Green Envy

The study of Green Buildings and their effects on employee wellbeing.

Ryan E. Meyer

University of the Witwatersrand

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Supervisor: Professor Andrew Thatcher.

Declaration

Name: **Ryan Eric Meyer**

Student Number: **794424**

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Abstract

This research conducted a post-occupancy evaluation of a green building within Johannesburg, South Africa. The study focused on the impact of indoor environmental quality features (IEQ) in green buildings on employee health and wellbeing as opposed to conventional buildings. This study investigated the overall satisfaction of IEQ features within a 5-star GBCSA rated building as well as the impact that IEQ features had on employee wellbeing, which was analyzed as two separate variables, physical and emotional wellbeing. The sample consisted of 4557 participants with 749 matched participants from 2017 to 2018. In line with global literature, a statistically significant result was found with regards to IEQ satisfaction, across health, performance and overall satisfaction. Although the majority of green building research has found an increase in both physical and emotional wellbeing as a result of the improvement of indoor environmental quality, this study found a statistically significant increase in the physical wellbeing of employees, however, a non-significant increase in employees' emotional wellbeing.

Keywords: Green Building, Employee Health &Wellbeing, IEQ Features.

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Table of Contents

Table of Figures:

Chapter 1: Introduction

One of the single greatest existential threats to human existence within the 21st century is climate change (Spratt & Dunlop, 2019). The impact of climate change has spread from agriculture, food and water security, to individual health (PSR, 2017). Many of nature's natural disasters such as floods, wildfires, hurricanes and tsunamis are as a result of climate change and the impact of global warming. The cause of this disaster is humanity itself, with the effects of human activity spanning from the early 20th century, to the present (NASA, 2018). One of the key talking points around climate change has been sustainability, as the earth may not be able to sustain/support human life on its current course.

Earth's natural resources which were once considered infinite are slowly beginning to deplete in its current toxic relationship with humanity. Resources which are vital to human existence, such as water, are becoming polluted and slowly beginning to dry out with the impact of changing climate. In conversations surrounding sustainability, buildings, humanity's source of shelter, have received attention globally, as large amounts of natural resources are involved during a building's life cycle which has a significant impact on the environment (US EPA, 2009). Buildings are essential to sustainability as it has been shown that the amount of energy and water consumed by buildings has a comparable impact on ozone depletion, carbon dioxide emissions, raw materials as well as waste to that of the entire transport and industry sectors (US EPA, 2009).

It is for this reason that identification and adoption of green methods and strategies has begun to support the design of buildings which are in line with sustainable development goals (Attaianese, 2018). Green buildings and their criteria have begun to fill the need for sustainable development. The criteria behind green buildings promote elements such as energy and resource efficiency, which thereby lessens the impact on the natural environment, as well as an improvement in employee health and productivity (Thatcher & Milner, 2012). It is for this reason that green buildings have entered into the realm of organisational psychology research as buildings which have a positive impact on the environment and reported to impact on the environment. They have also been reported as having an impact on employee health and wellbeing, however, this needs to be further explored, as it has rarely been investigated (Attaianese, 2018).

Employee health and wellbeing is also, as a construct, something which has become vague and obscure within psychological research. The term is widely used with many different interpretations of the construct and what it measures. This therefore complicates research into wellbeing within green buildings and the sustainability of their environment for occupants, as the construct of wellbeing is not fully conceptualised from one study to the next. The current study proposes a two factor model of wellbeing where the core construct of wellbeing is split into physical as well as psychological wellbeing, in an effort to accurately measure the construct in its entirety (Danna & Griffin, 1999; DeJoy & Wilson, 2003).

In line with suggestions made by other research which suggests that the most prevalent and established data collection method for occupation surveys is that of post-occupancy evaluation (POE), the current research aligns with this method of data collection (Kamaruzzaman, Egbu, Zawawi, Ali, & Che-Ani, 2011). Building off the research conducted by Laughton (2018), this study evaluates the perceptions of a green building's impact on employee health and wellbeing as well as the perceived indoor environmental impact within a South African sample post occupancy.

The rationale is the contestation within global literature as to the true effects of a green building on employee health and wellbeing. Although authors such as Allen et al. (2015) would like to advocate for green buildings as the source for a blanket increase in wellbeing, research such as Thatcher and Milner (2016) found that psychological wellbeing did not significantly increase within their research of green buildings. Further to this, Lee and Kim (2008) point towards the idea that IEQ features do not work in isolation to one another. With previous research focusing on singular IEQ features and their impact on wellbeing, this does not analyse the potential impact of multiple features interacting within the environment at once and how this might change an employee's sense of wellbeing.

The report will be set out using the following structure,

Chapter 2 will foreground the literature surrounding green buildings as well as research which has been conducted with respect to employee health and wellbeing within green buildings. The research will attempt to set up a framework for the discussion surrounding green rated

buildings as well as the contentions that arise within the literature. Chapter 3 will encompass the procedure and design undertaken within the research as well as describe the sample used within the research, the instruments chosen for variable measurement, as well as the ethical considerations which were addressed. Chapter 4 contains the results of the t-test and matched t-test analysis of post occupancy data. Chapter 5 will be devoted to a critical discussion of the results found within the previous chapter. This will be in an effort to situate the findings in respect of global trends as well as the literature analysed within Chapter 2.

Chapter 2: Green (Literature) Review

The following chapter will be dedicated to establishing the theoretical underpinnings of the research surrounding employee wellbeing as well as literature establishing the necessity for green buildings within the South African context. Research into green buildings has predominantly focused around the environmental benefits in countries such as the United States, Australia, the United Kingdom, China, Sweden and South Africa with each country utilising their own certification standards to assess these benefits (Thatcher & Milner, 2016). However, there has been less research focused on occupant's health and wellbeing within these sustainable buildings.

Green buildings and their history are closely tied to the trend of industrialisation, a by-product of which was the increase in urbanisation, with over 51% of the world's population being urbanised (Hanlon, 2007). This has resulted in more and more individuals spending time indoors with Klepeis et al. (2001) reporting that in a sample of 9386 US citizens, 87% reported that most of their time was spent inside buildings. These findings were similarly found in the United Kingdom as well as France, Greece, and other European countries where individuals may spend over 90% of their time indoors (Schweizer et al., 2007). With such a large number of individuals spending the majority of their time within buildings there was a surge to erect structures to house these large amounts of inhabitants.

With this increasing trend thought has moved to how to make these spaces more comfortable as well as healthier for the occupants within them. This review looks specifically at buildings in reference to commercial and office buildings rather than other building types as these are predominantly where humankind is spending most of their time. This can be seen with the increased energy use by buildings requiring to be heated, cooled and artificially lit, which has a significant impact on the environment as well as financial costs to organisations (Hedge & Dorsey, 2012). With these costs there was a need for a more sustainable solution not only to the environmental and financial effects of conventional buildings, but also an increased understanding of how these buildings may affect employee health. Green buildings have been attributed as part of this solution.

2.1 Green Buildings

Buildings have a costly impact on the environment from the beginning of their life cycle, marked by dust, water pollution and waste disposal, to their ending phase where the building is demolished and the remains are harboured in landfills (Zuo & Zhao, 2014). This is combined with the impact that the building's materials may have on the inhabitants. This includes the presence of Volatile Organic Compounds (VOCs) often found in 'older' buildings in the furniture, paint and building materials which have adverse effects on the occupants' health (Greenguard, 2018). The Environmental Protection Agency in the U.S states that green buildings are those buildings that are sustainable throughout their life cycle from the "siting to design, construction, operation, maintenance, renovation and deconstruction" which clearly differs from conventional buildings (U.S Environmental Protection Agency, 2016).

It is very difficult to solely define a green building in a singular term, as buildings by their very nature differ in key elements such as size, shape and use. It would therefore be very difficult to isolate a uniform descriptor for something which does not conform by its very nature. However, what seems to define a green building is the elements of green design which are incorporated into the building's construction. These elements could be defined as a form of green discourse, the language used when describing any element of design which relates to an interaction with the natural environment.

There is therefore a need to distinguish what is implied by green design as well as the features within it. Within green buildings, this is facilitated through a list of criteria, and especially Indoor Environmental Quality criteria or more commonly referred to as IEQ points. The list of criteria promote elements of green design which in turn increase energy and resource efficiency and could possibly facilitate an increase in physical wellbeing and satisfaction (Thatcher & Milner, 2012). These points are but an example of green discourse as IEQ features, given their association to energy and resource efficiency and their lessened impact on the environment are positioned within the literature as a positive outcome.

The terms used within green buildings that are denoted as 'points' imply their positivity where as long as it is green it is considered to be better. However, what is interesting is that the interplay between the building's efficiency and its occupants operate on an interrelated continuum, where the one will continually have an effect on the other. There is tension in the literature regarding this interplay. As stated by Hedge (2013), relatively few studies have

documented the impact of green design on occupants thereby questioning how positive certain features are on employee health and wellbeing?

These points are encompassed within the green building rating tools or certification systems which are multi criteria assessments, "where a score is awarded if it can be demonstrated that there is a compliance between specific characteristics of the building and a list of green criteria and parameters, and after having compared real performance with referenced ones" (Attaianese, 2018, p. 221). The sustainability of the building occurs by summing the results of the assessed criteria, as each criterion has a certain amount of weighted points available, which leads to the final rating score (Berardi, 2015). The rating systems analyse the project, matching relative levels of compliance to specific goals and requirements (Vierra, 2014). What is important to note is that although the rating tools are voluntary and country specific, their impact is global, with the programs designed to reduce the impact of the built environment on human health and the environment (Reed, Wilkinson, Bilos, & Schulte, 2011; Vierra, 2014).

2.2 Green Wellbeing

From the definition of a green building, we can begin to unpack exactly what is meant by employee wellbeing and how this fits into the wider construct of a green building. Sustainability within a green building is no longer just focused on whether the building is ecologically sustainable but physically and psychologically sustainable for its inhabitants (Attaianese, 2018). Green buildings are often assumed to lead to an increase in wellbeing given their higher indoor environmental quality. Indoor environmental qualities in their design, improve health outcomes

with features such as increased ventilation and thermal comfort control. Hedge (2000) was among the first researchers to highlight the link between employee health, office lighting, air quality, and sick building syndrome. This study follows the recommendation from Thatcher and Milner (2012) who separate out these constructs into independent measures, such as wellbeing, within ergonomics and organisational psychology literature which makes a distinction between psychological and physical wellbeing.

Although wellbeing is often used within literature as a common term within psychology, it lacks clear definition. Often it is vague and has little consistency within the literature. DeJoy and Wilson (2003) attempt to define wellbeing as the physical and emotional facets which effect employee health. This definition is supported by Danna and Griffin (1999), a more seminal text, who add that although wellbeing can refer to the actual physical health of the employee it may also refer to the psychological aspects of the work and its environment. It is therefore crucial that this term is broken down into clear variables to accurately study the effects of green buildings. Wellbeing in the context of this research combines the physical wellbeing as well as the emotional wellbeing, to create a wholistic understanding of the term.

Comparatively, physical wellbeing in the context of this research refers to the somatic experiences within the workplace; how an individual experiences physical comfort or more over physical discomfort as a result of poor ergonomics or general workplace design (Miller, Dorsey, & Jacobs, 2012). Physical discomfort is often a result of musculoskeletal issues which often results in poor work satisfaction (Demure et al., 2000). Often this form of physical discomfort centres around the employee's wrist and elbow regions as well as shoulder and back

discomfort, as a result of non-ergonomically designed workstations, overuse of particular muscle groups, which results in repetitive strain injury (RSI) (Newman, 2018). This is highlighted in early office research where the position of the keyboard with respect to the monitor on a desk could cause physical discomfort and strain (Lai, Kim, Eng, Keong, & Chui, 1998). Further to this physical wellbeing may refer more broadly to an individual's perception of their own health, whether they are feeling healthy as a result of their environment or if they feel generally unhealthy as a result of interacting with their work environment. Hedge (2000) points to key variables which impact on the physical health of building occupants being lighting, indoor climate, and air quality all of which are features located within IEQ criteria.

Emotional wellbeing refers to employees perception of psychological health and comfort, the importance of this cannot be understated within the research on green buildings. As pointed out by McGuire and McLaren (2009) the physical layout of a working environment can have a strong effect on employee wellbeing as a work environment that is comfortable as well as supportive has direct effects on employees' sense of emotional wellbeing. The relationship between the physical environment and psychological wellbeing has not been sufficiently researched however it has been known to be a crucial and significant relationship (Klitzman & Stellman, 1989).

Psychological comfort which is another facet of emotional wellbeing is used as an assessment of an individual's satisfaction with their environment, it deals with environmental design to assess "individuals perceptions of privacy" and control which sees territory as a primary component as expressed by Vischer (2007). This refers to both the "individuals

territory" such as their office or workstation as well as within their team workspace, this speaks to the idea of what an employee can consider as their space within the organisation (Vischer, 2007). Privacy and control are linked to territory as these are elements that give individuals a sense of status as well as control over their workspace and are the two key elements individuals use to perceive and judge their workspace (Vischer, 2007). What is interesting is that studies have shown that individuals who are moved out of private/enclosed offices into open workstations judge their workspace more negatively citing a lack of privacy, poor acoustic conditions, and issues of confidentiality, even if their job does not require any of these features (Vischer, 2008).

From this it can be seen that wellbeing is a multifaceted variable which is explored through two aspects of employee health, both an individual's physical health as well as their emotional/psychological health. The connection to the green building is highlighted through the idea that creating a workplace which is comfortable as well as healthy, will improve employee wellbeing (Ghodrati, Samari, & Shafiei, 2012). There is strong evidence to suggest that environmental features of the building have improvements on individual work performance (Heerwagen, 2000; Leaman & Bordass, 2007). There is evidence which links wellbeing and building quality, as an increase in one's work environment leads to an increase in wellbeing and thus to increased performance (Clements-Croome, 2014; Hedge & Dorsey, 2013). Greater productivity within the organisation is more profitable for the organisation, making it more attractive for leaders to consider green buildings as an alternative to conventional buildings. The overarching question from these constructs, is how is this translated into measurement within a green building, how are health outcomes assessed within green literature? This is predominantly

done through criteria such as Leadership in Energy and Environmental Design (LEED) and IEQ features.

2.3 Green Discourse

Feifer (2011) comments that 'greenness' as a term has become a risky attribute, as often the focus centres around energy consumption, rather than the actual long term impact that buildings have on their environment. Green buildings are often seen as more cost effective for their energy savings, rather than their perceived impact on the ecosystem in which the building is located. Sustainability, which often looks at whether a building can be truly sustainable throughout its life cycle often overlooks the sustainability of its precise social aspects, its occupants (Attaianese, 2018). Sorrento (2012) comments that previous models of the sustainable built environment distanced humans from the interaction, whereas a progressive relationship is needed, incorporating humans into the model of sustainable built environments.

Within the discussion of green buildings there is a certain element of discourse which takes place, an interchange between words such as LEED and IEQ certification, key features of green design. In an effort to encompass this new 'language' and its ever evolving vocabulary there needs to be a broad conception of these terms hence the creation of the term green discourse for this study. This term fills in the gaps for readers who are not acquainted with green literature and need assistance in the identification of its key constructs.

2.2.1 What is LEED in the greener scheme of things?

LEED is a formal rating system for Green Buildings, the acronym stands for Leadership in Energy and Environmental Design (US Green Building Council, 2019). Essentially LEED aims to produce "healthier, more productive places, reduced stress on the environment by encouraging energy and resource efficient buildings", which is an accurate description as to the purpose behind green buildings (US Green Building Council, 2019). LEED is an American rating system, developed in 1993, which is seen more predominantly within the global literature in comparison to other rating systems. However, as Thatcher and Milner (2012) comment, there are many other benchmarks and standard tools such as the British Establishment Environmental Assessment Method (1990), National Australian Built Environment Rating System (2000), Green Star Australia (2003), as well as Green Star South Africa (2008).

What is interesting to note is that although the South African Green Star rating is one of the newer rating tools, it has an added advantage as it allows the South African benchmark to learn from its predecessors and build from their developments. The Green Star rating tools are created for use on different building types such as the office, retail, public/education and multi-unit residential, which allows for the adaptability to different designs and intended use (Green Building Council South Africa, 2017).

There are nine categories which are assessed under the LEED certification system; location and transportation, sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, innovation, regional priority and integrative processes (Jones, 2016). With each of the categories being met, a ranking is given to the building

such as silver, gold, or platinum. The South African criteria differ slightly with ten categories being management, energy, water, land and ecology, innovation, indoor environmental quality, transport, materials, emissions and socio economic factors; with buildings achieving a ‘star’ rating such as a ‘five star’ rating (Green Building Council South Africa, 2017).

