Responsibility for good office air quality: hinging on awareness?

An exploration of stakeholder perceptions of air quality in Rotterdam offices and assignment of responsibility in its attainment

Master Thesis

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Preface

The MSc. in Global Business & Sustainability had a profound effect on my understanding of business, society and the environment and the interconnectedness between each. Being able to write a thesis stretching across these dimensions was a hugely challenging but ultimately rewarding experience. Thankfully, I had a number of people and systems of support orbiting around me that made it all possible.

The Happy City Lab, and everyone involved, receive my thanks for the sparking of ideas, the creative discussions and the leveraging of their contacts.

Thank you to my thesis supervisor, Lucas Meijs, for his openness to my ideas and endlessly interesting discussions. Thank you also to my co-reader Alexander Maas, who played a big hand in both getting me off the mark methodologically and seeing me through to the end.

To all my participants who gave up time to sit down with me: thank you

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To my fiancé – there is no one else I would rather have at my side in the face of challenge.

Executive Summary

The air inside a building can be up to five times more polluted than outdoor air (Wallace et al., 1986). Modern European citizens spend an inordinate amount of time indoors, including the office. Literature shows that occupants are exposed to health risks ranging from headaches to cardiovascular disease (Bell et al., 2009; Jones, 1999; Koistinen et al., 2008; RCP, 2016). Occupants perceive IAQ to affect comfort, in temperature, humidity and ventilation (Huizenga et al., 2006; Bluyssen, 2009; Sakellaris et al., 2016). Contemporary literature has exposed the economic benefits of improved air quality on absenteeism and productivity (Allen, 2016; Chang et al., 2016; MacNaughton et al., 2015). Despite the risks and benefits associated with IAQ, research in office environments is limited. Responsibility is conceived to be an important component in achieving good IAQ but research on responsibility for attaining and maintaining good IAQ is sorely lacking. This pilot study sets out to explore this field to upturn new insights or theoretical directions and catalyse derivative research in this underexplored field. Multiple stakeholders in office buildings are identified as a route to uncover holistic perceptions of IAQ and responsibility.

The study uses Rotterdam as the setting for the research. Key stakeholders in office air quality were identified in the context of the Netherlands. As an exploratory piece of research, grounded theory was selected as the methodological tool to gather and process data. Semi-structured interviews were held in Rotterdam with participants from key stakeholder groups to gather data, which was analysed using a constructivist grounded theory approach to produce theoretical categories and concepts.

Analysis of data elucidated the views of stakeholders on responsibility for IAQ in office environments. Comfort was of far greater significant to occupants than health concerns, with openable windows at centre of needs, conflicting with building manager concerns of cost, related to energy efficiency (Torcellini et al., 2006). Multiple regulations and bodies with interrelated effects put constraints on building managers and architects in understanding responsibility and making decisions that affect IAQ.

The perceptions of multiple stakeholders invoked theories around a relationship between awareness, the availability of IAQ information in the hands of stakeholders and responsibility, postulating that responsibility for good office air quality hinges on awareness. Responsibility was also shown to be contextual and fluid, for example differing between the design processes and existing buildings.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CO_2	Carbon Dioxide
CSR	Corporate Social Responsibility
EEA	European Environment Agency
EU	European Union
EC	European Commission
GT	Grounded Theory
HVAC	Heating, Ventilation and Air-Conditioning
HR	Human Resources
IAQ	Indoor Air Quality
IEQ	Indoor Environment Quality
NGO	Non-governmental Organisation
NO_2	Nitrogen Dioxide
PM	Particulate Matter
SDG	Sustainable Development Goal
USD	United States Dollars
WHO	World Health Organisation

Chapter 1. Introduction

Clean air is a prerequisite to the health and wellbeing of humans and the planet they inhabit, yet poor air quality persists across the globe. Poor air quality is not limited to the developing world; many cities in Europe exceed WHO Air Quality Guidelines, suffering economic consequences of lost productivity and health consequences of reduced inhabitant lifespans (EEA, 2016). The European Commission (EC) has identified "improving air quality" as one of three main challenges facing the Netherland's environmental law and policy (2017, p.4). The issuance of this goal can be connected to a substandard record on air quality. In 2011, Rotterdam severely transgressed per capita greenhouse gas emission limits, attributed to its port and related industry (Hoornweg et al., 2011). In 2015, the Dutch air quality NGO *Milieudefensie* reported that EU standards for NO2 were exceeded in 11 locations across the country, including Rotterdam (2015). This is a cause for concern but one that does receive increasing media coverage and government policy attention.

