the health issues associated with living or working in damp buildings. In Ghana for instance, Udofia et al. (2014) and Asamoah et al. (2012) have conducted studies on some respiratory health issues. However, from their findings, there was no linkages of the health issues suffered by the building occupants with the presence or absence of dampness.

However, the National Institute for occupational Safety and Health, NIOSH indicated that there is sufficient epidemiological basis that people living in damp and mouldy buildings are at a greater risk of developing upper and lower respiratory tract symptoms, allergic rhinitis, dyspnea, asthma, etc. Fatigue and weaknesses, muscle aches, cramps, joint pains, morning stiffness, abdominal pains, diarrhoea, headache, memory loss, confusion, learning difficulties, difficulty finding words, disorientation, mood swings, anxiety or panic, etc. are all key symptoms associated with mould resulting from dampness. This notwithstanding, there is still ongoing arguments concerning scientific evidence to back these assertions.

In a fact sheet presented and updated in January 2017, the WHO revealed that out of the 56.4 million deaths that occurred worldwide in 2015, about 54% were due to the top 10 causes. Among those causes were the Ischaemic heart disease and stroke (killing about 15 million people), chronic obstructive pulmonary disease (claimed 3.2 million lives) and lung cancer, trachea and bronchus cancers (recorded 1.7 million deaths). Also among such diseases were lower respiratory infections which was reported as the deadliest communicable disease (killing 3.2 million people). From the statistics presented by WHO, it is evident that respiratory infections played a key role in the death of people worldwide. Despite this finding, the WHO failed to state the exact causes of the respiratory infections. However, from literature and studies conducted worldwide, it is possible that dampness and mould could have accounted for some percentages of those infections.

In Ghana, the World Health Organization has conducted series of investigations on the causes of deaths in both children under 5 years of age and in adults as well. The report from the WHO indicated that acute respiratory infections were third in terms of the distribution and causes of deaths in children under five years old in Ghana (Figure 1).

Also, an earlier study conducted by WHO in 2012 had revealed that among the top 10 overall causes of deaths in Ghana, lower respiratory infections were the leading cause, killing 22.4 thousand people (Figure 2). A critical analysis of these trends show that respiratory infections are very popular amongst the diseases which cause deaths in both the young and the old in Ghana.

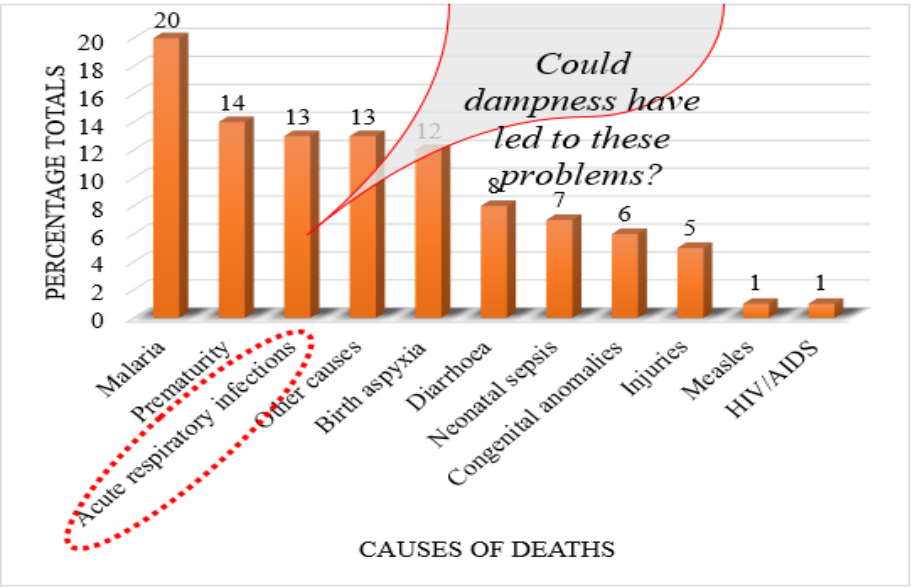

Figure 1. Distribution of causes of deaths in children under 5years old in Ghana (Source: World Health Organization, 2013)