Although rating tools may differ slightly from country to country, they still have the same fundamental features, the minor differences may be attributed towards what each country wishes to achieve and prioritise. For instance within the South African model there is an optional criterion for socio-economic upliftment, where the building receives points for the upliftment of socio-economic conditions around the development. This is aimed specifically at reducing the impoverishment of many South African communities, something which can be seen as sustainability within the country as a whole.

From the outlined criteria, there is a clear sense of how these factors may impact on the environment as well as the building’s sustainability. What is key to note is that many of the categories listed are scarce resources within South Africa such as water and electricity. Cape Town experienced a drought with Johannesburg implementing water shortages to conserve the resource. Further to this, the country as a whole bears the effects of electricity load shedding (Maxmen, 2018). Therefore, there is a concerted effort for green buildings to highlight these resources in an effort to be more sustainable both to the environment but also to the occupants within and around these buildings.

The host site for the current research is a 5-star-green-rated building by the Green Building Council of South Africa, located in Johannesburg Sandton, with the highest ranking points being water and innovation, once again highlighting the green building's commitment to resource sustainability. Some of the other features include high efficiency water and air cooled chillers, efficient lighting throughout the building, harvesting of grey and rain water for the irrigation and plumbing, indigenous landscaping within and outside the building as well as a green roof (GBCSA, 2017).

Although these features are crucial towards improving sustainability of the environment, the question is which of these features impacts the most with regards to employee health and wellbeing and how are these concepts interlinked? This is explored through what is listed within the ranking criteria as indoor environmental qualities or IEQ points.

2.2.2 IEQ for the greener good?

The areas within a green building in which people occupy, as well as work, is assed using indoor environmental quality, the impact of which may lead to a more comfortable, healthy and productive work environment (Thatcher & Milner, 2014). Green buildings as Zuo and Zhao (2014) point out, have higher IEQ points in respect of their conventional counterparts and therefore are attributed with improving occupants' health in contrast to conventional buildings with little to no IEQ points or features. Further categories such as aesthetics and location of employees, lighting, air ventilation as well as the materials used in the construction of office spaces, the ergonomics of the furniture as well as the layout of the office environment all

contribute towards the impact of the building's IEQ features (WBDG Sustainable Committee, 2018). These are the variables which interact most with occupants and therefore are the ones which are readily attributed towards their wellbeing, both physical and psychological. As Thatcher and Milner (2014) state, IEQ features:

> *will improve occupant's wellbeing and productivity through the better use of daylight, external views, improved ventilation systems, more 'fresh' air and less recycled air, better light quality (e.g. reduced glare and flicker), noise reduction, better thermal comfort ranges, increased personal control of the environmental conditions, and reduced toxins in the air (e.g. volatile organic compounds, formaldehyde, smoke, and other indoor pollutants)* (p.382)

In essence, they point out the many IEQ qualities that are at play within the indoor environment and how they may have an impact on employee health. Often IEQ features interact with some of the other green elements within the building such as energy consumption and efficient use of daylight, which would relate directly to the IEQ feature of lighting. The water consumption is intertwined with energy in respect of sufficient air conditioning and the ventilation of air which also interacts with the limitation of harmful substances within the building impacting on employee health and wellbeing. This constant interplay between the features and functions of green discourse have been termed 'the green continuum' by the author.

2.3 The Green Continuum

Following from a clear definition about what encompasses wellbeing as well as green design, specifically IEQ points, it is appropriate to merge the two together to gain a broad understanding of how one affects the other. As stated previously the indoor environmental quality within green buildings is specifically designed to improve health outcomes of individuals within a green building. Allen et al. (2015), summarise this within their review by stating that green buildings result in better 'health', as "adverse health effects are explicitly addressed within green building design credits" (p. 256). In isolation this has seen a positive relation within literature with different IEQ points contributing to certain health outcomes, however, there is the potential for both positives and negatives within each IEQ feature.

Air ventilation is one of the key areas with regards to IEQ features within a green building, with ventilation and temperature impacting on health as well as energy consumption. In respect of employee wellbeing, air ventilation is important as it removes air pollutants as well as bio-effluents (Wyon, 2004), with the constant flow of fresh air there is a lower chance of employees suffering from Sick Building Syndrome (SBS). This condition affects office workers from their prolonged time spent within a building, the symptoms of which include headache, dizziness, nausea, fatigue, lack of concentration, inflamed mucous membranes as well as eye and skin irritation (Brasche, Bullinger, Morfeld, Gebhardt, & Bischof, 2001; Hedge, Erickson, & Rubin, 1996). Research has also identified that mechanically ventilated buildings are more at risk as opposed to natural ventilation of fresh air (Bourbeau, Brisson, & Allaire, 1997).

The question is whether fresh natural air is ‘cleaner’ and healthier for participants. Hedge (2000) comments that air pollutants such as carbon monoxide even at minimal levels can impact on performance as well as motor and vigilance tasks. Given the air quality within a busy city district, there can be the assumption that carbon monoxide from traffic may get into the ventilation thereby hampering the effectiveness of the fresh/natural air which is polluted. This may be filtered out by the air ventilation system. This presents a dilemma, as the natural air within a building, may not always be truly natural but using air from outside the building may also impact on the health and wellbeing of the occupants.

In an effort to decrease the risk of SBS and enhance employee wellbeing, an increase in air ventilation is necessary, thus highlighting how the improvement of ventilation impacts employee wellbeing. Ghodrati et al. (2012) state that 68% of diseases are related to poor indoor air quality, thus showing how the increase in indoor quality can reduce the risk of employee illness detrimental to employee wellbeing. Increases in air ventilation decreases the chance of airborne pollutants stagnating within the building effectively ‘cleaning’ the air, thereby reducing potential SBS.

Allen et al. (2015) speak to the cost incurred as a result of SBS with lower productivity, reduced mental ability as well as higher absenteeism which will have financial implications on the organisation. Thus, it is more profitable for an organisation to invest in features such as air ventilation as it has knock-on effects within the organisation that goes beyond employee wellbeing and satisfaction. However, a potential negative which does need to be assessed is that individuals have different thermal comfort levels and with automated temperature controls this

may differ for everyone and cause discomfort as well as a lack of personal control over an employee's work space.

An interesting segue between this IEQ feature and another is lighting, both natural and ambient lighting. Lighting is essential to any office environment and is one of the most common factors across all office designs and it is responsible for 17% of energy consumption of buildings in the United States alone (CBECS, 2017). Given the impact that lighting can have just with regards to power consumption, green design attempts to mitigate the use of internal ambient lighting with the 'harvesting' of daylight through natural lighting sources/designs. This follows from a suggestion made by Hedge (2000), who states that the lighting system with the greatest benefits with regards to productivity, comfort and health, is that which has indirect ambient lighting coupled with user adjustable task lighting as well as the inclusion of daylight. The increase in daylight has the potential to improve health, awareness and well-being however the increase in natural lighting can also adversely increase the temperature within the building impacting SBS and glare (Jakubiec & Reinhart, 2012).

The chances of SBS may increase with natural lighting as this may increase the temperature which increases biological pollutants (Ghodrati et al., 2012). This translates into an increase in humidity, combined with the presence of potential volatile organic compounds (VOCs), may cause stress as well as allergies which impact negatively on employee health and wellbeing (Hedge, 2013). Increasing daylight also has the potential to increase glare within the building. Glare is the reflection of the sun on technological equipment such as computer screens,

windows and hard surfaces often resulting in headaches as well as eyestrain which impacts negatively on employee health (Jakubiec & Reinhart, 2012).

Research conducted by Abbaszadeh, Zagreus, Lehrer, and Huizenga (2006) speaks to the distribution of lighting complaints within green buildings ranging from "not enough daylight" to "reflections on the computer screen" as well as "too dark" (p. 368). This shows the interplay with regards to lighting within green buildings as although there are lower levels of ambient lighting within green buildings the increase in natural lighting has the potential to be an increased "source of glare and thermal gain" (Abbaszadeh et al., 2006, p. 369). Further, it is important to note that daylight changes direction throughout the course of the day and therefore is unpredictable in terms of consistent reliability and has a greater potential to fluctuate seasonally.

In assessing these two IEQ features it is clear that on their own, each IEQ feature has its positives as well as it's negatives, each has the potential to enhance employee wellbeing however, there is also a potential negative with regards to each IEQ feature in isolation. The contestation however, is that in respect of ventilation as well as daylight these two features have the potential to work in opposition to one another as if you increase natural lighting you have the potential to increase the thermal temperature, thus raising the need to increase ventilation and reduce temperature for others in the building which may make it uncomfortable.

It is therefore appropriate to assess these features as a form of 'green continuum', where an increase in one feature may have both negative and positive feedback loops which impact on one another. This contestation has not gone unnoticed as is highlighted by Lee and Guerin (2009)

who state that although IEQ is designed to enable healthier environments for occupants managers are concerned with its relationship to employee satisfaction, " major concerns are being raised about occupant's perceived quality of life in LEED-certified buildings" (p. 300).

There is also the potential for office design to work in opposition with IEQ features such as the layout of the office spaces within the building making desks too close to building perimeter (i.e. close to windows), which also has implications on employee health and wellbeing through similar mechanisms of air quality (McGuire & McLaren, 2009). Recent office design and layout has moved away from individual offices towards a more open plan design as these spaces have the potential to increase flexibility as well as enhance communication which enhances productivity as well as information sharing (Davis, Leach, & Clegg, 2011; Lee & Brand, 2005). However there is a trade off with open plan designs which have resulted in increased noise as well as distraction (Kim & de Dear, 2012). Although within the current research the target site has included a blend of both open and agile workspaces, which are more closed off supporting both privacy and communication (Keeling, Clements-Croome, & Roesch, 2015), there is still a focus on openness within the building design which has the potential for increased levels of noise and distraction.

Interestingly Gou, Lau, and Shen (2012) point out that although LEED features promote a more collaborative style of work there are issues with levels of noise. This therefore highlights once again the potential for IEQ features to act against each other, since although there is a move towards ensuring openness to facilitate new levels of creativity and communication, there is also a potential to have an impact on employee wellbeing as acoustic noise makes it difficult to concentrate (De Croon, Sluiter, Kuijer, & Frings-Dresen, 2005). Laughton and Thatcher (2018)

summarise this issue stating that "organisations need to take heed of such research and move towards a more evidence-based decision making when it comes to ergonomic design" (p.8), in response to office design not being based off research but rather what seems to be 'trendy' in design. A greater focus needs to be devoted to assessing how IEQ features work together/against one another within the green building design.

One of the key critiques behind IEQ features and their understanding within research is highlighted by Thatcher and Milner (2016) who stipulate that results between studies may differ as there is no commonly accepted way to measure these features and therefore results may differ from study to study. Therefore a more robust method of evaluating IEQ features within green buildings is needed. A standardised measure of green building features and their impact on occupants would help with regards to internal consistency between studies, as often employees have a form of halo effect with regards to IEQ features. Leaman and Bordass (2007) argue that occupants within green buildings may be more tolerant of IEQ features in contrast to conventional buildings, suggesting that just by virtue of working within a green building employees may have a distorted view of the features that impact on their wellbeing.

There needs to be an acknowledgement that this is not the first research that has been undertaken in an effort to research the connection between employee health and wellbeing within green buildings. Many studies globally contribute to the growing body of literature surrounding this topic and therefore need to be analysed. Some of the earlier research such as Clements-Croome and Baizhan (2000), found that respondents believed that the office environment had a direct impact on their health and wellbeing and that within conventional buildings the main

points of dissatisfaction revolved around thermal comfort, stuffiness, SBS, and crowded workspaces leading to an increase in noise discomfort. Their results also suggested that productivity could increase by 4% to 10% on the improvement of indoor environmental conditions (Clements-Croome & Baizhan, 2000). This research can be seen as a starting point drawing the link between wellbeing and some of the criteria addressed by IEQ features.

In a post occupancy study conducted by Heerwagen and Zagreus (2005), we see the same factors under investigation. Within this research it was found that acoustic quality as well as acoustic functionality were the lowest average scores, with issues such as speech privacy being cited as the main concern, with noise levels even being described as stressful (Heerwagen & Zagreus, 2005). However some of the more positive high scoring categories were lighting and air quality, showing an increase in perceived satisfaction with lighting and air quality within the respective green building. Critically, psychological wellbeing was found to be relatively high among 70% of the respondents (Heerwagen & Zagreus, 2005).

Research conducted by Hedge and Dorsey (2013) in respect of a post-occupancy survey, comparing post-occupancy results between two different green buildings, found that between both buildings the majority of concerns were issues of noise and occasional daylight and glare complaints. In their research it was established that there was a relationship between productivity and noise, the research also highlighted that as is the case with many other LEED certified buildings, thermal issues were of widespread concern (Hedge & Dorsey, 2013). Unfortunately there was no pre-occupancy evaluation which limits the conclusions drawn, however, the trend of noise discomfort seems to be predominant within the occupancy of green buildings.

In a comparative study conducted by Abbaszadeh et al. (2006), of green buildings to their conventional counterparts it was found that occupants within green buildings were more satisfied with thermal comfort and air quality, features such as lighting and acoustic quality were comparable to the conventional buildings and lighting levels and acoustic quality showed more dissatisfaction in comparison to conventional buildings (Abbaszadeh et al., 2006). When assessing the lighting dissatisfaction it was found that the majority of complaints centred around not enough daylight, as well as glare from office equipment, whilst acoustic complaints centred around issues of privacy such as too much acoustic noise within the office environment (Abbaszadeh et al., 2006).

Thatcher and Milner (2016), use a table as a visual means of representing increases and decreases within IEQ satisfaction to represent the different outcomes between studies. This summary of the data helps isolate the key findings within green building studies that arr relevant with regards to perception of IEQ features, the same concept can be seen below in Table 1.

Table 1. Perceptions of IEQ features in green buildings in contrast to conventional buildings.

Authors	Sample	Country	Measure	Satisfaction Increase	Satisfaction Decrease
Leaman and Bordass (2007)	Not Given	UK	BUS Survey	Glare from sun Ambient Noise	Glare from lights
Lee and Kim (2008)	40488	USA, Canada & Sweden	CBE Survey	Thermal comfort Air Quality	Lighting quality Acoustic quality
Armitage, Murugan, and Kato (2011)	351	Australia	Self-developed IEQ Survey	Lighting	Air temperature Privacy
Gou et al. (2012)	216	Hong Kong	BUS Survey	Green Building One: Noise Green Building Two: Lighting	 Lighting Noise and Temperature
Ravindu, Rameezdeen, Zuo, Zhou and Chandratilake (2015)	65	Singapore	Self-developed IEQ Survey	Lighting Privacy	Ventilation Thermal comfort

As can be seen from the global literature as well as from the table, most of the core complaints focus around lighting as well as acoustic discomfort within the green buildings. However one needs to acknowledge that some of the more positive aspects were fresh air circulation, views of nature, as well as access to sunlight and natural lighting (Abbaszadeh et al., 2006; Leaman & Bordass, 2007). Although these results are useful in gaining a benchmark for

the possible outcomes of the current study, there is substantially less literature which focuses on the impact of IEQ features on employee wellbeing.

2.4 To green, or not to green, that is the question…

The question then shifts as to whether IEQ features impact on employee wellbeing, as there are both positives and negatives associated within every IEQ feature. Although the global trend is to immediately attribute IEQ features towards an increase in health, such as the research by Miller et al. (2012) stating that indoor categories are aimed at "creating a healthy, comfortable and productive environment for occupants" (p.2310), there is, the question as to whether this is improving employee health and wellbeing at both a physical and psychological level? Allen et al. (2015) in their systemic review state that green buildings result in better health outcomes with "adverse health effects being addressed within green building design credits" (p.256). However, this is not broken down into physical and psychological variables of wellbeing.

Although IEQ points are generally attributed to increasing a 'broad' range of health outcomes it is often the physical health that is assessed and broadly termed as health and wellbeing. However, as explained previously, wellbeing is a more complex construct which is multi-faceted and therefore needs to be assessed both physically and psychologically. In the research conducted by Allen et al. (2015) their review included cases where green buildings exhibited "fewer sick building symptoms… better physical and mental health" (p.256), however the constructs were not broken down and explained. Interestingly, research conducted by Thatcher and Milner (2012) found that contrary to global claims, green buildings did not always

enhance perceived physical and psychological wellbeing within a South African sample. This highlights a possible point of contention, as to whether green buildings truly increase employee physical and psychological health or whether the building is attributed with unwarranted wellbeing claims.

2.5 Is it truly greener pastures?

This study intends to build on the critique by Leaman and Bordass (2007) with regards to occupants being more susceptible and accommodating of IEQ features simply by being in a green building, by analysing IEQ features as well as health outcomes in isolation from one another. This is to separate out whether employees are feeling healthier both physically and psychologically as a result of the green building or if they are merely enjoying the cooler air and increased natural lighting. By analysing each feature in isolation it becomes possible to draw out whether IEQ features truly do have an effect on employee wellbeing.