More disconcerting however, is the statistic that many European citizens spend approximately 90% of their life inside homes, schools, offices, supermarkets, restaurants and other indoor locales (Jantunen et al., 2011; Carrer et al., 2008). This figure is amplified in significance alongside a much-cited statistic from the United States' Environmental Protection Agency that indoor air pollution is between two to five times higher than outdoor air pollution (Wallace et al., 1986), replicated in contemporary studies on, for example, concentrations of Volatile Organic Compounds (VOCs) within buildings (Kotzias et al., 2004). Thus, healthy indoor air, a basic human right, presents itself as a thought-provoking field of research (WHO, 2000).

Given its air pollution track record and its accessibility as a research setting, Rotterdam is a worthy setting for research on indoor air quality (IAQ). The Dutch government has acted to change IAQ in schools with the provision of CO2 sensors in classrooms. This follows the publication of a report critical of the air quality in Dutch schools (IAQ Expert, Interview, 21 June 2017; Kotzias et al., 2004). But little regulatory progress has been made in offices (Hasselaar & Morawska, 2003). Why not? Perhaps occupants or organisations are not aware of the risks of poor air quality or the benefits of good air quality, suppressing any discourse. Or perhaps flexibility and responsibility is purposefully passed to market forces.

The long-term health impacts of IAQ are well covered in literature (Koistinen et al., 2008; RCP, 2016; SCHER, 2007). As to the benefits, a growing segment of literature has identified a causal relationship between air quality and productivity, representing a business case for optimal IAQ in occupational settings (Allen et al., 2016; Chang, Zivin, Gross, & Neidell, 2016). Fulfilling occupant needs is an important part of building design, of which IAQ is one component. The limited perception research of IAQ in offices has shown a fair degree at dissatisfaction with the

air quality alongside limited occupant awareness of the risks and benefits (Bluyssen et al., 1996; Hamilton et al., 2016). Given sensory limitations, perceptions of IAQ are only one fragment of effectuating good air quality in offices. To achieve and maintain good IAQ in the office requires those accountable to live up to, and be held up to, their responsibilities. But, office settings are complex. Buildings may be owned, managed, maintained and leased by different organisations. Multiple organisations may lease offices within one building. The number of pollutant sources is many. Ownership and control does not lie firmly with the government but with a multitude of stakeholders, who may share responsibilities (US EPA, 1997). In this complex picture it is valuable to gain an understanding of how responsibility is shared or how it is seen to be assigned. Given the lack of attention IAQ responsibility has received and the complexity deriving from the range of stakeholders, the stakeholders themselves are proposed as a route to explore the topic of responsibility. This hitherto largely ignored branch of research is the focal point of this paper. This research thusly sets out to explore the perceptions of IAQ in offices among multiple stakeholders of the office setting and whom they see as responsible for attaining and maintaining good air quality. As a relatively novel line of research, I assume an exploratory approach, pursuing interrelated lines of enquiry as they appear.

In the following sections, further context about the legal and regulatory mechanisms that apply in the Netherlands and the relevance of the topic in academic, managerial and other fields is provided.

1.1 Rotterdam Context – Governance and Regulations

Rotterdam is selected as the focal location of this research. To provide minimal context, Rotterdam is a city in the region of South Holland in the Netherlands. Its population as of January 2017 is 629,606 (CBS, 2017). The city has a strong industrial heritage from its petro-chemical sector and still operates one of the largest container ports in the world.

As the research focus is on responsibility, the legal context is deemed valuable in ascertaining the coverage provided by the law and understanding where responsibility legally lies. Reflecting in detail on Dutch standards, how they are measured and what is excluded requires its own research paper. What this section provides is a broad overview of the regulatory environment applicable to offices in Rotterdam, the sources of regulations from EU to municipality level and what they address.