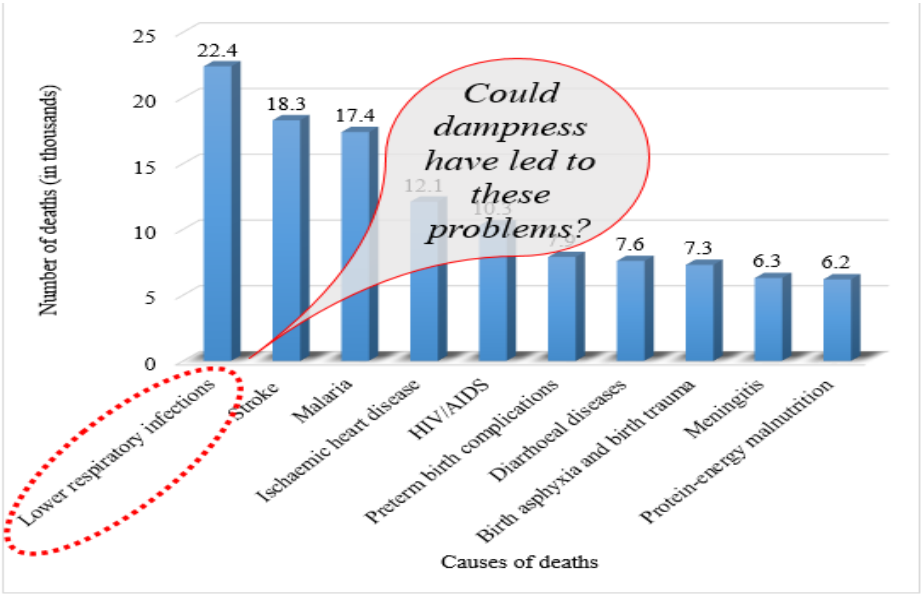

Figure 2. Overall causes of deaths in Ghana (Source: World Health Organization, 2012)

WHO (2012) was silent on the examples of such respiratory infections. However, literature has shown that asthma is one of such respiratory infections that affect young children exposed to damp conditions in buildings. The question that this study asks is, is it possible that some of the acute respiratory infections

(Figure1) and the lower respiratory infections (Figure 2) could have resulted from the fact that the occupants may be living in damp and mould affected buildings? The answer to this question is 'YES'. This is because research has shown that dampness is everywhere in Ghana, and one out of every ten residential buildings suffers from one form of dampness or the other (Agyekum et al., 2013). Based on this documentary evidence, it is possible that dampness could have contributed significantly to some of the deaths caused by the acute and lower respiratory infections in Ghana.

Consistent associations between dampness (that results in moulds) and respiratory symptoms in occupants have been recorded (National Institute for Occupational Safety and Health, NIOSH, 2012). When there is excessive moisture in a building, there is an increase in the indoor microbial growth on building materials and other surfaces. The structural components of microbes (i.e. spores and fungal fragments) that develop as a result of the favourable conditions may pose serious threats to the health of occupants (NIOSH, 2012).

A study undertaken by the Institute of Medicine, IOM, (2004) found that there exist associations between exposure to damp indoor environments and cough, wheeze, upper respiratory tract symptoms and exacerbation of asthma. According to NIOSH (2012), the WHO published guidelines for indoor air quality, dampness and mould in 2009. A review was conducted on scientific literature up to July 2007. From the review, the WHO concluded that there was sufficient epidemiological evidence to conclude that occupants of damp buildings stood a higher risk of developing upper and lower respiratory tract symptoms. In a study by Fisk (2007) to determine the percentage increase in health outcomes of occupants living in damp houses and those in damp free houses, the percentage increases were 50% for current asthma, 33% for ever diagnosed asthma, 30% for asthma development, 50% for cough, 44% for wheeze, and 52% for upper respiratory tract symptoms (NIOSH, 2012). A look at these statistics further confirm the dangers of developing both upper and lower respiratory tract infections when one lives in a damp affected building.

From these reports, together with studies conducted worldwide on the health effects of dampness on building occupants, it has become evident that dampness in one way or the other may pose serious health threats to occupants. Studies on the associations between dampness and the health of occupants is still at the infantry stage in Ghana. It has not yet been confirmed in Ghana that such respiratory tract infections are as a result of damp conditions in buildings.

4. Conclusion

Buildings may be prone to persistent moisture ingress from several sources. Occupants who dwell in such buildings may be exposed to microbial emissions that result from the breakdown of the materials affected. Adverse health effects associated with moisture problems have been well documented worldwide. This study was conducted to create awareness on the negative health impact posed by dampness on building occupants. An extensive literature survey was conducted. Issues raised on the subject matter in 15 journal papers were reviewed and used as a basis for the study. Key amongst the lessons learned from the literature search is the fact that there are many health issues associated with living in damp housing conditions. The review clearly

showed that being exposed to damp conditions could trigger a number of upper and lower respiratory tract infections, as well as skin diseases. Building occupants are encouraged to be aware that living in damp affected buildings could result in respiratory related problems, allergic related problems, dermatological problems, mental problems amongst others. If awareness can be created among designers, builders and occupants on how and why dampness problems occur, this will be the cheapest and easiest way to start preventive measures.