This therefore highlights two distinct research questions which will be answered by the current study.

RQ1: Is there a difference in perceptions of IEQ features between the green building and the conventional building?

It is hypothesised that although there will be an overall satisfaction with regards to IEQ features in general, elements such as lighting and noise discomfort will remain a key source of discomfort for occupants within the green building.

RQ2: Is there a significant difference between the health outcomes, both physically and psychologically in respect of the green building and the conventional building?

It is hypothesised that there will be an increase in physical and psychological wellbeing of participants, given the allocation of IEQ features towards the improvement of physical and psychological health. This has been pointed out in the literature with the implication that a healthy workplace should increase physical and emotional wellbeing.

Given that this study forms part of a larger study, the points of overlap and difference need to be accounted for. The research conducted by Laughton (2018) focused more on spatial dynamics within the work environment only emphasising the period before the transition to the green building. However, the data collected here consisted not only of spatial planning, but measures of IEQ features, and physical and psychological wellbeing all of which are key factors within the current research. Although the key focus area of the study was different, there are some key factors which can be extracted from the research going forward. The first being that office design has an effect on how individuals perceive their environment and crucially that other extraneous influences such as one's job demands, the nature of the work as well as organisational culture, likely play a much larger role on individual wellbeing than office layout and design (Laughton & Thatcher, 2018).

Some of the other considerations which stem from global literature revolve around the timing of the study, the sample size as well as the assessment of IEQ features. The timing is crucial as is highlighted by Singh, Syal, Grady, and Korkmaz (2010). One of the major limitations to this research was that the pre- and post-test research was conducted at different times within the year. Seasonal adjustments as well as weather patterns are normally consistent from one year to the next and it is therefore crucial in order to eliminate extraneous 'weather' variables to ensure that data are collected at the same time between the two studies. Further to this seasonal adjustments often impact on allergies as well as respiratory complications (asthma) and the common flu, which may be attributed to symptoms of SBS, therefore this potential bias needs to be eliminated.

Complications around sample size are generally related to statistical power as is highlighted within the research by Allen et al. (2015). However there is a much greater challenge with regards to the sample, being how much of the sample can be matched from one sample set to the next, this is a crucial element to any pre/post-test research as it assures that there are no other attributing factors that may impact on the results. With regards to the evaluation of IEQ features, there not only needs to be a standardised tool for their measurement, but there also needs to be an acknowledgement that IEQ features do not act in isolation as is seen in research conducted by Lee and Kim (2008). They need to be analysed in conjunction with one another to understand what trade-offs are made and how they impact on the continuum within the work environment. This research factors both of these limitations in mind, as there is a sufficient sample size both matched and unmatched as well as a measure which investigates IEQ features

in conjunction with one another along with key elements such as their overall impact on the work environment, health and productivity.

In conclusion, this literature review has defined the key variables within the study, discussing their theoretical underpinnings as well as their impact within the global literature. Terms such as the green building and LEED certification were discussed to fully conceptualise the need to study not only the buildings but their occupants' health and wellbeing. The term wellbeing was deconstructed to understand exactly how it would be viewed within the current research and as to why it is crucial to analyse both physical and psychological wellbeing. The trade-off within IEQ features and the continuum on which they operate was also highlighted to expose possible contentions within the literature surrounding their impact on employee health and wellbeing.

Chapter 3: Methods

This chapter is devoted to an in-depth discussion of the methods used in the study. The chapter is broken down into the design of the research, procedural analysis, instrumentation, method of analysis as well as ethical considerations that were adhered to within the study. This chapter is to provide a description of how the research was conducted and all steps taken in data collection.

3.1 Research Design

Research design within social science research is a hotly contested debate, as assumptions within each design dictates the conclusions which may be draw from the study's results. This research is a non-experimental, repeated measures design. It may be considered longitudinal, given the pre-test, post-test comparisons that are being made and the research will be situated within the quantitative paradigm as constructs will be evaluated and analysed using statistical techniques.

Although this research is non-experimental, given the investigation of a relationship between building design and employee wellbeing, a debate can be made around causality and the claims that may be attributed to the results. Methodologically non-experimental designs do not contain stringent scientific regulations that are attributed to causality such as IV manipulation, control groups or random assignment (Babbie & Mouton, 2001). However, these features are usually considered experimental and therefore conducted under stringent 'laboratory' conditions.

These conditions are used to ensure that extraneous variables are limited and cannot impact on the study, otherwise known as non-spuriousness. LoBiondo-Wood, Haber, Cameron and Singh (2014) argue that although experimental settings, being both field and laboratory are considered more reliable and scientific, there is still an element which is artificial as the researcher still exerts a certain amount of control over the process and is not authentic to reality.

This degree of scientific control is not possible within the current study as the study is being conducted within an organisation. Given the fluctuation of the business environment there are many factors which are out of the researchers control, which cannot be controlled experimentally or artificially. This however, then impacts on the causal claims that may be attributed to the results. Prince, Jhangiani and Chian (2015) speak to this complication by stating that causal conclusions may be drawn from non-experimental research where the independent variable cannot possibly be manipulated and the conditions for random assignment or control groups is limited or not suitable. This speaks to the issues encountered within the design of the current research as the independent variable cannot strictly be manipulated and having control groups is just not practical. Therefore, it can be seen how a scientific experimental design does not strictly fit within the feasible options for the current research.

A further set of guidelines are established for the concept of causality. Causality within the social science, is linked to the argument surrounding the cause and effect of the green building on employee wellbeing. One of the key features behind IV manipulation is that the cause needs to precede the effect for temporal precedence. However, within the current research the cause has preceded the effect as the participants within the pre-study did not have access to

the green building, thereby establishing a form of temporal precedence. Although there is no control group the within-subjects comparison between the two studies may offer a form of co-variation as a change from the pre-group to the post-group shows the absence and presence of the IV on the DV. Further given that the building features are being analysed one can control for non-spuriousness through matching of participants as through the study design, as building features and certain IEQ features are being analysed thereby factoring out rival hypotheses for the observed phenomena.

3.2 Procedure

As previously stated, the study is longitudinal, so in essence the procedure is ongoing from the previous study, which began in 2017 with a pre-occupancy survey, conducted in a different study. The period in which both studies were conducted is fairly similar with data collected from the 7th to the 18th of August 2017 and 13th to the 27th of August 2018. However, the procedure that was followed in 2017 was the same as the current study in 2018.

After permission was granted from the Human Research Council Ethics Committee (Appendix A) the study's survey was compiled based on the scales used from the previous study, to ensure continuity. Similarly, the online web-based platform of Survey Monkey was used to compile and distribute the survey to employees. An e-mail containing the participant information sheet (Appendix B) was sent out to all employees within the organisation explaining the purpose of the research as well as asking for voluntary participation. Included in the information sheet was the ethical considerations as well as the assurance of confidentiality and anonymity. The e-mail was sent from the wellbeing division of the organisation to all employees in the organisation

and the contact details of the researcher and supervisor were included and participants were encouraged to participate over a three-week period.

Upon the closure of the survey, the data was downloaded onto a Microsoft Excel Spreadsheet, where the data was 'cleaned', this process involved removing participants who did not complete more than 75% of the items as well as those who answered the survey more than once. After the data was cleaned, the data between 2017 and 2018 was matched, using a unique work code identifier to create a matched participant ID, which was then linked to the participant ID. A third ID was then created, linked to the data set and the other two ID's were deleted. This ensured that the unique work code identifier was not carried forward and anonymity was upheld. The data was then transferred into IBM SPSS v25 for analyses.

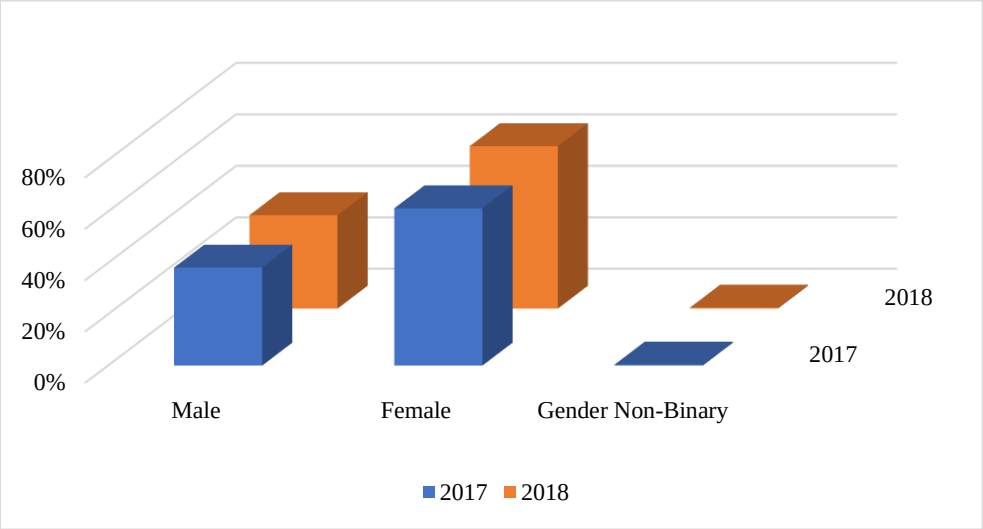
3.3 Sampling

The sample that will be analysed consists of two sets, that of 2017 as well as that of 2018. Both of these samples were sourced from a well-known South African organisation which focuses on insurance, medical aid administration, investments, and financial services. This organisation has gained reputability within South Africa as it focuses on wellbeing and rewards for healthy living, making it an interesting sample choice for research into employee health and wellbeing. The approximate number of employees in 2017 was 7 000 however, this increased to 8 000 for the year of 2018. The number of individuals who responded to the 2017 survey was 2065, establishing a response rate of 29.5% and the number of individuals who responded in 2018 was 2649, with a higher response rate of 33.11 %. Once cleaned, 137 responses from 2017 and 293 responses from 2018, were removed for not completing over 75% of the survey as well

as 22 duplicate responses from 2017 and 26 duplicate responses from 2018, this was as a result of employees answering the survey more than once. The final sample consisted of 1908 responses from 2017 and 2329 from 2018. With 749 matched responses between the two data sets, which amounts to 17.68% of the total sample, which although may seem like a small percentage of the sample it is an adequate matched sample set.

In terms of combined descriptive statistics of the sample, 37% of the sample was male, 62% were female and less than 1% were gender non-binary (did not assign a gender). Interestingly enough as one can see in Table 2 as well as Figure 1, there was not a significant difference with regards to gender across the two studies.

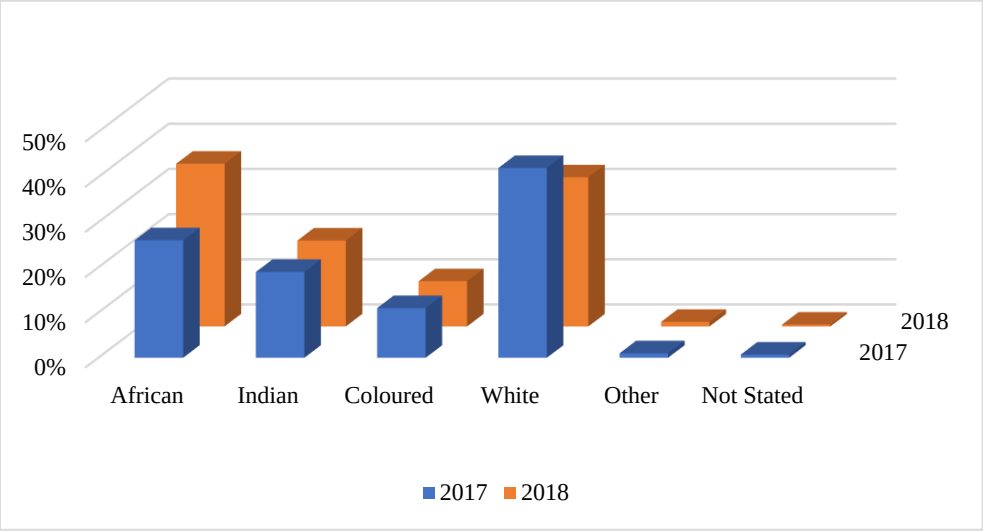
Figure 1: Gender Demographics



The breakdown of racial demographics within the sample is as follows, 32% African, 19% Indian, 10% Coloured, 37% White, less than one percent identified as Other as well as not stated. In terms of difference between the samples, there is a slight increase in African

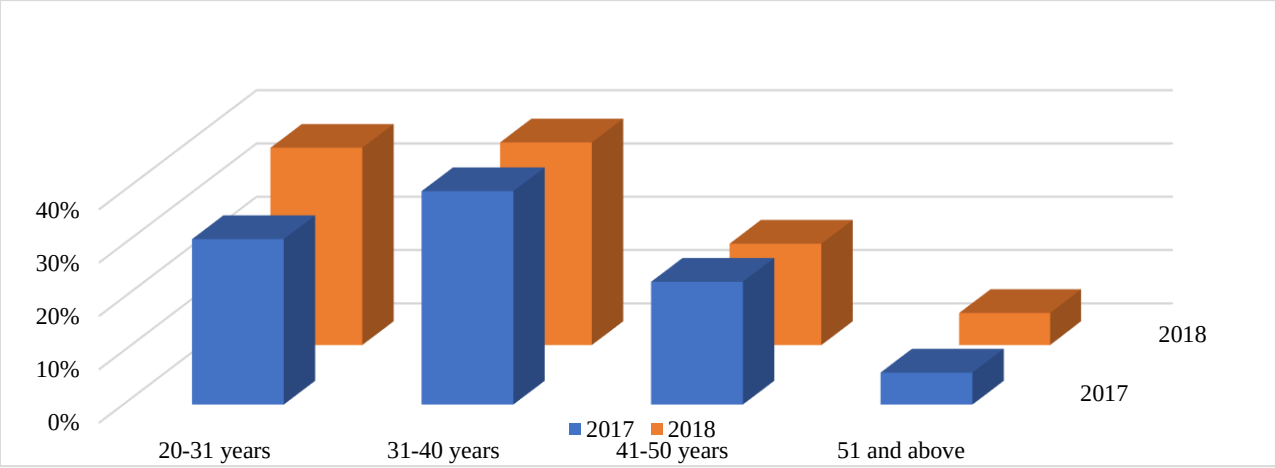
respondents and a slight decrease in White respondents within the sample. This is visually depicted in Figure 2.

Figure 2: Racial Demographics



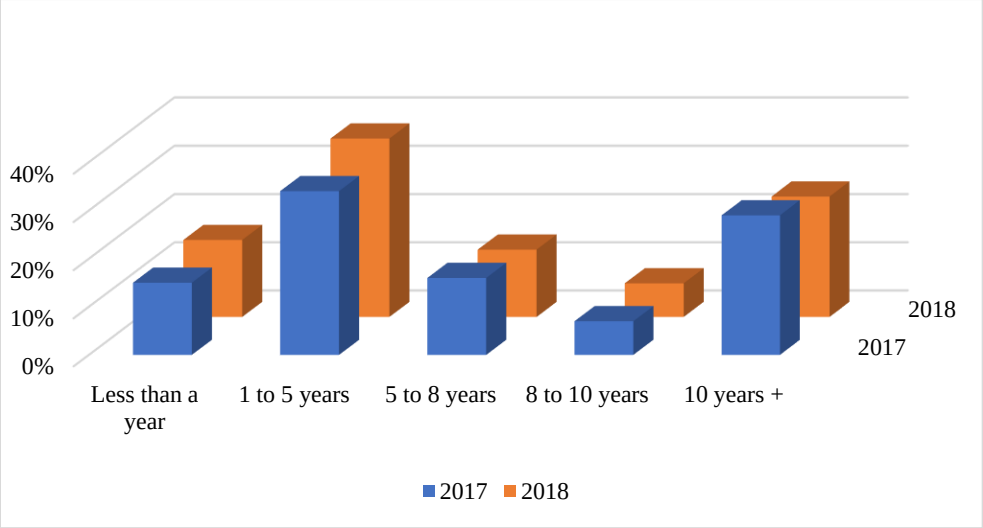
The age range was quite dispersed within the sample with 34% of the sample falling between the age of 20-31, 39% of the sample between the ages of 31-40, 21% falling within the range of 41-50 and 6% falling above 51 years of age. From this demographic it can be seen that the age range is skewed towards the younger age categories, as seen in Figure 3.