The EU, following recommendations of its own scientists alongside those of the international science community, has been setting emissions standards and guidelines since the 1970s. The Netherlands, as an EU member state, is required to achieve a set of mandatory and universal air quality standards with yearly exposure limits per person. It is also encouraged to adopt

recommended policies and non-mandatory IAQ standards issued by the European Committee for Standardization. Related is the attainment of outdoor air quality standards, building standards, energy performance requirements, emissions limits and regulations on chemicals, toxins, building materials and any other items that may influence office air quality.

In the Netherlands, several government bodies are nodes within the air quality regulatory environment. However, government bodies on indoor air quality, and in particular office air quality, are not immediately identifiable, having no dedicated department. The Dutch National Institute for Health and Environment (in Dutch: *Rijksinstituut voor Volksgezondheid en Milieu*) sets out regulations as to the maximum permissible presence of/human exposure to selected air contaminants per year, as derived from EU directives such as Air Quality Directive 2008/EC/50 - for example, the ceiling for PM2.5 is set at 25 μg/m^3, and the legislation contains a provision for meeting the WHO guideline of 10 μg/m^3 by 2030 (EU, 2008)[1]. However, regulations do not cover the full spectrum of air contaminants and can in cases be far removed from WHO and other guidelines.

Three sources exist for indoor air regulations in the workplace in Netherlands: one universal, applying to all employees, and two contextual, depending on occupation, employee contracts and office building age. The Working Conditions Decree (in Dutch: *Arbeidsomstandighedensbesluit*) is a universal code that addresses indoor air components including minimum ventilation rates[2] and pollutant limits, including asbestos and benzene (from nearby parking lots/streets) but does not comprehensively address all compounds, heavy metals or gases. For example, it is apparent from speaking with a Dutch IAQ expert that rules pertaining to office equipment, materials and furnishings are few and far between (IAQ Expert, Interview, 21 June 2017). Additionally, regulations depend upon the age and character of the building. For example, many pre-war buildings still standing in Rotterdam are categorised as monuments, a grading that denotes a building of cultural or heritage value. Such buildings are not subject to the same requirements as new buildings. The emphasis is instead on maintaining the aesthetics (Architect A, Interview, 26 May 2017). Further, the regulations can "stretch" or be "movable" (Architect B, Interview, 6 June 2017).

This links to the second source – building codes (in Dutch: *Bouwbesluit*) - which impose regulations on such IAQ factors as ventilation and pollution levels. It is in accordance with these codes that new buildings are constructed. However, existing buildings appear to be in most aspects exempt from the latest building codes, with IAQ recommendations given rather than mandatory codes (Kunkel et al., 2017). Due to the extensive range of codes that buildings

[1] Particulate Matter (PM) is a common air pollutant type. The number affixed, in this case 2.5, refers to particle size, with a particles of 2.5 micrograms classified as 'fine' in granularity.
[2] Ventilation rates: as per the building codes, buildings must provide 30 m^3 / hour of fresh air per person undertaking light physically demanding work.

must comply to, a number of trade-offs exist in decision-making about construction design, materials, technical installations and upgrades. The two that stand out are fire requirements and energy efficiency. Understanding of trade-offs is up to the understanding and knowledge of the involved parties, as requirements and recommendations laid out do not give consideration towards interactions with other building factors such as air quality (ibid).

One development that is gaining ground in the Netherlands and that may facilitate a transition to greater focus on occupant health and wellbeing is building standards and certifications, such as Leadership in Energy and Environmental Design (LEED), BRE Environmental Assessment Method (BREEAM) and the WELL Building Standard (WELL). All of these standards acknowledge the importance of occupant health and wellbeing alongside energy efficiency and environmental considerations.

The third source is working conditions terms set out in collective contracts administered by industries and unions, meaning a company must be signed up to collective contract agreements in order for collective contract terms to apply to employees. One drawback is that employees should be knowledgeable about the details of their collective contracts in order to understand their rights. These three sources and the regulations they contain relating to air quality in the office environment are shown in Appendix A: Dutch Legislation on Air Quality.