During the design stage of a building, there can be low or no-cost decisions regarding the passive ventilation that will have a significant impact on moisture management. The most important no-cost decision is related to window openings. When the architectural team place the windows of buildings preferably on opposite sides to maintain a cross air flow, it is the most effective way to remove internal moisture. Once architectural designers are made aware of this problem, these simple solutions could be applied at an early stage of the design.

During the construction stage, the constructor should ensure that the design decisions and details are properly constructed. Coordination between construction companies and building designers (architects and engineers) will enhance moisture control in the building. Moreover, construction companies have to deal with moisture problems at the construction site.

During construction in warm weather, doors and windows should be kept open to allow for natural drying of joint compound, tile grout, and paint. Prior to the usage of the building, occupants and managers need to be on the lookout for standing water or slow water leaks. Once the water is identified, it is important to locate its source. Keeping buildings dry, healthy, and safe is not a complicated process. It requires attention to detail and constant vigilance so that small problems do not explode and become large.

To ensure that the problem is very well controlled, there should be adequate education and training of all stakeholders involved in buildings and its related health issues. These trainings could be in the form of seminars, workshops, continuing professional developments, community talk shows, amongst others for all the various stakeholders involved. Government and private entities should provide continuing support for research and demonstration projects that develop education and training for building professionals (architects, contractors, etc.). The solutions offered may not only be related to educating people (designers, constructors and occupants). It may also be related to the economic conditions of the country and the people, where the government and private entities could make plans for alternative living places for low-income citizens.

References

Agyekum, K., Ayarkwa, J., Koranteng, C. and Adinyira, E. (2013), "Preliminary assessment of dampness in walls of residential buildings in four climatic zones in Ghana", *Journal of Sustainable Development*, Vol. 6, No. 9, pp. 51-61.

Agyekum, K., Salgin, B. and Danso, A.K. (2017), "The health impacts of damp housing conditions: Lessons for occupants living in damp tropical buildings", in 6th International Conference of Infrastructure Development in Africa proceedings of the international conference in Kumasi, Ghana, 12-14 April, 2017, pp. 257-269.

Ahianba, J.E., Dimuna, K.O. and Okogun, G.R.A. (2008), "Built environment decay and urban health in Nigeria", *Journal of Human Ecology*, Vol. 23, No. 3, pp. 259-265.

Al horr, Y., Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A. and Elsarrag, E. (2016), "Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature", *International Journal of Sustainable Built Environment*, Vol. 5, No. 1, pp. 1-11.

Arku, G., Luginaah, I., Mkandawire, P., Baiden, P. and Asiedu, A.B. (2011), "Housing and health in three contrasting neighbourhoods in Accra, Ghana", *Soc Sci Med*, Vol. 72, No. 11, pp. 1864-1872.

Asamoah, A.S., Forson, A.G. and Boakye, D.A. (2012), "A Review of epidemiological studies of asthma in Ghana", *Ghana Medical Journal*, Vol. 46, No. 2, pp. 23-28.

ASHRAE (2012), "ASHRAE Position document on limiting indoor mould and dampness in buildings", Approved by ASHRAE Board of Directors June 27, 2012, Reaffirmed by ASHRAE Technology Council January 27, 2016.

Ayanbimpe, G.M., Wapwera, S.D. and Kuchin, D. (2010), "Indoor air mycoflora of residential dwellings in Jos Metropolis", *African Health Sciences*, Vol. 10, No. 2, pp. 172-176.

Baiden, P., Arku, G., Luginaah, I. and Asiedu, A.B. (2010), "An assessment of residents' housing satisfaction and coping in Accra, Ghana", Journal of Public Health, Vol. 19, No. 1, pp. 29-37.

Bholah, R. and Subratty, A.H. (2003), "Humid building problems in Mauritius", *Indoor and Built Environment*, Vol. 12, No. 4, pp. 221-225.

Bonnefoy, X. (2007), "Inadequate housing and health: An overview", *International Journal of Environment and Pollution*, Vol. 30, No. ¾, pp. 411-429.

Bornehag, C.G., Blomquist, G., Gyntelberg, F., Järvholm, B., Malmberg, P., Nordvall, L., Nielsen, A., Pershagen, G., Sundell, J. (2001), "Dampness in buildings and health. Nordic Interdisciplinary Review of the Scientific Evidence on Associations between Exposure to "Dampness" in Buildings and Healh Effects (NORDDAMP)", *Indoor Air*, Vol. 11, No. 2, pp. 72-86.