Figure 3: Age Demographics



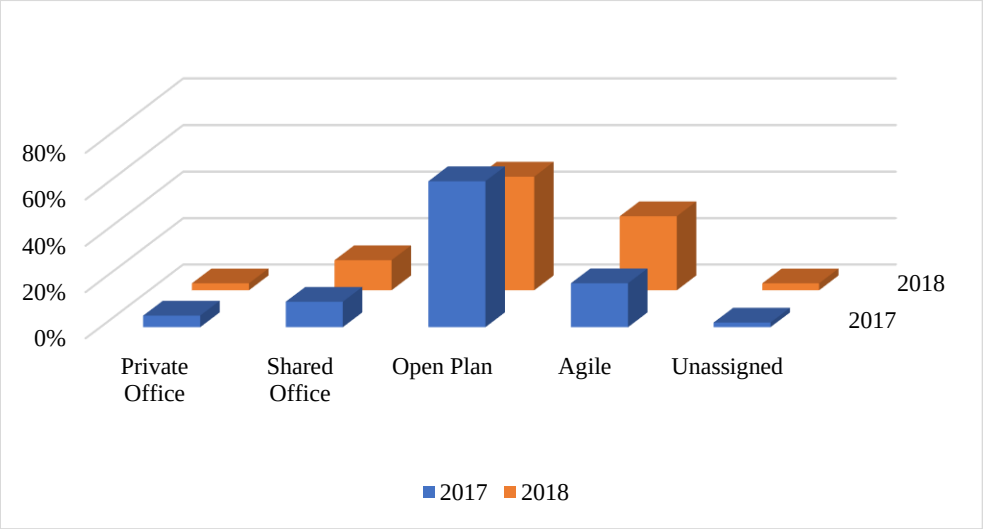
With regards to employee tenure we can see that the majority of the individuals have been at the organisation with 35% working between 1 and 5 years, 15% working from 5 to less than 8 years, 6% working from 8 to less than 10 years, and 28% working for longer than 10 years, with 15% of individuals working for less than a year. This is visually represented in Figure 4.

Figure 4: Tenure Demographics



Something of great interest, is the layout of the office environment as the pre-study research focused on office planning and layout, this is seen with the data skewing towards open plan offices as well as agile workspaces. With 55% of the sample working within open plan offices with cubicles, 26 % working in agile work spaces, 12% working in shared offices, 4% in a private office and 2% working in unassigned work spaces. This is graphically represented in Figure 5.

Figure 5: Office Layout



A further breakdown demographics that were captured is located in Table 2, below.

Table 2: Descriptive Statistics

Descriptor	2018	Percentage	2017	Percentage
Gender				
Male	846	36.4%	729	38.2%
Female	1471	63.2%	1169	61.3%
Gender Non-Binary	10	0.4%	8	0.4%
Race				
African	845	36.3%	503	26.4%
Indian	439	18.9%	355	18.6%
Coloured	232	10%	208	10.9%
White	777	33.4%	801	42%
Other	24	1%	25	1.3%
Not stated	10	0.4%	14	0.7%
Age				
20-31 years	863	37.1%	590	31%
31-40 years	881	37.9%	766	40.2%
41-50 years	446	19.2%	436	22.9%
51 & Older	133	5.7%	110	5.8%
Not stated	4	0.2%	4	0.2%
Tenure				
Less than a year	382	16.4%	278	14.6%
1 – less than 5 years	863	37.1%	638	33.5%
5 – less than 8 years	334	14.4%	308	16.2%
8 – less than 10 years	164	7%	124	6.5%
10 years or more	584	25.1%	558	29.3%
Layout				
Private Office	77	3.3%	100	5.2%
Shared Office	296	12.7%	211	11.2%
Open plan with cubicles	1142	49.1%	1199	62.9%
Agile workspace	749	32.2%	357	18.7%
Unassigned reserved	63	2.7%	39	2%

3.4 The green building in question

It may be beneficial at this point to provide a description of the green building that is under investigation. The building in question, received its 5 star green rating from the Green Building Council of South Africa in September 2017, with a total of 74 points (GBCSA, 2017). The 147 000msq building was designed to foster creativity, collaboration and innovation with its open plan design, which has two atria connected by a circulatory concourse as can be seen in Image 2 (GBCSA, 2017). Something which is unique within the current building, is that the ground floor consisting of retail outlets such as a grocery store, pharmaceutical company as well as restaurants, is open to the general public and the company encourages their members to come and interact with their building and staff. On the top floor of the building is a form of 'vitality level' which consists of a running track, gym as well as a space to host healthy eating cooking classes.

Figure 6: Scale miniature of the green building

Figure 7: Birds eye view of scale miniature.

An essential element to indoor environmental quality, air conditioning and temperature, is controlled with high efficiency water and air cooled chillers, which are the big grey vents seen in Image 3, which keep the building at a constant 22 degrees Celsius. Also it can be seen in Image 3, the use of both natural lighting as well as smart electronic occupancy sensor lighting throughout the building.

Figure 8: Air conditioning and lighting image.

Image 4 highlights the different spaces that are within the building, showcasing the combination of agile spaces as well as open-plan offices. The different colours within the building are used to differentiate between the floors and there are noise dampening boards scattered throughout the open plan offices.

Figure 9: Open and agile spaces.

This 5 star green rated building has more ‘behind’ the scenes factors which contribute to the rating such as the environmental waste management systems as well as indigenous landscaping and grey water harvesting, which contribute to aspects of sustainability however, do not contribute towards indoor environmental quality. The last factor which needs to be assessed is the focus on movement within the office environment, there are sporting facilities located on the roof which encourages people to move and be healthy, as can be seen in Image 5 and 6.

Figure 10: A side picture of the running/walking track on the roof.

Figure 11: A multipurpose sports ground on the roof.

3.5 Instruments

3.5.1 Demographic Questionnaire

A short demographic questionnaire was used to acquire descriptive data from the sample. This included Gender, Age, Race, Job Level, Business Unit, Tenure and specific questions relating to building layout, such as location. If participants were located in the green building this would be further broken down into the area and floor. Further questions included the layout of the office space and whether this was allocated to them on a permanent basis. All of this data is used to describe the sample and is not used in conjunction with any wellbeing data, or analyses.

3.5.2 Perceived Indoor Environmental Quality Satisfaction

The Green Building Environmental Survey developed by Prof. Alan Hedge of Cornell University and Prof. Julie Dorsey at Ithaca College was designed to be used as a comparison tool between LEED certified buildings and conventional buildings (Hedge & Dorsey, 2012). This measure asks individuals about their experiences at their respective workstations in an effort to gauge not only their perception but their awareness of IEQ features within their work environment.

The measure assesses eight conditions of perceived satisfaction within the IEQ features as well as their impact on health and performance. The features analysed were the same for all three levels of satisfaction which were air temperature, air freshness and quality, noise, office lighting, daylight, office furniture and overall workstation satisfaction. The first question is phrased such as “How do you feel about the following factors at your current work station?” and

participants can answered on a four-point Likert type scale ranging from “Very uncomfortable/ Very Poor” to “Very comfortable/ Very Good”. The second question measured the perceive impact of the IEQ features on performance measured the same eight features on a five point Likert type scale ranging from 1 being “Definitely hinders work performance” to 5 “Definitely helps work performance”. The third question assessed the perceived impact of IEQ features on health, with a five-point Likert type scale ranging from 1 being “Definitely makes me feel less healthy” to 5 being “Definitely makes me feel healthier”.

As there were no scoring criteria laid out by Hedge and Dorsey (2012), it was taken that low scores were negative symbolising dissatisfaction with the IEQ conditions and high scores were positive symbolising satisfaction, therefore a score of 8 (minimum score) would be dissatisfaction whilst a score of 32 and higher (maximum score) would be extreme satisfaction. Hedge and Dorsey (2012) ran a varimax rotation factor analysis on their scale measuring health indicators and found them to be structurally appropriate.

No reliability estimates were provided by Hedge and Dorsey (2012) however in the research conducted by Laughton (2018) it was found that perceived satisfaction of IEQ features had a reliability of $\alpha = 0.75$ and perceived effect of IEQ on health had a reliability of $\alpha = 0.91$ and the perceived effect of IEQ on performance had a reliability of $\alpha = 0.9$, all of which were above the acceptable minimum for reliability estimates.

3.5.3 Perceived Health

Perceived health is an important variable to consider within the research as it is the variable which links the employees perceived health to the IEQ and physical environment variables. Although there is a question devoted to health within the scale developed by Hedge and Dorsey (2012) there is a need for a health indicator which does not focus solely on the IEQ factors within the building.

The GABO or Acoustic Annoyance within Open Plan Offices (in English as it is a French Acronym) was designed by Pierrette, Parizet, Chevret, and Chatillon (2015) as a method of establishing perception of an employee's work environment. Although the scale does focus predominantly on the noise environment with regards to acoustics there is a section of the scale which relates directly to perceived health. This section of the GABO was based on the health questionnaire of Grosjean et al. (2008) which measured participants' perceptions of their own perceived physical health, psychological health, pain, and stress (Perrin Jegen & Chevret, 2017).

Questions on perceived health were rated on a five point Likert type scale with the first two questions being rated as 1 "Very Poor" and 5 "Very Good", an example of this question would be "Overall, I think that my health is:". The second and third questions had anchors of 1 being "Very low" and 5 being "Very high" with an example of the question being "Overall, I think that my morale is:". The final set of questions have anchors of 1 being "Never" and 5 being "Constantly" an example question being "I have headaches".

Overall the health section of the GABO consists of 14 items however 4 items were removed as not to conflict with the Physical Comfort Scale with questions such as “I have back pain” and “I have pains in my arms”. As there are no scoring guidelines outlined by Pierrette et al. (2015) high scores were considered to be positive whilst low scores were considered to be negative. After reverse scoring 6 of the items an individual’s highest score would be 50 whilst the lowest score would be 10. Although this scale was not used within the pre-test, Laughton (2018) suggested that future research should include the scale. Therefore there is no previous reliability in the pre-test nor none provided by Pierrette et al. (2015).

3.5.4 Perceived Noise Discomfort

The Acoustic Annoyance within Open Plan Offices (GABO) was further used for operationalisation of the variable of perceived noise discomfort, which is the main focus of the GABO questionnaire. The scale measures the way in which employees perceive their acoustic environment as well as the factors which may influence their perceptions (Pierrette et al., 2015). The original complete form of the GABO was 67 items grouped into five categories of questions, namely demographics, the noise environment, noise sensitivity as well as the perception of health, which were used to operationalise the Perceived Health Variable.

In the pre-study it was found that the questions relating to noise discomfort were too long and became tedious, it was therefore reduced to six questions, one item for each main source of noise and one for the general level of noise (Laughton, 2018). This shortening of the GABO was also undertaken within the current research so as to ensure the compatibility of results. The six questions were presented on a five point Likert type scale with 1 being “Never” and 5 being

"Constantly". Questions were phrased as "At your workstation, you hear machines running (ventilation, computer, printer etc.):".

As stated previously there were no scoring procedures outlined by Pierrette et al. (2015) and it was therefore scored with higher scores representing high levels of noise discomfort experienced by employees at their workstation and the lower the score, the lower their perceived discomfort with noise in their environment. In the pre-test study it was found that the six item scale had an internal consistency reliability of $\alpha = 0.73$ which is suitable for internal consistency.

3.5.5 Physical Discomfort

Physical Discomfort was operationalised using the Nordic Musculoskeletal Questionnaire (NMQ-E) based on the standardised Nordic Musculoskeletal Questionnaire developed by (Kuorinka & Andersson, 1987). The NMQ-E which is the extended version was developed by Dawson, Steele, Hodges and Stewart (2009) measuring musculoskeletal pain and related activity prevention reliably by means of self-administration mainly within an occupational sample. This variable is different to the perceived health variable as it is assessing physical pain and not perceptions of health. Given the ability for the NMQ-E to screen for musculoskeletal pain, this assessment may provide light on ergonomic factors which may be impacting on employee health.

The full NMQ-E comprises of 99 items, 11 questions for 9 regions of the body including neck, shoulders, upper back, elbows, wrists/hands, lower back, hips/thighs, knees and ankles/feet which allows for 99 possible identified points of discomfort. The questions are asked

dichotomously “yes” or “no” and are structured so that the participant would first report whether they had felt pain followed by questions of prevalence (Dawson et al., 2009). In the study conducted by Laughton (2018) the NMQ-E was shortened resulting in 9 items rather than 99. This was done by using the first question of each section of the NMQE however excluding the prevalence question and the dichotomous answers of yes and no, were changed to a five point Likert scale to include frequency of pain where 1 = Never, 2 = 1-2 times a week … 5 = several times every week.

The shortening of the NMQ-E was not seen as problematic as the tool was not being used as a diagnostic tool but rather for research purposes. The shortening also enhanced the reliability in the pre-study pilot from $\alpha = 0.63$ to $\alpha = 0.86$ and $\alpha = 0.91$ for the final study Laughton (2018), which is a sufficient internal consistency reliability.

3.5.6 Psychological Comfort

Laughton (2018) developed a 6 item scale based off of Vischer's (2007) concept of environmental comfort. This scale was used to test whether employees felt that they belong in their workplace as Vischer (2007) states that psychological comfort is linked to social aspects within the individuals environment such as the design and management of the workspace. This leads to three key aspects of “territory, privacy and control” (p.24). The primary component to the model is the relation to a sense of territory, both individual and group territory, which has 2 items within the scale and sense of privacy and control where both had 2 items. These are the elements through which people perceive and judge their workspace with regards to psychological comfort.

The 6 items were measured on a five point Likert scale with 1 being the anchor for 'Never' and 5 being the anchor for 'Always' , meaning that the higher an individual scored the higher their perceived level of psychological comfort. Examples of the items being measured is "I feel like I belong in my own workspace" and "I feel like I can complete my work in confidentiality". The reliability for the pilot scale conducted by Laughton (2018) was $a = 0.708$ with a reliability of the final study being $a = 0.719$, which is sufficient reliability for use in the current study.

3.5.7 Psychological Wellbeing

The Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) developed by Tennant et al., (2007) is a suitable scale for measuring psychological wellbeing. It was developed with the aim of capturing a wide conception of wellbeing which includes affective emotional aspects, psychological functioning, and cognitive-evaluative dimensions (Tennant et al., 2007). This scale is more suited to this research as it was designed to support mental health promotion initiatives with a focus on the positive aspects of wellbeing such as positive affect, interpersonal relationships, and psychological functioning (Tennant et al., 2007).

In the pre-study a shortened version of the WEMWBS was used, being the SWEMWBS which is a 7 item scale measured on a 5 point Likert type measure with 1 being the anchor for "None of the time" and 5 being the anchor for "All of the time". The reason for the shortened scale is that it related more to functioning rather than feeling which provides a slightly different perspective on wellbeing (Laughton, 2018; Tennant et al., 2007). The scale asks individuals to

rate their experience over a period of two weeks to assess their long term psychological wellbeing. The internal consistency of the 7 item scale according to Tennant et al.(2007) is estimated as 0.82 which is acceptable and the pre-test reliability of the scale was $a = 0.865$ which is fairly high and therefore acceptable for use in the current research.

3.6 Method of Analysis

Analysis of the variables is how the results are obtained in a quantitative research project. Statistical analysis was used to extract the information from the variables to establish a proposed outcome. This is done through variance, which is the extent of difference between a set of scores (Salkind, 2012). The analyses that will take place is the independent samples t-test and the matched pairs t-test.

3.6.1 Independent Samples t-test

The independent samples t-test is an inferential statistic most commonly used in determining significant differences between the means of two independent population groups (Kenton, 2018). The t-test looks at the t-statistic, distribution values and the degrees of freedom to assess the level of difference between the two sets of data (Kenton, 2018). The t-statistic will have a positive value if the first mean is larger than the second mean and negative if it is smaller (Trochim, 2006). The significance value which was set at $a = 0.05$ will indicated whether the two means were statistically different from one another.

3.6.2 Matched pairs t-test

Matched pairs t-test is a t-test that assesses the difference between matched mean scores within a population. The matched pairs t-test evaluates the same values as the t-test, with the

exception that the values were taken from the same sample group. The interpretation of the t-statistic as well as the level of significance remains the same. Often used for test re-test purposes, the matched sample t-test is an essential statistical tool in assessing significance within a particular sample.

3.7 Ethical Considerations

In conducting any form of psychological research, the key underpinnings of that research, are the numerous ethical considerations as outlined by the Health Professions Council of South Africa as well as the Human Research Council Ethics Board within the University of the Witwatersrand. In line with these considerations, the following ethical considerations were upheld. Participants within the research were informed within the participant information sheet, the intention of the research, along with the ethical considerations such as informed consent, confidentiality and anonymity, participation and right to withdraw as well as debriefing and protection of information.