None of the sources mentioned herein clearly stipulate overarching responsibility for the provision of healthy office air in the Netherlands. However, the sources do provide an indication of responsibility at various levels: the government for its setting of regulations in line with EU directives and building codes, stakeholders in the building process that are responsible for meeting building codes, and employers for providing the conditions stated in its employment contracts, among other considerations.

The Centre for Environment Quality (in Dutch: Het Centrum Milieukwaliteit), an institute belonging to The National Institute for Health and Environment, “did indoor air quality studies in the past” according to one of their civil servants but the department has since been closed due to budget cuts (MIL, email correspondence, 9 June 2017). In Rotterdam, knowledge about indoor air quality is held at municipality level at the GGD Rotterdam-Rijnmond, which hosts a Health & Environment department responsible in this area. Studies into IAQ are done in collaboration with or outsourced to consultancies such as BBA Indoor Environmental Consultancy, who “focus on healthy buildings” (BBA, email correspondence, 2017). However, this team is geared towards public health, not occupational health.

The municipality manages enforcement of indoor air quality regulations in commercial buildings. This appears to be limited to requesting maintenance logs and logs related to the inspection of technical installations and ventilation equipment (Building Manager, Interview,

19 June 2017). Given that logs focus more on the reliable operation and maintenance of equipment than detailed air quality reports, a straightforward assumption to make is that a portion of responsibility lies with the EU in its drafting of Machinery Directives. Or from a CSR perspective, with the manufacturer, to ensure its equipment is optimal for the health of users. Then again, if the responsibility is market driven then perhaps it also lies with the vendors or building managers.

Lastly, air quality is further influenced by NGOs and social actors, such as Longfronds (a Lung Foundation) that promote better air quality and lobby for improved regulations. This network of regulatory control and influence as I envisage it, from the legislation set by the EU down to companies, is shown in Figure 1 below.

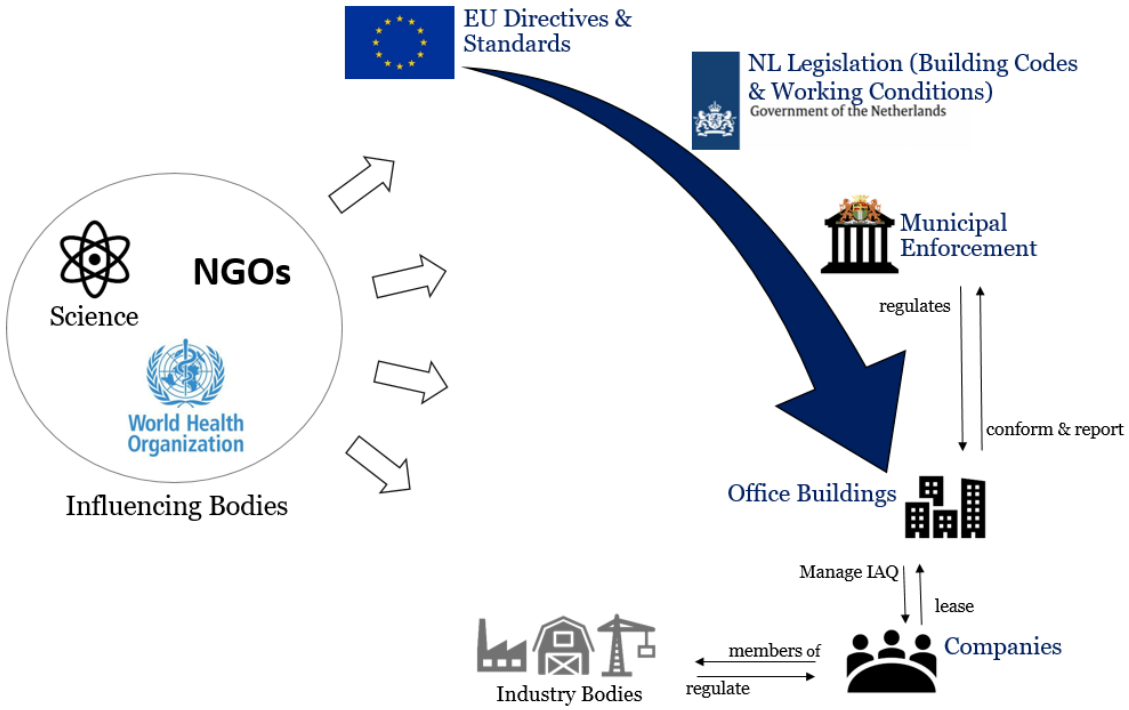

Figure 1: Regulatory Environment in Rotterdam, Netherlands (Source: this research)