Burkinshaw, R. and Parrett, M. (2003), "Diagnosing damp", 1st ed. London: RICS.

Dacquisto, D.J., Crandell, J.H. and Lyons, J. (2004), "Building, moisture and durability: Past, present and future work", Report for US Department of Housing and Urban Development, Office of Policy Development and Research, Washington, D.C., Prepared by Newport Partners, LLC Davidsonville, Maryland. October 2004.

Dedesko, S. and Siegel, J.A. (2015), "Moisture parameters and fungal communities associated with gypsum drywall in buildings", *Microbiome*, No. 3.

Egan, M., Kearns, A., Mason, P., Tannahill, C., Bond, L., Coyle, J., Beck, S., Crawford, F., Hanlon, P., Lawson, L., McLean, J., Petticrew, M., Sautkina, E., Thomson, H. and Walsh, D. (2010), "Protocol for a mixed methods study investigating the impact of investment in housing, regeneration and neighbourhood renewal on the health and wellbeing of residents: the GoWell programme", *BMC Med Res Methodol*, No. 10.

Emenius, G., Svartengren, M., Korsgaard, J., Nordvall, L., Pershagen, G. and Wickman, M. (2004), "Indoor exposures and recurrent wheezing in infants: A study in the BAMSE cohort", *Acta Paediatr*, Vol. 93, No. 7, pp. 899-905.

Fisk, W.J., Eliseeva, E.A. and Mendell, M. (2010), "Association of residential dampness and mould with respiratory tract infections and bronchitis: A meta-analysis", *Environmental Health*, No. 9.

Fisk, W.J., Lei-Gomez, Q. and Mendell, M.J. (2007), "Meta-analyses of the associations of respiratory health effect with dampness and mould in homes", *Indoor Air*, Vol. 17, No. 4, pp. 284-296.

Glass, S.V. and TenWolde, A. (2009), "A review of moisture balance models for residential indoor humidity", paper presented at the 12th Canadian Conference on Building Science and Technology, Montreal, Quebec.

Govender, T., Barnes, J.M. and Pieper, C.H. (2011), "The impact of densification by means of informal shacks in the backyards of low-cost houses on the environment and service delivery in Cape Town South Africa", *Environ Health Insights*, No. 5, pp. 23-52.

Harriman, L.G., Lstiburek, J. and Kittler, R. (2000), "Improving humidity control for commercial buildings", *ASHRAE J*, Vol. 42, No. 63, pp. 24-30.

Institute of Medicine (2004), "Damp indoor spaces and health", available at: https://www.nap.edu/read/11011/chapter/1#iii (accessed 17 February 2017).

Islington Health and Care Scrutiny Committee (2015), "Review of the health impacts of damp housing conditions", available at: https://democracy.islington.gov.uk/documents/s5439/Review%20of%20the%20health%20impacts%20of%20damp%20housing%20conditions%20Final.pdf (accessed 17 February 2017).

Karvonen, A.M., Hyvärinen, A., Roponen, M., Hoffmann, M., Korppi, M., Remes, S., Mutius, E., Nevalainen, A. and Pekkanen, J. (2009), "Confirmed moisture damage at home, respiratory symptoms and atopy in early life: A birth-cohort study", *Pediatrics*, Vol. 124, No. 2, pp. 329-338.

Kilpeläinen, M., Terho, E.O., Helenius, H. and Koskenvuo, M. (2001), "Home dampness, current allergic diseases, and respiratory infections among young adults", *Thorax*, Vol. 56, No. 6, pp. 462-467.

Kreiger, J. and Higgins, D.L. (2002), "Housing and Health: Time again for public health Action", *Am Journal of Public Health*, Vol. 92, No. 5, pp. 758-768.

Lawrence, R.J. (2006), "Housing and Health: Beyond disciplinary confinement", *Journal of Urban Health*, Vol. 83, No. 3, pp. 540-549.

Maritta, S.J., Nordman, H., Piipari, R., Uitti, J., Laitinen, J., Karjalainen, A., Hahtola, P. and Jaakkola, J.J.K. (2002), "Indoor dampness and molds and development of adult-onset asthma: A population-based incident case-control study", *Environmental Health Perspectives*, Vol. 110, No. 5, pp. 543-547.

Maxim, D. (2013), "Health effcts of exposure to indoor fungi: Case Study-The Restorers of Mural Paintings", *European Journal of Science and Theology*, Vol. 9, No. 3, pp. 149-157.