The key ethical concern within research, is the safety of the participants, no harm both physically and psychologically would occur as result of participation within the current research as no sensitive subject matter or vulnerable group would be analysed within the research. Participants were assured of this as well as the voluntary nature of the research. Further to this, participants were informed that the information would be gathered in the form of an online survey, which would take approximately15-20 minutes to complete, with no consequence nor benefit resulting from participation (or non-participation) in the research. Informed consent was ensured both with informing participants their submission of results would be considered as

consent to the data being used within the study, as well as a check box at the beginning of the survey specifically asking for informed consent.

Participants were given the right to withdraw from the research at any time up to the submission of results, adhering to the anonymity of the results and were further assured with regards to confidentiality. Confidentiality was upheld as although the information was gathered on the company's Survey Monkey account, only the researcher had access to the scoring sheet and guidelines, meaning that the company could not draw any meaningful conclusions about specific individuals from the data. Although an area of potential concern would be that of anonymity, as a result of the matching process, the matching process was undertaken using a triple coding system before any ID's were associated with results which ensured anonymity throughout.

Permission to store the anonymised data as well as its use for future research was granted by participants, who were informed that the data would be protected using a double lock system, being stored in an encrypted file on a password protected laptop. Participants who wished to receive feedback were asked to contact the researcher 6 months after the completion of the questionnaire for a summary of the findings. With any queries being directed to the research or supervisor.

Permission to conduct the research in line with the ethical consideration above, was granted by the Human Research Ethics Committee Protocol Number (Appendix A) as well as the host organisation (Appendix C).

Chapter 4: Results

This chapter will analyse the statistical results, namely the results of normality, reliability, correlation coefficients as well as the results associated with the research questions, which made use of t-tests and matched pairs t-tests.

4.1 Normality

One of the key assumptions of many of the parametric tests used within psychological research need to meet the key assumption of normality, or that the sampling distribution about the mean is normal. All inferential statistics are based on the assumption that the value under investigation will exhibit a bell curve no matter how many samples are taken and the distribution is calculated across the samples (Mordkoff, 2016).

Although the Central Limit Theorem suggests that any mean is assumed to be normally distributed as long as the sample size is above 30 (Salkind, 2012), tests such as the skewness coefficient as well as kurtosis values will be used to formally investigate the normality of each data set. Skewness values allow for the indication of symmetry of the distribution as opposed to the complete symmetrical curve of a normal distribution. Skewness coefficients are considered acceptable when they fall between the range of -1 and 1 (Huck, 2009). Kurtosis coefficients often thought to measure ‘peakedness’ of the distribution actually rather indicate the extremity of the tail (Westfall, 2014). These coefficients are considered acceptable within the range of -2 and 2 (Gravetter & Wallnau, 2013). Additionally, Kolmogorov-Smirnov and Shapiro-Wilk tests were

conducted. For both statistics normality is assumed when if $p > a$ meaning the test statistic is positive (Huck, 2009).

As can be seen in Table 3, most of the normality values are within the range or skewness and kurtosis except for Physical Discomfort with a Skewness value just outside of the range of 1. However as can be seen with the Kolmogorov-Smirnov and Shapiro-Wilk test statistics are within the range of normality and therefore it can be stated that normality assumptions are upheld within the 2017 data set.

Table 3: Descriptive statistics for 2017 data set

Scale	Mean	Std. Dev.	Minimum	Maximum	Skewness	Kurtosis	Kolmogorov-Smirnov	Shapiro-Wilk
Satisfaction of IEQ	21.19	4.395	0	32	-0.426	1.450	0.126	0.966
Effect of IEQ on Performance	24.12	7.013	0	40	0.146	0.871	0.153	0.958
Effect of IEQ on Health	22.77	6.008	0	40	0.559	1.683	0.209	0.932
Combined IEQ Score	68.02	15.675	6	112	0.223	0.872	0.095	0.982
Noise Discomfort	17.45	4.789	5	30	0.313	-0.370	0.058	0.981
Physical Discomfort	16.36	7.623	0	45	1.043	1.009	0.132	0.941
Psychological Comfort	18.13	5.337	5	30	0.209	-0.526	0.053	0.986
Psychological Wellbeing	25.65	4.951	2	35	-0.483	0.832	0.150	0.835

All coefficients for Kolmogorov-Smirnov and Shapiro-Wilk were significant $p = (0.000)$ *at* $\alpha = 0.05$

Within Table 4 there is a similar trend for 2018 with all of the values being within the acceptable range except for the Physical Discomfort scale with a skewness value of 1, which arguably could be considered as within the range. There is a concern for the normal distribution

values of Satisfaction of IEQ features with a kurtosis value of 3.593, however, in conjunction with the skewness, Kolmogorov-Smirnov and Shapiro-Wilk test statistics it can be considered that the variable meets the assumption of normality. The other variables, once again using Kolmogorov-Smirnov and Shapiro-Wilk test statistics show that the data has met the assumption of normality for the 2018 data set.

Table 4: Descriptive statistics for 2018

Scale	Mean	Std. Dev.	Minimum	Maximum	Skewness	Kurtosis	Kolmogorov-Smirnov	Shapiro-Wilk
Satisfaction of IEQ	24.21	4.353	0	32	-0.740	3.593	0.144	0.930
Effect of IEQ on Performance	27.98	7.435	0	40	-0.261	0.504	0.126	0.947
Effect of IEQ on Health	26.46	7.029	0	40	0.129	0.763	0.200	0.922
Combined IEQ Score	78.65	16.869	0	112	-0.082	0.735	0.086	0.969
Perceived Health	41.88	7.077	9	56	-0.731	0.691	0.085	0.067
Noise Discomfort	15.48	5.352	0	30	-0.90	0.736	0.073	0.976
Physical Discomfort	15.22	7.602	0	45	1.000	1.461	0.155	0.917
Psychological Comfort	18.51	5.916	6	30	-0.100	-0.511	0.043	0.983
Psychological Wellbeing	25.68	5.110	2	35	-0.478	0.648	0.526	0.249

All coefficients for Kolmogorov-Smirnov and Shapiro-Wilk were significant $p = (0.000)$ *at* $\alpha = 0.05$

Within Table 5 all of the values fall within the range for normality and therefore it can be stated that the combined data for 2017 and 2018 meets the assumption of normality.

Table 5: Descriptive Statistics for Combined Data

Scale	Mean	Std. Dev.	Minimum	Maximum	Skewness	Kurtosis	Kolmogorov - Smirnov	Shapiro -Wilk
Satisfaction of IEQ	22.87	4.616	0	32	-0.519	1.884	0.145	0.930
Effect of IEQ on Performance	26.27	7.509	0	40	-0.068	0.405	0.126	0.947
Effect of IEQ on Health	24.80	6.846	0	40	0.335	0.867	0.200	0.922
Combined IEQ Score	73.95	17.136	0	112	0.088	0.472	0.086	0.970
Perceived Health	41.8674	7.06934	9	56	-0.731	0.684	0.085	0.967
Noise Discomfort	16.23	5.355	0	50	-0.130	0.656	0.071	0.976
Physical Discomfort	15.49	7.791	0	45	0.906	1.170	0.154	0.919
Psychological Comfort	18.09	5.874	5	30	-0.033	-0.507	0.042	0.983
Psychological Wellbeing	25.67	5.040	2	35	-0.477	0.715	0.146	0.842

All coefficients for Kolmogorov-Smirnov and Shapiro-Wilk were significant $p = (0.000)$ *at* $\alpha = 0.05$

4.2 Reliabilities

Reliability, as defined by Salkind (2012) is the extent to which a scale consistently measures a variable over time. This is of key importance within the current research as there needs to be a level of reliability from the pre-test scores to that of the post-test scores, ensuring that we are comparing results that are reliable across time. One of the methods used to minimise potential error, is the assessment of internal consistency reliability or Cronbach alphas. It is essential to analyse the reliabilities across time to ensure that none of the scales lowered in their reliability estimate. Henson (2001) comments that Cronbach alpha has become the most common form of evaluating reliability within psychological measures.

All of the reliability estimates depicted in Table 6 are within the range for acceptable reliability and most scales' reliability improved from 2017 to 2018, which may have been as a result of an increased sample size. However, from this we can see that the same amount of consistency across the two samples indicating strong reliability of the measures across time.

Table 6: Reliability Analyses

Scale	No. of Items	2017 α	2018 α	Combined α
Satisfaction of IEQ	8	0.840	0.855	0.863
Effect of IEQ on Performance	8	0.917	0.920	0.923
Effect of IEQ on Health	8	0.911	0.932	0.928
Perceived Health	11	-	0.832	-
Noise Discomfort	6	0.770	0.772	0.777
Physical Discomfort	9	0.854	0.863	0.860
Psychological Comfort	6	0.719	0.721	0.720
Psychological Wellbeing	7	0.865	0.784	0.866

4.3 Correlations

Correlation coefficients, namely Pearson's correlation coefficient, are used in establishing the strength of relationship between different variables as well as the direction of the association. Correlations are essentially a measure of an effect size, with the description of the strength and direction of the relationship. Hinkle, Wiersma, and Jurs (1998) provides a general guide for the interpretation of the co-efficient as a rule of thumb.

- .90 to 1.00 Very high positive correlation
- .70 to .90 High positive correlation
- .50 to .70 Moderate positive correlation
- .30 to .50 Low positive correlation
- .00 to .30 Negligible correlation

The inverse of which would be negative correlation coefficients, such as -.90 signifying a very high negative correlation. Although this is an ideal interpretation, in realistic social science research the guidelines are less stringent than that of medical research.

Table 7: Correlations for 2017 data

	Satisfaction of IEQ	IEQ on Performance	IEQ on Health	Perceived Health	Noise Discomfort	Physical Discomfort	Psychological Comfort
IEQ on Performance	.655**						
IEQ on Health	.686**	.734**					
Perceived Health	.	.	.				
Noise Discomfort	-.341**	-.253**	-.273**	.			
Physical Discomfort	-.266**	-.201**	-.254**	.	.332**		
Psychological Comfort	.330**	.316**	.304**	.	-.171**	-.061**	
Psychological Wellbeing	.149**	.167**	.192**	.	.070**	.046*	.529**

*All correlations are significant at 0.01** level except those indicated by * which are at a 0.05 level.*

Table 8: Correlations for 2018 data

	Satisfaction of IEQ	IEQ on Performance	IEQ on Health	Perceived Health	Noise Discomfort	Physical Discomfort	Psychological Comfort
IEQ on Performance	.670**						
IEQ on Health	.660**	.738**					
Perceived Health	.383**	.342**	.348**				
Noise Discomfort	-.275**	-.225**	-.223**	-.239**			
Physical Discomfort	-.260**	-.210**	-.208**	-.479**	.396**		
Psychological Comfort	.348**	.314**	.310**	.419**	-.153**	-.111**	
Psychological Wellbeing	-.042*	-.035**	-.032**	-.032*	-.375**	-.283**	-.395**

*All correlations are significant at 0.01 level, as indicated by ** which is below 0.01 level and * which is below 0.05 level*

Table 9: Correlations for Combined data

	Satisfaction of IEQ	IEQ on Performance	IEQ on Health	Perceived Health	Noise Discomfort	Physical Discomfort	Psychological Comfort
IEQ on Performance	.688**						
IEQ on Health	.695**	.753**					
Perceived Health	.382**	.340**	.347**				
Noise Discomfort	-.334**	-.264**	-.271**	-.234**			
Physical Discomfort	-.260**	-.270**	-.227**	-.479**	.367**		
Psychological Comfort	.341**	.319**	.311**	.418**	-.165**	-.083**	
Psychological Wellbeing	.182**	.181**	.191**	.480**	.111**	.018**	.552**

*All correlations are significant at the 0.01 ** level.*

As can be seen in the correlation matrix tables, the values which held the strongest relationships were that of the IEQ features with strong positive relationships in each of the datasets, with the highest value reaching $r = 0.753$ which was also significant at the 0.01 level. The negative correlations were to be expected as they represented discomfort, therefore an increase in IEQ for instance would have a negative relationship with Noise Discomfort.

4.4 Research Question One: Is there a significant difference between the data collected in the Green Building (2018) and that of the Conventional Buildings (2017) with regards to perceptions of IEQ features?

To answer this research question, one needs to assess the Indoor Environmental Qualities such as air temperature, office lighting and office furniture within the three subscales of overall IEQ satisfaction, perceived effect of IEQ features on individual performance as well as the perceived effect of IEQ features on health.

Table 10: Means and Standard Deviations

	2017 Mean	2017 Std. Dev	2018 Mean	2018 Std. Dev
Perceived Satisfaction of IEQ Features	21.23	4.395	24.29	4.194
Perceived Effect of IEQ on Performance	24.17	7.064	28.12	7.302
Perceived Effect of IEQ on Health	22.78	6.036	26.60	6.843

As can be seen from the means taken from the two samples, there is an overall improvement on employee's perception of IEQ features. Further, all of the means are statistically significant between the two groups. Perceived satisfaction of IEQ features is significant with $t(3723.802) = 22.074; p = 0.000\ ; d = 0.7123$, perceived effect on performance $t(3828.662) = 17.644\ ; p = 0.000; d = 0.540$, perceived effect on health $t(3873.591) = 19.060; p = 0.000; d = 0.592$, all of which show that there is a significant difference between IEQ perceptions between the conventional and the green building.

On further analysis, it is important to fully understand which of the IEQ features contributed towards the significant difference to see which elements are seen as an improvement between the green building in comparison to the conventional buildings. Table 11 shows the breakdown of IEQ features within the perceived IEQ Satisfaction whilst Table 12 and Table 13 show the breakdown between perceived IEQ's impact on performance and health respectively.

Table 11: Breakdown of Perceived IEQ Satisfaction

	Mean 2017	Std. Dev	Mean 2018	Std. Dev	Test Statistic	Significance
Air Temperature	2.55	0.795	3.02	0.747	18.536	0.000*
Air Freshness	2.51	0.833	3.06	0.744	21.604	0.000*
Air Quality	2.53	0.826	3.05	0.778	20.330	0.000*
Noise	2.48	0.873	2.69	0.828	7.514	0.000*
Office Lighting	2.89	0.749	3.15	0.750	10.992	0.000*
Daylight	2.65	0.909	3.13	0.774	17.495	0.000*
Office Furniture	2.79	0.739	3.08	0.745	12.218	0.000*
Overall Conditions	2.83	0.670	3.11	0.661	13.400	0.000*

* Represents significance at $p < 0.0001$

Table 12: Breakdown of Perceived IEQ Impact on Performance

	Mean 2017	Std. Dev	Mean 2018	Std. Dev	Test Statistic	Significance
Air Temperature	2.81	1.144	3.59	1.162	18.396	0.000*
Air Freshness	2.92	1.114	3.61	1.107	19.386	0.000*
Air Quality	2.90	1.132	3.59	1.164	18.543	0.000*
Noise	2.64	1.178	2.96	1.261	8.136	0.000*
Office Lighting	3.18	1.079	3.60	1.143	11.592	0.000*
Daylight	3.18	1.056	3.65	1.095	13.567	0.000*
Office Furniture	3.23	1.065	3.58	1.143	9.850	0.000*
Overall Conditions	3.20	1.085	3.65	1.096	12.749	0.000*

* Represents significance at $p < 0.0001$

Table 13: Breakdown of Perceived IEQ Impact on Health

	Mean 2017	Std. Dev	Mean 2018	Std. Dev	Test Statistic	Significance
Air Temperature	2.56	1.073	3.26	1.137	19.508	0.000*
Air Freshness	2.64	1.079	3.39	1.101	21.433	0.000*
Air Quality	2.62	1.089	3.37	1.127	20.827	0.000*
Noise	2.89	0.824	3.13	0.966	8.228	0.000*
Office Lighting	2.99	0.854	3.31	0.992	10.778	0.000*
Daylight	3.02	0.954	3.46	1.021	13.889	0.000*
Office Furniture	2.98	0.856	3.30	1.013	10.434	0.000*
Overall Conditions	2.98	0.871	3.40	0.965	14.003	0.000*

* Represents significance at $p < 0.0001$

As can be seen from each individual table, each IEQ feature had a significant difference, meaning that each of the factors had a significant impact towards the difference between the green building and the conventional building.

One of the key features to any post intervention study is the ability to match data to the previous sample responses, linking the answers directly from the pre to the post study. Fortunately, this was able to be done within the current study, with a total of 749 matched participants. This matched data is crucial to analysing whether there have been any direct effects on the sample which completed the survey in the conventional building and then again within the green building.

With regards to the green design features, Table 14 illustrates the means between the matched pairs, whilst Table 15 shows the results of the matched pairs t-test.