1.2 Stakeholders

This paper takes a multiple-stakeholder perspective towards the research topic, a decision justified in Chapter 3 as the best approach to explore narratives around office air quality and responsibility. The review of the regulatory environment in the Netherlands, along with initial conversations held with an office user and an architect, contributed to the compilation of an onion diagram of stakeholders, shown below in Figure 2. This was developed using the office as the central point and identifying stakeholders in layers as according to their direct relation to the office space. This is a simplified and generalised mapping given that stakeholders depend much on the company, the office space it rents and the building it's housed within.

Figure 2: Stakeholder onion diagram of office IAQ stakeholders (Source: this research)

This issued a short list of key stakeholders, who form the focus of the research:

- Office users, who use the space and report any issues
    - Including vulnerable groups such as asthma sufferers
- Managers, who make decisions about office location, environment and employee wellbeing
- Building managers, who manage the building environment, maintenance and occupant complaints
- Building owners, who make financial and longer term decisions
- Architects who design the building and office space, and who subcontract air quality engineers
- Air Quality and Ventilation Engineers, who install equipment and ensure equipment meets regulations
- Equipment manufacturers, who design equipment according to market / regulatory requirements
- Rotterdam municipality, who make local policy and enforce regulations, and its
    - Planning permission office and its aesthetic board, who create conditions for building construction and approve decisions on equipment that can affect appearance
- Dutch government, who set national laws, regulations and policy about buildings and working condition
- EU, who set directives and guidelines on air quality
- Air quality experts, who conduct research and give advice about indoor air

1.3 Research Objectives

The research aims in the first place to study the perceptions that multiple key stakeholders have of clean air in the office, in the role of a pilot study. An array of questions is thrown up by the initial look at the topic such as: Do occupants have knowledge about IAQ and is it important? What are the concerns and experiences of other key stakeholders? Who is responsible for clean air in offices? The objectives of the research are to follow the paths of these questions and ground theory in this field. In doing so, this paper aims to set the way for more comprehensive studies in this field, to build on the methods used and to test or develop the emergent theoretical concepts. Recommendations emanating from the cross-analysis of perceptions that are developed may be used as a basis on which to develop policy or shape corporate approaches to employee wellbeing.

1.4 Relevance

Environmental

Air quality and its impacts reveals implications for the trifecta of people, profit, and planet; dimensions which must all be respected to achieve sustainability (Elkington, 1994). At a planetary level, poor air quality can be viewed both as a cause and a symptom of climate change; as emissions of CO_2, NO_2 and Methane increase, the worse the air quality becomes (Prather et al., 2003; Dentener et al., 2006). Simultaneously, air quality's sensitivity to climate change means it is affected by climate-induced weather changes (Jacob & Winner, 2009). Further, certain building materials have been shown to emit contaminants that, over time, can be damaging not just for occupants, but for the atmosphere as a whole (Wallace et al., 1987; Bribián et al, 2011). Therefore, as net emitters of pollutants, it could be argued that there is a moral responsibility on buildings to emit used air in a cleaner state than it was when it was drawn in. Stakeholder views on environmental impacts and related responsibility could have an effect on future responsibility assignment.

Managerial

Poor air quality has a measureable economic impact, backed up by of authoritative estimates by the US EPA, the World Bank and IHME, the WHO (2011; 2016; 2015). Reports by the European Commission estimate that absences due to air related sickness cost Dutch companies €584 million per year (2017). Flipping the perspective, good air quality in offices has benefits on productivity and reduced absences (Williams, 2016). Reports on this topic have not gone unnoticed in the business community, particularly in cities with notoriously poor air quality, leading global companies like Siemens to introduce clean air initiatives in their offices (Siemens, 2017, April 12). In this paper's search for understanding IAQ responsibility in office settings, stakeholder perceptions may reveal whether managers and organisations should be

more proactive in promoting good office IAQ. It may also supply indicators of whether some responsibility lies with HR departments.