Mudarri, D.H. (2016), "Valuing the economic costs of allergic rhinitis, acute bronchitis and asthma from exposure to indoor dampness and mould in the US", *Journal of Environmental and Public Health*, Vol. 2016, pp. 1-12.

NIOSH Alert (2012), "Preventing occupational respiratory diseases from exposures caused by dampness in office buildings schools and other non-industrial buildings", DHHS (NIOSH) Publication No. 2013-102, November 2012.

Norbäck, D., Wieslander, G., Nordström, K. and Wålinder, R. (2000), "Asthma symptoms in relation to measured building dampness in upper concrete floor construction", and 2-ethyl-1-hexanol in indoor air", *Int Journal Tuberc Lung Dis*, Vol. 4, No. 11, pp. 1016-1025.

Oreszczyn, T. and Pretlove, S.E.C. (1999), "Condensation targeter II: Modelling surface relative humidity to predict mould growth in dwellings", *CIBSE A Build Serv Eng Res Technol*, Vol. 20, No. 3, pp. 143-153.

Park, J.H., Schleiff, P.L., Attfield, M.D., Cox-Ganser, J.M. and Kreiss, K. (2004), "Building-related respiratory symptoms can be predicted with semi-quantitative indices of exposure to dampness and mould", *Indoor Air*, Vol. 14, No. 6, pp. 425-433.

Pekkanen, J., Hyvärinen, A., Haverinen-Shaughnessy, U., Korppi, M., Putus, T. and Nevalainen, A. (2007), "Moisture damage and childhood asthma: a population-based incident case-control study", *European Respiratory Journal*, Vol. 29, No. 3, pp. 509-515.

Sandrolini, F. and Franzoni, E. (2006), "An operative protocol for reliable measurements of moisture in porous materials of ancient buildings", *Build Environment*, Vol. 41, No. 10, 1372–1380.

Simoni, M., Lombardi, E., Berti, G., Rusconi, F., La Grutta, S., Piffer, S., Petronio, M.G., Galassi, C., Forastiere, F., Viegi, G. and The SIDRIA-2 Collaborative Group. (2005), "Mould/dampness exposure at home is associated with respiratory disorders in Italian children and adolescents: the SIDRIA-2 Study", *Occupational and Environmental Medicine*, Vol. 62, No. 9, pp. 616-622

Straube, J. (2007), "Review and hygrothermal simulations of planned insulation retrofit to Hitchcock Hall, Dartmouth College", Report, 31 Jan 2007 (reformatted 22 Feb 2007).

Straube, J. and Schumacher, C. (2007), "Interior insulation retrofits of load-bearing masonry walls in cold climates", *Journal of Green Building*, Vol. 2, No. 2, pp. 42-50.

Straube, J.F. (2002), "Moisture in Buildings", ASHRAE J, Vol. 44, No. 1, pp. 15-19.

Thrasher, J.D., Gray, M.R., Kilburn, K.H., Dennis, D.P. and Yu, A. (2012), "A water-damaged home and health of occupants: A case study", *Journal of Environmental and Public Health*, Vol. 2012, pp. 1-10.

Tischer, C.G., Hohmann, C., Thiering, E., Herbarth, O., Müller, A., Henderson, J., Granell, R., Fantini, M.P., Luciano, L., Bergström, A., Kull, I., Link, E., von Berg, A., Kuehni, C.E., Strippoli, M.P., Gehring, U., Wijga, A., Eller, E., Bindslev-Jensen, C., Keil, T., Heinrich, J. and ENRIECO consortium (2011), "Meta-analysis of mould and dampness exposure on asthma and allergy in eight European birth cohorts: an ENRIECO initiative", *European Journal of Allergy and Clinical Immunology*, Vol. 66, No. 12, pp. 1570-1579.

Udofia, E.A., Yawson, A.E., Aduful, K.A. and Bwambale, F.M. (2014), "Residential characterisitics as correlates of occupants' health in the Greater Accra Region, Ghana", *BMC Public Health Journal*, No.14.

Wang, H., Li, B., Yang, Q., Yu, W., Wang, J., Liu, Y., Ou, Y. and Sundell, J. (2013), "Dampness in dwellings and its associations with asthma and allergies among children in Chongqing: A cross-sectional study", *Chinese Science Bulletin*, Vol. 58, No. 34, pp. 4259-4266.

World Health Organization (2012), "Ghana: WHO statistical profile", available at: http://www.who.int/gho/en/ (accessed 4 September 2016).

World Health Organization (2013), "Ghana: WHO statistical profile", available at: http://www.who.int/gho/en/ (accessed 4 September 2016).