Table 14: IEQ Matched Means and Std Deviation

		Mean	Std. Deviation
Pair 1	Perceived Satisfaction of IEQ (2017)	21.38	4.347
	Perceived Satisfaction of IEQ (2018)	23.89	4.447
Pair 2	Perceived Effect of IEQ on Performance (2017)	24.36	6.851
	Perceived Effect of IEQ on Performance (2018)	27.46	7.190
Pair 3	Perceived Effect of IEQ on Health (2017)	22.65	5.940
	Perceived Effect of IEQ on Health (2018)	25.85	6.837

From the means, we can see that the same trend is seen within the matched sample and the unmatched sample, with the green building means (2018) showing a higher mean than that of the conventional building means (2017), meaning an improvement in indoor environmental quality satisfaction as well as their perceived influence on performance and health.

Table 15: IEQ Paired Sample t-Test

					95% Confidence Interval				
		Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig.
Pair 1	Perceived Satisfaction of IEQ	-2.517	5.131	0.187	-2.885	-2.149	-13.423	748	0.000
Pair 2	Perceived Effect of IEQ on Performance	-3.096	8.523	0.311	-3.707	-2.485	-9.942	748	0.000
Pair 3	Perceived Effect of IEQ on Health	-3.200	7.361	0.269	-3.728	-2.672	-11.898	748	0.000

It is clear from the matched pairs t-Test that even within the matched sample, there is a definite increase in the perceived effect of the indoor environmental quality, with Satisfaction of IEQ features, $t\ (748) = \ -13.423; p = 0.000$, Perceived effect of IEQ on performance,

$t(748) = -9.942; p = 0.000$ and Perceived effect of IEQ on health, $t(748) = -11.898; p = 0.000$ all being significant at $p < 0.05$.

Therefore, given that there is a statistically significant difference in both the matched and the unmatched sample data, it can therefore be said that there is a significant difference between the data collected within the green building in comparison to that of the conventional building in respect of green design features.

4.5 Research Question 2: Is there a significant difference in employee's physical/psychological wellbeing between the Green Building and the Conventional Buildings?

To assess employee wellbeing the following question will be assessed using a combination of the scales that assessed employee health and wellbeing namely, Noise Discomfort, Physical Discomfort, Psychological Comfort and Psychological Wellbeing. The unmatched sample data will once again be compared to the matched sample data to explore whether they present similar patterns/trends of results.

In assessing the noise discomfort, it can be seen from Table 16 that the mean decreases from the 2017 sample to that of the 2018 sample, which shows a decrease in the mean noise discomfort experienced by employees within the green building.

Table 16: Noise Discomfort Means and Std. Deviations

	2017 Mean	2017 Std. Dev	2018 Mean	2018 Std. Dev
Noise Discomfort	17.20	5.172	15.56	5.310

This was also statistically significant as $t(3874) = -9.435; p = 0.000; d = 0.312$, in assessing the matched sample we can see a similar trend with regards to the means as displayed in Table 17

Table 17: Noise Discomfort Paired Means and Std. Deviation

		Mean	Std. Deviation
Pair 1	Noise Discomfort (2017)	17.42	5.011
	Noise Discomfort (2018)	16.29	5.648

Table 18: Noise Discomfort Paired Sample t-Test

					95% Confidence Interval				
		Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig.
Pair 1	Noise Discomfort	1.126	5.825	0.213	0.708	1.543	5.288	748	0.000

Table 18 shows the matched pairs t-Test results which are statistically significant $t\ (748) = 5.288; p = 0.000$ which shows that there is a significant difference between the means collected within the conventional building and the green building, with a reduction in noise discomfort across both of the samples, matched and unmatched.

Table 19: Physical Discomfort Means and Std. Deviations

	2017 Mean	2017 Std. Dev	2018 Mean	2018 Std. Dev
Physical Discomfort	15.84	7.948	15.09	7.456

Physical Discomfort also has a reduced mean between the data from 2017 and 2018 however it is interesting to see that the mean does not differ drastically, however the difference is still significant $t(3700.438) = -2.974; p = 0.003; d = 0.097$. Table 20 shows the matched mean difference between the two samples with a similar data trend showing less physical discomfort with the green building sample.

Table 20: Physical Discomfort Paired Means and Std. Deviation

		Mean	Std. Deviation
Pair 1	Physical Discomfort (2017)	16.13	8.016
	Physical Discomfort (2018)	15.44	7.666

Table 21 shows the matched pairs sample t-test result which like the unmatched sample is statistically significant $t(748) = 2.405; p = 0.016$.

Table 21: Physical Discomfort Paired Sample t-Test

					95% Confidence Interval				
		Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig.
Pair 1	Physical Discomfort	0.694	7.901	0.289	0.127	1.261	2.405	748	0.016

It is necessary to see the distribution differences between the two data sets, as can be seen in Table 22, where the frequency percentages are displayed between the year 2017 (the first line) and 2018 (the second line). From the percentages, it can be seen that the majority of individuals responded to 'Never' with regards to physical discomfort. However, there are a few regions of the body which still have high levels of physical discomfort which need to be acknowledged.

Table 22: Frequencies for Body Regions.

	Never	1-2 Times a month	3-4 Times a month	Once Every Week	Several times every week
Neck	28.2 %	24.5%	13.7%	10.7%	17.6%
	33.8%	27%	11.9%	8.8%	13.7%
Shoulders	31.2%	21.4%	12.6%	11.3%	17.3%
	34.8%	25%	12.2%	9.8%	13.2%
Upper Back	40.6%	17.9%	10.9%	9.1%	13.1%
	47.8%	16.9%	9.2%	7.9%	10.4%
Elbows	70.4%	8.1%	4.3%	2.9%	2.3%
	77.6%	7.5%	3%	2.1%	1.8%
Lower Back	34.4%	22.2%	13.1%	9.2%	14.4%
	40.1%	23.3%	12.1%	9%	10.5%
Hips	70.8%	8.1%	3.8%	2.5%	3%
	76.7%	8.1%	2.8%	2.3%	2.9%
Wrists/Hands	57.1%	15%	7.8%	4.4%	5.1%
	65.4%	13.5%	5.9%	4.3%	4.2%
Knees	72%	7.5%	4.3%	3%	2.6%
	75.9%	9%	3.8%	2.2%	2.3%
Ankles/Feet	70.4%	9.2%	3.9%	2.9%	3.3%
	73.6%	9.8%	3.9%	3.1%	3.4%

In assessing the different regions of the body between the two years, it can be seen that the most significant differences were located around the neck $t\ (3714.786) = -4.374; p = 0.000$, shoulders $t\ (3961.081) = -3.233; p = 0.000$, upper back $t\ (3712.297) = -3.233; p = 0.000$ and lower back $t(3964.281) = -3.160; p = 0.000$ regions of the bodies, as can be seen in Table 2.

Table 23: Means and t-Test for Body Regions

	Mean 2017	Mean 2018	Test Statistic (t)	Significance (p)
Neck	2.48	2.26	-4.374	0.000*
Shoulders	2.42	2.26	-3.233	0.001*
Upper Back	2.10	1.92	-3.178	0.000*
Elbows	1.23	1.19	-1.631	0.103
Lower Back	2.26	2.11	-3.160	0.002*
Hips	1.23	1.25	0.624	0.533
Wrists/Hands	1.53	1.48	-1.463	0.143
Knees	1.26	1.26	0.073	0.942
Ankles/Feet	1.30	1.34	1.303	0.193

The same trend was experienced with the matched sample as can be seen in Table 24, which shows the mean comparison between the matched sample and Table 25 the matched pairs t-Test comparison.

Table 24: Paired Means and Std. Deviations for Body Regions

		Mean	Std. Deviation
Pair 1	Neck (2017)	17.42	5.011
	Neck (2018)	16.29	5.648
Pair 2	Shoulders (2017)	2.51	1.566
	Shoulders (2018)	2.35	1.465
Pair 3	Upper Back (2017)	2.12	1.544
	Upper Back (2018)	1.97	1.468
Pair 4	Elbows (2017)	1.23	0.985
	Elbows (2018)	1.18	0.805
Pair 5	Lower Back (2017)	2.30	1.525
	Lower Back (2018)	2.09	1.441
Pair 6	Hips/Thighs (2017)	1.27	1.065
	Hips/Thighs (2018)	1.31	1,008
Pair 7	Wrists/Hands (2017)	1.58	1.259
	Wrists/Hands (2018)	1.52	1.131
Pair 8	Knees (2017)	1.29	1.049
	Knees (2018)	1.31	0.954
Pair 9	Ankles/Feet (2017)	1.29	1.059
	Ankles/Feet (2018)	1.37	1.021

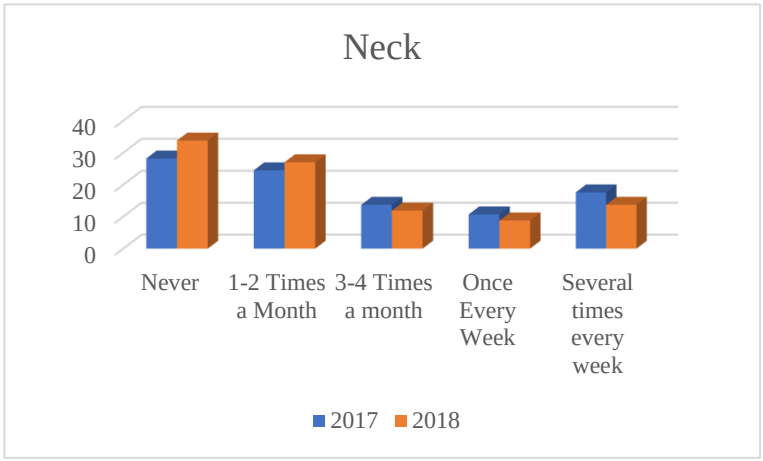
Table 25: Body Regions Paired Sample t-Test

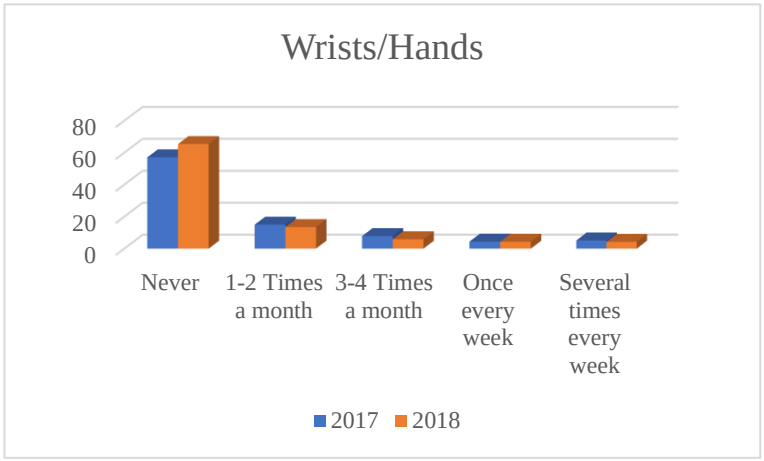
					95% Confidence Interval				
		Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig.
Pair 1	Neck	.204	1.583	0.058	0.091	0.318	3.532	748	0.000*
Pair 2	Shoulders	.160	1.510	0.055	0.052	0.269	2.904	748	0.004*
Pair 3	Upper Back	.148	1.702	0.062	0.026	0.270	2.383	748	0.017*
Pair 4	Elbows	052	1.013	0.037	-0.021	0.125	1.407	748	0.160
Pair 5	Lower Back	0.202	1.628	0.059	0.085	0.318	3.389	748	0.001*
Pair 6	Hips/Thighs	-0.036	1.235	0.045	-0.125	0.053	-0.799	748	0.424
Pair 7	Wrists/Hands	0.059	1.363	0.050	-0.39	0.157	1.180	748	0.239
Pair 8	Knees	-0.021	1.129	0.041	-0.102	0.060	-0.518	748	0.605
Pair 9	Ankles/Feet	-0.073	1.233	0.045	-0.162	0.015	-1.630	748	0.104

The significant differences can be seen visually with a clustered bar chart as seen in Figure 4 where the graph representing the neck area is more distributed, the wrists/hands region, the data is skewed heavily towards less physical discomfort. However, there is a clear increase in the less

physical discomfort with regards to the 2018 sample (yellow bars) which shows the 2018 sample skews more towards less physical discomfort.

Figure 12: Neck and Wrists/Hands Bar Chart





Psychological comfort as can be seen between the two sample means increased from the conventional building to the green building, as can be seen in Table 26.

Table 26: Psychological Comfort Means and Std. Deviations

	2017 Mean	2017 dd Dev	2018 Mean	2018 Std. Dev
Psychological Comfort	17.59	5.734	18.54	5.867

Further this difference is statistically significant as $t(3874) = 4.338; p = 0.000; d = 0.181$. However, this is not the same with the matched sample, as can be seen in Table 27 and Table 28

Table 27: Psychological Comfort Paired Means and Std. Deviations

		Mean	Std. Deviation
Pair 1	Psychological Comfort (2017)	17.96	5.647
	Psychological Comfort (2018)	18.31	5.898

Table 28: Psychological Comfort Paired Sample t-Test

					95% Confidence Interval				
		Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig.
Pair 1	Psychological Comfort	-0.352	6.518	0.238	-0.820	0.115	-1.480	748	0.139

Although the means are seen as similar, with regards to the increase of psychological comfort with the green building sample, the matched sample does not reach significance as $t(748) = -1.480; p = 0.139$. This may suggest that although overall psychological comfort increased, those individuals who moved from the conventional building to the green building did not see a significant difference in their perception of psychological comfort, which needs to be discussed further.

Table 29: Psychological Wellbeing Means and Std. Deviations

	2017 Mean	2017 Std. Dev	2018 Mean	2018 Std. Dev
Psychological Wellbeing	24.35	7.289	24.63	7.161

Psychological wellbeing as can be seen between the two different samples, does not have a substantial difference and it is a difference of 0.28, which in addition is not statistically significant $t(3874) = 0.768; p = 0.442; d = 0.013$, it may be something worth investigating as the mean data shows that the majority of the individuals fall between the anchors of "some of the time" and "often", with the responses skewing towards "some of the time". It is also worth noting that the significance as seen in the unmatched sample is replicated with the matched sample as seen in Table 31.

Table 30: Psychological Wellbeing Paired Means and Std. Deviations

		Mean	Std. Deviation
Pair 1	Psychological Wellbeing (2017)	24.92	6.569
	Psychological Wellbeing (2018)	24.64	6.618

Table 31: Psychological Wellbeing Paired Sample t-Test

					95% Confidence Interval				
		Mean	Std. Dev	Std. Error	Lower	Upper	t	df	Sig.
Pair 1	Psychological Wellbeing	0.276	7.959	0.291	0.295	0.847	0.950	748	0.342

Psychological wellbeing in respect of the matched sample is nonsignificant with $t(748) = 0.950; p = 0.342$. This may need further investigation as it shows that psychological wellbeing is something which is not impacted by the transition to the green building, which may suggest that this is something inherent within the organisation.

The final variable which needs to be assessed is the perceived health variable, this is the variable which was only measured with the 2018 sample however it does yield interesting results. With regards to perceived health the mean for this variable was $\mu = 42.08; std.dev = 6.944$ given that the maximum for this scale is 56 and the minimum is 11 we can see that this is a fairly high mean, meaning that the individuals within the green building on average found that their perceived health was relatively high.

In response to research question two being whether there is a significant difference in employee wellbeing, one can say with a fair degree of certainty that employees' physical wellbeing increased significantly with regards to employee perception of their physical health, as each of the variables associated with physical health such as Noise Discomfort and Physical Discomfort decreased significantly, meaning that employees felt less discomfort in the green building which was mirrored in the matched sample. Further to this, employee perceived health as indicated by the mean data, was quite high and therefore can be used as an aid to state that overall employee perception of health is quite high in the green building.

However, across the variables measuring psychological wellbeing being Psychological Comfort and Psychological Wellbeing, there is contestation as only one of the variables, being unmatched sample data of Psychological comfort, achieved a significant difference. Psychological wellbeing across both the unmatched and matched sample data achieved non-significant results. It can therefore be said that given that only one aspect of one variable

achieved a significant result, there is insufficient evidence to demonstrate a significance between the green building and conventional building with regards to psychological wellbeing.

Therefore, to fully answer research question two, it should be stated that although there is a significant difference between the physical wellbeing of individuals between the green building and the conventional building, the same cannot be said in respect of psychological wellbeing and this variable needs to be investigated. It is therefore prudent to stress that physical wellbeing increased however there is insufficient evidence to suggest that psychological wellbeing increased as a result of the transition to the green building.

Chapter 5: Discussion

This chapter is devoted to an in-depth analysis and theoretical discussion of results found in Chapter 4 with reference to results and trends found within the global literature. There is a need not only to understand results as they are presented but a necessity to position them within the 'greener scheme of things' to contribute to the discussion around the impact of green buildings on employee health and wellbeing.