Public awareness and dissatisfaction at air quality, particularly in cities, has arguably created a gap in the triangular relationship between business, society, and government (van Tulder & van Der Zwart, 2005) that can be exploited by private intervention. Emerging in the 1990s, a business argument for proactive attitudes towards environmental concerns has come to the fore. The economic argument rests on a variety of factors but essentially boils down to two main aspects: exploiting opportunities to increase revenue and exploiting opportunities to reduce cost, while reducing environmental impact (Stefan & Paul, 2008). Already, building standards such as WELL have come to the fore and are used as a marketing tool by property developers. Opportunities also exist for other IAQ solutions such as sensors and filters. Understanding stakeholder perceptions of IAQ and importance attributed to it may indicate market readiness or acceptance for further market-based solutions and innovations. Or should users simply have good air, without having to resort to market solutions?

Academic

According to Hasselaar & Morawska, indoor air has become a major topic of research but, simultaneously, progress has been limited, *"particularly in residential and non-industrial environments like offices"* (2003; p3). Applying the filter of stakeholder perceptions narrows the scope of existing research further. Multi-country research into user perceptions of and satisfaction with air quality found that 67% were satisfied with the quality of air in their office buildings (Huizenga et al., 2006). However, this research still leaves a question over awareness of health impacts, how that might change perceptions and who responsibility lies with, with an assumption that this will be a growing issue. On this front, this paper hopes to embark down new paths of research. Any exploration or new theoretical concepts in this limited band of research will help to develop and broaden the field.

A prediction that I received from an indoor air expert was that the framing of air quality on health will *"change from outdoor air quality (measured in ppm) to outdoor and indoor personal exposure"* (Royal Haskoning DHV, email correspondence, 4 July 2017). If this prophecy were to come true it would shift the general approach on air quality and pollution to one that better balances indoor and outdoor attention. If the future emphasizes indoor air quality and exposures more than it does now, this research would come to have greater academic salience.

Societal

In terms of health and human development, air pollution is the "fourth-largest threat to human health, behind high blood pressure, dietary risks, and smoking" (IEA, 2016, p13). As Bickerstaff

and Walker opine, there is a realisation that clean air is a social issue and, as such, requires a more inclusive, sustainable approach to address it (2001). Thus, it is to be expected that there exists considerable societal awareness and personal investment in the topic. This research aims to establish if there is an appropriate amount of awareness amongst office stakeholders. Moving toward responsibility, the use of multiple key stakeholders can identify where society as a whole does, and should, assign responsibility in the issue of office IAQ. This research, in its comparison of different stakeholder perspectives, identification of interests and conflicts and its identification of relationships between stakeholders, aims to provide an understanding of how society can address office air quality in a positive manner.

1.5 Research Structure

This paper is structured as follows. Following this introduction to the research issue and the field this research aims to explore, Chapter 2 confronts the extant publications and theory on indoor air quality and topics stemming from the sources that emerged during the research process. The literature review is followed by the research design in Chapter 3. In this chapter, research methodology choices are described and justified. Chapter 4 lays out the results of the data collection. In Chapter 5 the results are discussed, interpreted and spun out into various interpretations and narratives. The final chapter, Chapter 6, address the limitations of this paper and suggests future avenues of research.

Chapter 2. Literature Review

2.1 IAQ Definition, Pollutant Sources and Effects

A review of extant documents and scientific literature is presented in this chapter. It may be of relevance to note that much of the literature was identified and reviewed concurrently with the data collection and analysis process as new areas emerged, as befits a constructivist grounded theory approach as detailed in Chapter 3 (Charmaz, 2006). Following this approach, I limited my initial exposure to the full gamut of literature in order not to be overly influenced by pre-existing concepts and theories in the hope that these will be drawn out more naturally from the data. However, as it was necessary to have a basic grasp of indoor air quality, its causes and effects and so forth to be able to earn the respects of participants and proficiently conduct interviews, background literature was viewed at the initial stages (Saunders, Lewis, & Thornhill, 2008). This approach is supported by McGhee et al. who argue that this should not impose any constraints on the possibility of grounded theory emerging and has brings into play the opportunity for reflexivity (2007). Further literature was expounded upon following interactions with participants that revealed further avenues of research. As this research is not a scientific analysis of concentration levels of certain pollutants, or a risk analysis, such detailed publications are excluded from this review, being surplus to requirements.