One of the first discussion points, needs to centre around the argument of causality. Although this research takes the form of a non-experimental design, which traditionally does not allow for the establishment of causality. Although not as stringent as a true experimental study, one can see how causality is something which cannot be excluded from the current research as some of the research design features do lend themselves to causal conclusions. Further, one needs to consider the context of the research to assess whether it would be feasible to conduct a form of true-experimental study that is not perceived as artificial by employees, to examine their true perceptions of their environment and the impact that may have on wellbeing, thereby necessitating the use of a non-experimental research design and the allowance of causal claims.

5.1 Perceived effect of green design (IEQ) features

With regards to green design features specifically with regards to IEQ features, there is a clear increase in the perceived benefit of the IEQ features as well as their perceived satisfaction,

their perceived impact on health, as well as performance. This fits the trend within global literature, especially with regards to perceived health and performance. It is often highlighted within the literature that IEQ features have a direct impact on health as well as performance indicators (Singh et al., 2010; Thatcher & Milner, 2014).

Global literature found that often the most cited issues related to IEQ features were the issues surrounding lighting, acoustic discomfort, as well as thermal comfort levels (Abbaszadeh et al., 2006; Hedge & Dorsey, 2013). However, this was not seen within the current literature with all of the IEQ features contributing to an overall satisfaction as well as perceived impact on health and performance. Issues relating to thermal comfort levels, noise, and lighting were not seen as antagonists. This may be attributed to the building design, which may be of possible inquiry for future research, if the current building has managed to limit these antagonistic effects with its current design. However, this may speak to the critique raised by Leaman and Bordass (2007) stating that users of green buildings are more tolerant of indoor environmental qualities and therefore less likely to cite them as potential antagonists to productivity, satisfaction and health. It will be interesting to note if these features remain as positive aspects in future research within the same green building.

A possible contention which was highlighted within the literature was whether IEQ features interacting with one another and not in isolation would yield significantly different results. This seems not to be an issue with respect to the current study. When all of the features were combined along the three main factors of perceived satisfaction, performance, and health, all of the features were significant thereby showing that there is not a trade-off between the

features, but rather a symbiotic interaction where the features work in unison rather than antagonistically.

Critically, it needs to be expressed that all buildings may have different responses with regards to IEQ features, given that the buildings themselves have different layouts, design, as well as budget for IEQ improvement. This therefore makes it difficult to assess the features in respect of the differences within the building. It is also worth noting that building design has a major impact on IEQ satisfaction and therefore it needs to be considered as to how to integrate design within measurements of IEQ satisfaction to fully understand how to optimise the features from one building to the next.

What is interesting to note within the literature as well as within the pre-study is that open plan offices have reduced IEQ satisfaction (De Croon et al., 2005; Laughton, 2018). However, within the current building the majority of the space, as can be seen within the demographics, are open plan offices and there is a statistically significant increase within the perception of IEQ features within the current study. This may be due to a blend of both open plan offices as well as agile work spaces. However, it may also relate to the office design as open plan offices are often constructed differently with the materials used, their positioning as well as their internal features. In this case it may be beneficial for future research to see which elements of design occupants found enhanced their perception of IEQ features.

All of the results found with regards to IEQ features were significant at the level of $p < 0.0001$ which within the social sciences is an extremely strong significant difference as often the level of significance is set at $p < 0.05$ (Babbie & Mouton, 2001; Salkind, 2012). This highlights the significant difference of green design features within a green building as compared to a conventional building. However, something which does need to be considered is the moderate effect sizes. The effect size on overall satisfaction is relatively high at 0.7123 however with regards to health and performance it is 0.592 and 0.540, respectively. These are still relatively decent sizes of effect, coupled with the strong significant difference, should be a motivating factor for more organisations to consider moving towards green buildings. There is a clear distinction on all three levels of perceived satisfaction, health and performance between the green building in contrast to the conventional building.

Although overall these results do tend to match the trend within global literature, which states that green buildings are more inclined towards being healthier more productive as well as having a general satisfaction with regards to their indoor environment, there are also conversely more recent studies which have found that IEQ features are more dependent on the sample as well as the building design, with less satisfaction being associated with LEED buildings (Altomonte & Schiavon, 2013). However, this strengthens the call made by Thatcher and Milner (2016) for a more standardised method of analysing IEQ features. This research used the same measure for both the pre- and the post- study and achieved a significant result. This should therefore serve as a benchmark for future studies in an effort to standardise how IEQ is measured for greater comparability across global results.

5.2 Significant difference in employee wellbeing between the green building and the conventional building.

Given that wellbeing is something which is multifaceted and in the context of this research has been distinguished between physical as well as psychological wellbeing it needs to be assessed as such. Many studies synthesize the physical and emotional health into one variable and one construct and do not fully distinguish the difference between emotional health and physical health.

To begin with the assessment of noise discomfort, questions may be raised as to why acoustic noise is being placed under wellbeing, however research has found that there is a relationship between noise and wellbeing (Livi, Pica, Carrus, Rullo, & Gentile, 2018). Further to this Pierrette et al. (2015) highlight the relationship between acoustic noise and productivity as well as a sense of wellbeing as often acoustic noise has the ability to disrupt concentration as well as have permanent damage to one's hearing. This therefore further impedes on an individual's sense of wellbeing.

It is seen within the literature that open plan offices are credited with more noise than private enclosed spaces (Perrin Jegen & Chevret, 2017). It is therefore interesting to note a statistically significant decrease in noise discomfort within the current study, as the predominant design of the office layout within the current green building is that of an open plan office. It therefore shows a discrepancy within the literature as there is a clear decrease in noise in conjunction with an open plan office design. This therefore could highlight a possible point of

inquiry for further research to examine how the target site has designed their open plan spaces to facilitate the reduction of acoustic and ambient noise. Further to this, it could be interesting to measure the level of noise to which employees find tolerable globally, in an effort to ascertain acceptable levels within green buildings. This will begin to facilitate the creation of noise discomfort as a variable which can be measured by means other than participant self-report.

With regards to physical discomfort, this is the variable which is most associated with somatic forms of physical health and therefore is a strong indication of an individual's perception of their physical wellbeing. There is a statistically significant difference with regards to physical discomfort within the matched as well as the unmatched sample, showing that the green building is perceived as more comfortable. However, the areas which individuals highlight as having a significant increase in comfort are the neck, shoulders, upper back, as well as lower back. These regions are most notably associated with one's posture as well as the ergonomic layout of the office furniture.

Although there are definite improvements within the physical comfort level, there are still factors which need to be addressed, this includes the prevalence of physical discomfort. When looking at the prevalence with regards to how often individuals feel discomfort, the data shows that the majority of prevalence falls between never and 1-2 times a month. However, the third highest prevalence is 7 times weekly. This shows that although the majority of individuals within the green building experience less physical discomfort there is a proportion of individuals who experience prevalent physical discomfort almost every day, which needs to be assessed further.

It is also pertinent to point out that although regions such as the neck, shoulders, upper and lower back saw a significant improvement, there are regions of the body which experienced higher (non-significant) levels of discomfort within the green building. This includes the hips as well as the ankles and feet, with knees showing no change in discomfort. This is something which may be important to note for future inquiry as these areas of the body may be attributed with issues relating to office furniture. This may prove to be something which is difficult to improve or manage as the use of agile and open plan offices limits the impact of ergonomic preference for individual users as they do not have a permanent allocated work station.

Physical comfort, although a really strong indication of an individual's comfort levels, does not have the ability to filter out many of the extraneous variables that impact on physical discomfort, such as previous sports injuries, the possibility of having furniture outside of the office environment which may impact on one's level of comfort. Therefore, there is a recommendation that a stronger measure of inquiry is found to assess workplace comfort in relation to ergonomic factors to ensure the change is directly related to the green building.

Although a new variable added to the study, perceived health still allowed for insight into an individual's perceived health within the work environment. This variable found that on average individuals perceived their level of health to be above average with a strong trend towards "very good". This is a strong indication that aligns with literature trends. Occupants of green buildings experience an overall increase in health outcomes (Allen et al., 2015). The limitation to the use of the perceived health variable with regards to the current study, is that there were no reference points from the previous study to establish whether there is a statistically

significant difference between perceived health in the green building with respect to the conventional building. This is something future research may take into consideration in their evaluations.

From the physical wellbeing variables, it can be said that there is a clear increase in physical wellbeing and physical health outcomes between the green building and the conventional building which is something that has been well supported within global literature findings previously (Allen et al., 2015; Hedge, 2000; Thatcher & Milner, 2014). Many of the statistically significant differences were at the level of $p < 0.0001$ which as stated previously is the standard for significance within medical research (Babbie & Mouton, 2001). It can therefore be said that the impact of the green building had a statistically significant positive impact on the physical health of employee wellbeing. In assessing psychological wellbeing, through the variables of psychological comfort as well as psychological wellbeing there was an interesting contrast to physical wellbeing.

In terms of the variable psychological comfort, although overall there was a statistically significant difference between the green building and the conventional building, there however was a non-significant difference with regards to the matched sample. This raises suspicion as these were individuals who can be linked between the two samples and are known to have been directly impacted by the move to the green building.

Although there is an overall significance there still needs to be an understanding that psychological comfort is something which has not significantly improved from the conventional building to the green building. The significance found with the unmatched sample may be attributed to individuals who moved from other organisations to the host organisation, however, the key focus is with the matched sample data. The matched sample shows that although individuals moved from a conventional building to a green building, they did not experience a significant difference in their perception of territory, privacy and control. This may relate back to literature which states that individuals relocated to a green building found dissatisfaction in the office design citing issues of privacy and control as a core reason, given the open plan design (Vischer, 2007).

What is of interest is the variable of psychological wellbeing, which found a non-significant result with both the matched and the unmatched sample data. This is important to note as the scale used to operationalise the variable of psychological wellbeing only focused on the positive aspects of psychological wellbeing being psychological functioning, positive affect and interpersonal relationships (Tennant et al., 2007). Given the focus on positive variables it is interesting that none of the samples experienced an increase in psychological wellbeing. This may point out that green buildings do not have a significant impact on psychological wellbeing of the employees within them.

Although an interesting finding it corresponds with literature within South Africa, as was pointed out in the literature review, research conducted by Thatcher and Milner (2012), green buildings did not have a positive effect on psychological wellbeing in the workplace. This may be an inherent trait within South African green building samples, which would need to be researched further. This non-significant result may point towards the fact that there are other extraneous variables which affect psychological wellbeing that cannot be improved with green design features. Laughton and Thatcher (2018) positioned the argument quite well, stating that extraneous influences such as job demands, the nature of the work, and organisational culture have a much wider impact on individual psychological wellbeing, although their argument was with respect to office design, the same statement may be true for green design features. This is backed by Vischer (2007) who supports the notion for future research to include constructs of job demands and workplace stress into the model of psychological wellbeing.

Another facet of psychological wellbeing which has yet to be discussed, is the context in which the study is located. South Africa is a country with high crime statistics as well as a 18.8% of the population living with HIV (AVERT, 2019). This is a key extraneous variable which South African wellbeing research needs to acknowledge as well as discussed, as research has shown that the high crime statistics as well as HIV have implications on wellbeing within South African samples (Cluver, Gardner, & Operario, 2007; Powdthavee, 2005). This is something which has been relatively ignored within South African green building research. However, there needs to be an acknowledgement that this is a prevalent issue within South Africa and may have an impact on participants' physical as well as psychological wellbeing. If someone has recently been a victim of crime there psychological wellbeing and comfort levels may be impacted by the trauma

and thereby impacting on the variable. Likewise if an individual has been diagnosed with HIV, they will be on medical treatments which may be a threat to their physical health as well as their psychological health. Future research may look at ways of analysing this variable in respect to wellbeing, within the South African context.

Critically, Dolan, Knight, Metcalfe, Peasgood, and White (2007) speak to a similar concern that was raised with regards to the measurement of IEQ features, which is finding a lack of shared understanding about wellbeing. This is important to note as although it is crucial to situate the results of the current study with respect to global literature, there will always be the question of what exactly each study is measuring in terms of wellbeing. It is therefore difficult to make meaningful comparisons between research findings with regards to green design and wellbeing as each study conceptualises and measures wellbeing differently. Future measurements and research need to explore the possibility of creating a commonly accepted measure and description of the variable wellbeing, one, which as this research stipulates, needs to be separated into physical and psychological wellbeing.

5.3 Limitations and direction for future research

Any study of a large nature has certain limitations which are either beyond the authors control or is suggested to be included as a factor within further research to continually develop and strengthen future research in the field of green design as well as employee wellbeing.

Although it was not possible to conduct a true experimental design within the context of the current research, a possible limitation revolves around random assignment. Random assignment limits the influence of extraneous variables on the sample group, which is something that may be lacking within the current research. Further to this the inclusion of a control/contrast group, would allow for greater control of extraneous variables and add towards the comparability of results between the two groups. Although it was not possible within the current research to include random assignment as well as control/contrast groups, this is something which needs to be considered in respect of future research in an effort to strengthen the research design.

A limitation experienced within the current study which is something to consider for future research is the inclusion of qualitative results to supplement the statistical analyses. It would be of great interest to understand employee perception of the green building as well as a gain a deeper understanding of how they perceive the green design features to impact on their wellbeing. Often with statistical results, such as those found with regards to psychological wellbeing, it is said that further investigation needs to be conducted to establish as to why the results are non-significant. With the inclusion of a qualitative component there is the chance to

gain a deeper understanding as to the non-significant results as participants could highlight key themes within psychological wellbeing which they feel need to be addressed.

Although this research project was thorough within its investigation of employee wellbeing in relation to green design, one of the key limitations which has been discussed not only within the literature but within the discussion, is the inability to compare statistical results to a global norm, as there is no consensus as to how to correctly measure IEQ features within a green building. The creation of a scale which is used globally would allow for the comparison between samples internationally which would benefit global research greatly.

This therefore would impact on the generalisability of the results found within the current research. Although results found within the current research will differ to other studies given the different scales and measurements, this study can still be used as a method of comparison as to the results found with regards to IEQ satisfaction as well as its impact on health and performance. The results that were found with regards to psychological wellbeing can also be used as a possible source of inquiry and possible discussion for future research. Given that this research is a post occupancy pre- post-test design the findings within the current research can be used to stimulate further research into green buildings within South Africa.

Further to this, the research conducted the study on one green building, with one sample set within Johannesburg, South Africa. This further limits the generalisability of results, as one cannot generalise the findings of the current research to a sample population in a different green building in Cape Town for instance. This study may however be considered to form a benchmark

for further comparative studies to be conducted on green buildings within South Africa, however, on its own it does not represent a wholistic South African sample. Further research may look at the inclusion of different sample sets as well as different geographic locations to situate the research there by increasing the generalisability of the results, however, this was not feasible within the current study.

A possible direction for future research would be to see if the results found within the current research are sustained into the future. Given that the host site was fairly new (less than a year old) when the study was conducted, employees may still be in the honeymoon phase of inhabitants within their new building. It would therefore be interesting to continue the longitudinal research with the current building to see whether employee perceptions of IEQ features as well as their wellbeing are sustained

Chapter 6: Conclusion

Green buildings are an essential tool for sustainability, their resource and energy efficiency lessening their impact on the environment, this may become a global necessity in the near future with the fight against global warming intensifying. It is for this reason that research into the wellbeing of green building occupants is essential in the field of organisational psychology as well as the research surrounding green buildings themselves. However, research into these buildings does need additional clarity, in the realm of employee wellbeing.

This research which analysed a sample consisting of 4 557 green building occupants, 749 of whom were able to be matched between samples, pre- and post - occupancy. A combination of matched pairs t-test between both samples found that claims of increased IEQ satisfaction across health, performance and overall satisfaction within the literature is supported by the current research, with statistical significance across all three levels of the IEQ satisfaction variable. Claims of increased employee wellbeing, however, needs further investigation as although physical wellbeing showed a statistically significant positive difference, the same was not found with psychological wellbeing.

Recommendations for future research revolves mainly around the need for global standardisation around not only the methods for analysing green buildings but the measures which are used to do so. Further to this, key variables within the research such as employee health and wellbeing needs commonly accepted definitions between green researchers. This will

culminate in the generalisability of results globally as well as draw greater comparisons between sample sets.

Although this research highlights some issues with regards to the investigation and research of green buildings, overall the support for green buildings and their positive impact on employee wellbeing is found throughout the literature as well as the findings of the current study. The increase in satisfaction among indoor environmental quality is perceived to impact on employee health and productivity as well as increase employee perception of physical health. This is important as although research often highlights potential negatives, positive aspects of these buildings also needs to be acknowledged.

The impacts of global warming and climate change are affecting the sustainability of our environment, which in turn will impact on the sustainability of human existence. Key sectors such as industry and construction are joining the fight against climate change with the integration of green building features within modern construction. This allows for organisations to truly limit their impact on the environment and commit to sustainability, not only of the environment around them, but of their occupants' health and wellbeing as well.

§Thank you§

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Appendices

Appendix A: Human Research Ethics Committee Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (SCHOOL OF HUMAN & COMMUNITY DEVELOPMENT

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: MORG/18/006 IH**
PROJECT TITLE:	The study of green buildings and their effects on employee wellbeing
INVESTIGATORS	Meyer Ryan
DEPARTMENT	Psychology
DATE CONSIDERED	28/06/18
DECISION OF COMMITTEE*	Approved

This ethical clearance is valid for 2 years and may be renewed upon application

DATE: 28 June 2018

CHAIRPERSON
(Dr Colleen Bernstein)

cc Supervisor: Prof. Andrew Thatcher
Psychology

DECLARATION OF INVESTIGATOR (S)

To be completed in duplicate and **one copy** returned to the Secretary, Room 100015, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure be contemplated from the research procedure, as approved, I/we undertake to submit a revised protocol to the Committee.

This ethical clearance will expire on 31 December 2020

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B: Participant Information Sheet

Psychology
School of Human & Community Development
University of the Witwatersrand
Private Bag 3, Wits, 2050
Tel: 011 717 4503 Fax: 011 717 4559

June 12, 2018

Good day.

My name is Ryan Meyer and I am a Masters student at the University of the Witwatersrand. In order to obtain my Master's degree in Organizational Psychology, I am required to conduct a research project. I would like to invite you to kindly participate in my research project, the aim of which is to explore the effects that a green building may have on employee health and wellbeing.

In order to participate in the study, you will need to complete the attached survey. The survey should take approximately 15 – 20 minutes to complete. Your responses will be kept strictly confidential and anonymous. There is no consequence nor benefit for completing the survey or participation. The completion and return of this questionnaire are regarded as consent for your responses to be used in this research project. It is completely acceptable for you to choose not to participate and this will not be held against you in any way.

Anonymity will be ensured throughout the research process, a form of matching will be taking place against previous data collected, however this will be done by the organisation and I will have no access to any identifying information and the organisation will not have access to the marking key to make meaningful sense of the data. Data from this research will be stored on a password protected laptop, with no identifying characteristics. In addition your consent to participate in this research will act as consent to store the anonymised data for future research.

Feedback in the form of a summary of the research findings will be emailed to you at your request 6 months after the completion of this questionnaire, a mini report will however be provided to the company once the research has been completed. If you have any queries, please do not hesitate to contact me or my Supervisor.

Yours sincerely
Ryan Meyer

Prof. Andrew Thatcher
Supervisor
Chair of Industrial/Organisational Psychology
Tel: 0117174533
E-Mail: Andrew.Thatcher@wits.ac.za

Ryan Meyer
Masters in Organisational Psychology
Cell: 0797494959
E-Mail: Ryan.Meyer@students.wits.ac.za

Dr. Colleen Bernstein
Masters Course Co-Ordinator
Tel: 0117174538
E-Mail: Colleen.Bernstein@wits.ac.za

Appendix C: Permission from host organisation.

Discovery
Central Services

20 June 2018

To whom it may concern

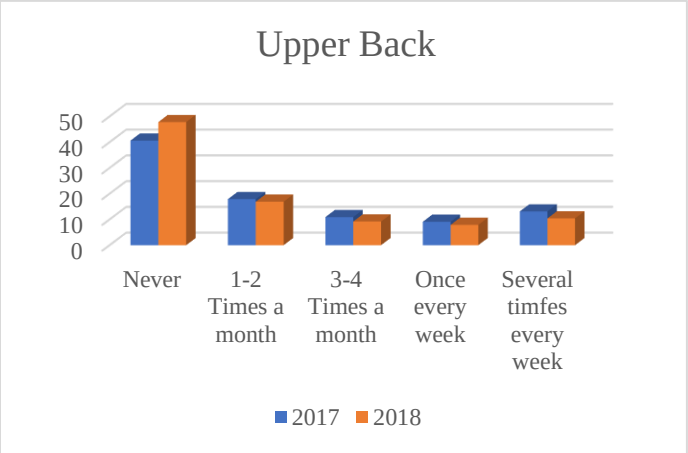
This is to confirm that Ryan Meyer will assist us in conducting the second part of the Wits Comfort Study for our 5 star green rating 1 Discovery Place.

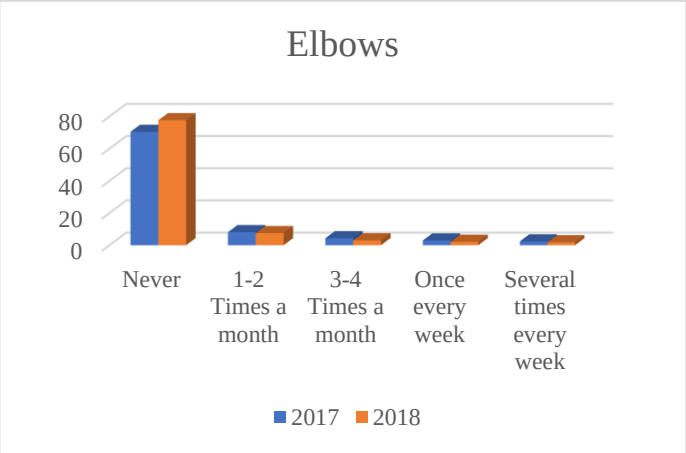
Yours sincerely

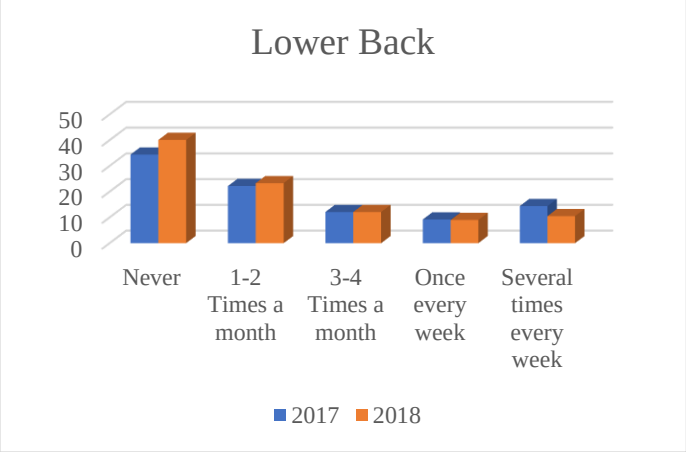
David Pierre-Eugene
Head : Group Facilities

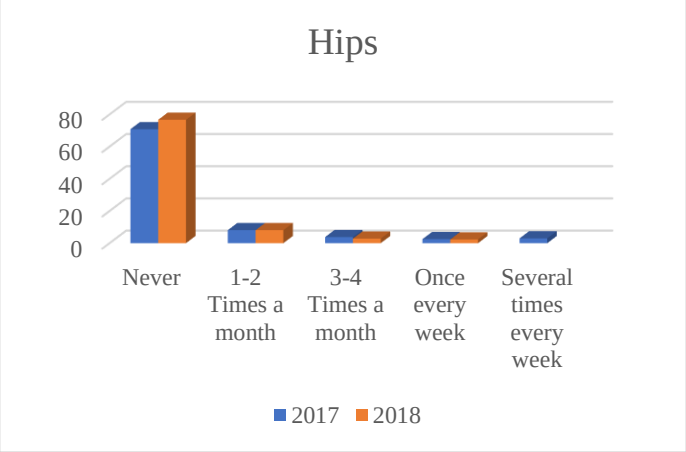
1 Discovery Place, Sandton, PO Box 786722, Sandton 2146 | Tel (011) 529 2888 (Switchboard) | Fax (011) 539 5503 | www.discovery.co.za

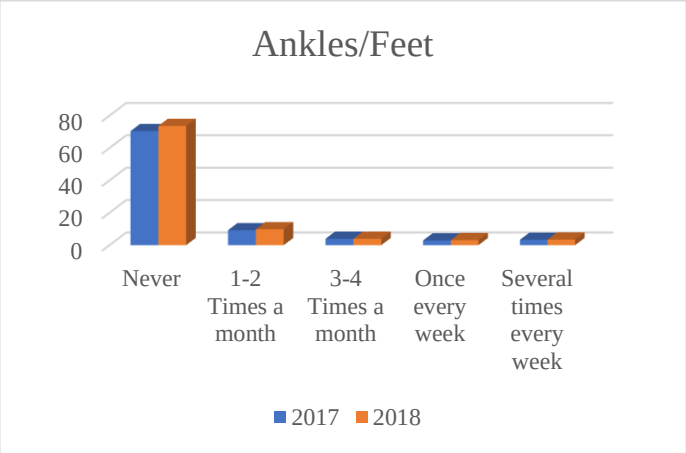
Appendix D: NMQE Graphs

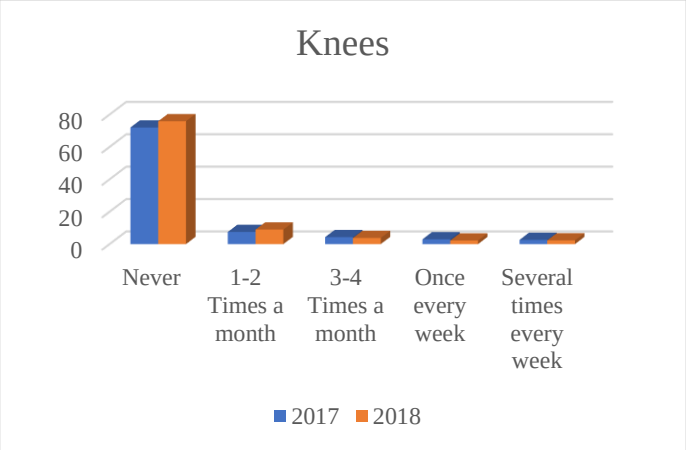


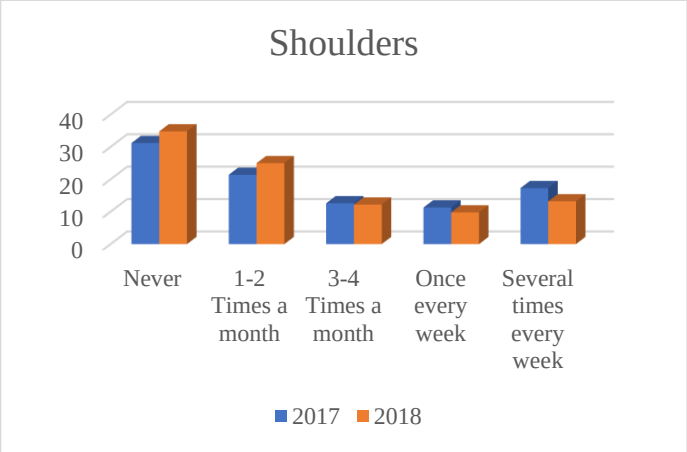











Shoulders
40
30
20
10
0
Never
1-2 Times a month
3-4 Times a month
Once every week
Several times every week
2017
2018

Appendix E: Supervisor Contract

16. STATEMENT OF PRINCIPLES FOR POSTGRADUATE SUPERVISION

IN A CONTEXT OF ACADEMIC FREEDOM AND WITHIN A FRAMEWORK OF INDIVIDUAL AUTONOMY AND THE PURSUIT OF KNOWLEDGE THIS AGREEMENT IS WRITTEN IN THE BELIEF THAT THERE IS A RECIPROCAL RELATIONSHIP AND MUTUAL ACCOUNTABILITY BETWEEN SUPERVISOR AND STUDENT.

THE SUPERVISOR AND THE STUDENT:

1. Will establish agreed roles and clear processes to be maintained by both parties. In the case of joint supervision everyone's role needs to be clarified.
2. Will meet regularly and as frequently as is reasonable to ensure steady progress towards the completion of the proposal, research report, or dissertation or thesis. This time varies but the normal minimum requirement for face-to- face contact, spread across each year of registration is: 10 contact hours for an Honours project, 15 contact hours for a Masters by research report and 24 contact hours for a Masters by dissertation and a PhD.
3. Will keep appointments, be punctual and respond timeously to messages.
4. Will keep one another informed of any planned vacations or absences as well as changes in his or her personal circumstances that might impact on the work schedule. Unplanned absences or delays should be discussed as soon as possible and arrangements should be made to catch up lost time.
5. Will ensure that research on animal or human subjects is conducted according to the procedures and the requirements of the relevant University Ethics committee.
6. Will together complete progress reports on the research project, as requested by each Faculty Graduate Studies Committee.

THE SUPERVISOR:

1. Undertakes to provide guidance for the student's research project in relation to the design and scope of the project, the relevant literature and information sources, research methods and techniques and methods of data analysis.
2. Has a responsibility to be accessible to the student.
3. Will be prepared for meetings with the student. This includes being up-to-date on the latest work in his/her area of expertise.
4. Will expect written work as jointly agreed, and will return that work with constructive criticism within a timeframe (a suggestion of 2-4 weeks) jointly agreed at the outset of the research.
5. Will provide advice that can help the student to improve his/her writing. This may include referrals for language training and academic writing. The supervisor will provide guidance on technical aspects of writing such as referencing as well as on discipline specific requirements. Detailed correction of drafts and instruction in aspects of language and style are not the responsibility of the supervisor.
6. Will support the student in the production of a research report, dissertation or thesis. Provision should be allowed for adequate, mutually respectful, discussion around recommendations made.
7. Will assist with the construction of a written time schedule which outlines the expected completion dates of successive stages of the work.
8. Will ensure the student has the opportunity to present work at postgraduate/ staff seminars/national/international conferences as appropriate.
9. Will assist with the publication of research articles as appropriate.
10. Will discuss the ownership of research conducted by the student in accordance with the University guidelines and rules on intellectual property, co-authorship and copyright.
11. Will ensure that the research is conducted in accordance with the University's policy on plagiarism.
12. Will ensure that the student is made aware in writing of the inadequacy of progress and/or of any work where the standard is below par. Acceptability will be according to criteria previously supplied to the student.
13. Has a duty to refuse to allow the submission of sub-standard work for examination, regardless of the circumstances. If the student chooses to submit without the consent of the supervisor, then this should be clearly recorded and the appropriate procedures followed.

THE STUDENT:

1. Undertakes to work independently under the guidance of the supervisor. This includes reading widely to ensure that the literature pertinent to his/her chosen topic has been identified and consulted.
2. Is obliged to make appointments to see the supervisor and will arrange meeting times well in advance.
3. Will think carefully about how to derive maximum benefit from these contact sessions by planning what he/she wants in these sessions.
4. Should submit written work for discussion with the supervisor well in advance of a scheduled meeting. The kind and frequency of written work should be agreed with the supervisor at the outset of the research.
5. Undertakes to submit written work that is relatively free of basic spelling mistakes, incorrect punctuation and grammatical errors. Responsibility for the accuracy of language, the overall structure and coherence of the final research report, dissertation or thesis rests with the student.
6. Undertakes to heed the advice given by the supervisor and to engage in discussion around suggestions made. Ultimately the student has to take responsibility for the quality and presentation of the work.
7. Should strive, within reasonable bounds, to maintain a focus on his/her research area and to work within the agreed time schedule.
8. Will prepare material for presentations at seminars and conferences.
9. Undertakes to submit papers for publication.
10. Agrees to honour agreements about ownership of the research and in accordance with the University's guidelines and rules in relation to co-authorship, copyright and intellectual property.
11. Will ensure that the work contains no instances of plagiarism and that all citations are properly referenced and that the list of references is accurate, complete and consistent.
12. Agrees to work in accordance with the criteria of acceptability as supplied by the supervisor.
13. Undertakes not to place the supervisor under undue pressure to submit work for examination until the supervisor is satisfied that it has reached an acceptable level of quality.

I confirm that I have read and understood this statement and agree to be guided by its principles

Name of student: Ryan E Meyer
Student's signature:
Name of Supervisor: Prof A Thatcher
Supervisor's signature:
Name of Co-Supervisor:
Co-Supervisor's signature:
The broad area of study is: Employee Health & Wellbeing
Provisional submission date is: 8/5/2018
Degree: MA Org Psych
School: HCD
Faculty: Humanities.
Date: 04/05/2018

Specific agreements pertaining to: ownership and joint publication, funding, etc. may be attached and signed.

GRIEVANCE PROCEDURES. It should be acknowledged that during the course of the research, both students and supervisors can feel aggrieved. In this event, matters should be dealt with as swiftly as possible by the parties involved and, if necessary, the appropriate Postgraduate Coordinators and Committees. There is, in addition, a University Grievance Policy to help guide deliberations. It is available on www.wits.ac.za/prospective/postgraduate.