Indoor air is a complex field because of the number of variables which differ among geography, climate, cultural habits, building types and working life, and population sensitivity among others (SCHER, 2006). It is also a relatively narrow field, with one dominant journal, "Indoor Air". Yet there is a growing body of literature around it. It overlaps with the fields of indoor environment quality (IEQ), with studies of indoor air within IEQ studies cropping up in "Building and Environment" or "Indoor Environment" journals, as well as in epidemiology journals. Building designers categorise IAQ within Indoor Environment Quality (IEQ), which consists of the thermal environment[3], lighting, acoustics, air quality and vistas, among other factors (EC, 2017; Bluyssen et al., 2013). A study of employee satisfaction in office spaces across Europe along IEQ dimensions found air quality to be ranked lowest in satisfaction (Sakellaris et al., 2016). This confirms the importance of IAQ in offices as an issue, giving reason to understand views on air quality of stakeholders beyond only employees. If office workers see air quality as poor, what then does the literature constitute as good indoor air quality? Nathanson provides a definition of air quality oriented to the workplace: *"the physical, chemical, and biological characteristics of indoor air in non-residential workplaces with no internal industrial processes or operations that can affect the comfort or health of the occupant"* (1993, p.5). Good air quality is defined by Hasselaar and Morawska as air that

[3] The thermal environment appears both in IAQ and IEQ categorisations.

contains *"low concentrations of pollutants that are detrimental to human health and wellbeing"* (2003, p.2). Thus, indoor air quality is irrevocably connected to the health and comfort of air occupants, not just the level of contamination. To extrapolate one level, it may be posited that good indoor air quality may have the added condition of at least doing no harm to the comfort or health of any occupants. From an organisational perspective, this could be said to be an *inactive* stance, focusing on doing no harm rather than maximising good (van Tulder et al., 2014).

The literature on the technical aspects of indoor air quality: characteristics, emission sources, pollutants and measurement is extensive. Sources of airborne contaminants inside a building typically can be traced to the human occupants, the building materials and furnishing and equipment. (EC, 2017; Fanger et al., 2000; Hasselaar & Morawska, 2003; Jones, 1999; Koponen et al., 2001; Wallace et al., 1987; Wargocki et al., 1999; Wargocki et al., 2000). Outdoor air can be a major contributor to indoor pollutants (Bluyssen et al., 2003; Jenkins et al., 1992; Klepeis et al., 2001; Koistinen et al., 2008; SCHER, 2007; Seppänen, Fisk, & Mendell, 1999). Where mechanical ventilation is used, that can also be a source of office pollution if not installed or maintained properly (EC, 2017). The pollutants at play in the office environment commonly include volatile organic compounds (VOCs) such as benzene and formaldehyde, particulate matter, as well as concentrations of gases such as carbon monoxide, sulfur dioxide, nitrogen and radon (Bernstein et al., 2008; EC, 2017; Koistinen et al., 2008, Kotzias et al., 2004; Salthammer, 1999; SCHER, 2007; WHO, 2006). In the workplace, employees that suffer from allergies or have certain sensitivities are more susceptible to negative health impacts from poor air quality (HEI, 1995). Thus, office workers who suffer from allergies may have different requirements of indoor air quality than non-allergy sufferers and may even view its importance in a different way. It also raises a question of how much consideration allergy sufferers are given in air quality decisions. Do other users, managers, building owners and equipment manufacturers give enough weight to allergy sufferers and other susceptible groups?

Health effects of indoor pollutants extend far beyond allergies. There is widespread recognition of the connection between air pollution and increased rates of "*hospital admissions and deaths from cardiovascular diseases, respiratory diseases and lung cancer*" (RCP, 2016, p.iv,; Bell et al., 2009; Jones, 1999; Koistinen et al., 2008; Meijer et al., 2002; Spengler and Samet, 1991; SCHER, 2007; US EPA 1997). Fisk (1999), in a broad review of IAQ health impact literature, found a moderate to strong evidence of indoor environment influences on health effects, such as respiratory effects, allergies, irritative concerns and even carcinogenic effects. In general, modern EU citizens spend the vast majority of their lives inside, in schools, shops, restaurants, offices and other buildings (Carrer et al., 2008; Clayton et al., 1993; Hänninen et al., 2003; Jantunen et al., 2011). With an average working week of over 34 hours and an unemployment

rate of 6.1% as of May 2017 in the Netherlands, the office represents a significant proportion of sunk time for adults of working age (CBS, 2017). The amount of time that people spend in the office, one of the driving forces for selecting this line of research, means that the type of negative health impact suffered is likely to be chronic illness related to long-term exposure to low dosages of air contaminants (Bernstein et al., 2008; EEA, 2016). Long-term exposure to chemical components of PM2.5 has been directly and causally linked to an increased risk of hospitalization and mortality from cancerous, cardiovascular and respiratory diseases (Peng et al., 2009). The long-term nature of health impacts in the workplace poses challenges not only for the linkage between cause and effect but also on the assignment of responsibility. A weighty ethical question hangs in the air: is the minimum satisfactory level acceptable or should optimal air quality for all be prioritised?

Commonly recurring in the literature is the importance of ventilation. The SCHER report and Hasselaar, who frames ventilation as *"the cornerstone of healthy indoor air"* (2007; p.17, 2002), emphasize the importance of ventilation. Improving ventilation is also an economically viable option, as the health benefits that can be gained outweigh the amount it would cost a company per-person (MacNaughton et al., 2015). Jaakkola, Heinoneon and Seppänen concluded in their study that no ill effects or higher incidence of symptom reporting can be traced to mechanical ventilation (1991). Conversely, poor ventilation leads to a higher number of health complaints (Seppänen et al., 1999). This does not account for all HVAC system types in all conditions and presumably requires the responsibility of the maintenance team or owner to keep systems running cleanly and efficiently. And perhaps requires the responsibility of government in installing and enforcing appropriate ventilation and maintenance regulations. Additionally, the source of the air may play an important role, with responsibility on engineers to place the intake in the best location or insist on high quality filters.

It has also been suggested that ventilation systems in buildings, in place of openable windows, could protect people from ambient particles (Janssen et al., 1982; Seppänen & Fisk, 2002). Thus, sealed building envelopes may be important in building design (Hänninen et al 2004). Where windows are openable, is there a responsibility on occupants to understand the levels of indoor and outdoor pollution levels before exposing entire offices to health risks? It could be argued that designers of buildings are responsible for ensuring sealed building envelope while outdoor air pollution is unsatisfactory. Design is also an important consideration in the recent drive by owners to achieve efficiency through building energy savings, which has led to tighter indoor environment control, reducing 'leakage'. The rebound effect of this are air throughput reductions and deterioration of indoor air quality (Hasselaar & Morawska, 2003). Therefore, building design presents a tricky balancing act for designers and HVAC engineers and arguably puts an onus on decision makers to consider any potential trade-off between

energy efficiency and air quality. Much research has been conducted on occupant comfort and the conjoining topic of building design which has a strong modifying effect (see Bluyssen et al, 2011; Frontczak & Wargocki, 2011; Frontczak et al., 2012; Humphreys, 2005; Zalejska-Jonsson et al., 2013); hence the need to recognise building designers and ventilation specialists as stakeholders.

2.2 IAQ Perception Studies

Occupant comfort can be affected by humidity, temperature, smell and ventilation, all within the IAQ domain (Huizenga et al., 2006; Bluyssen, 2009; Olesen, 2005; Sakellaris et al., 2016). While occupant discomfort may not necessarily indicate any health issues, the two are closely related (Fanger, 2000). Studies of occupant comfort and wellbeing are often performed using perception methodologies. The majority of perception studies related to IAQ occur in the broader field of IEQ, with aims to identify comfort factors that occupants value the highest (see, for example, Frontczak, 2011; Huizenga et al., 2006; Lai et al., 2007; Pejtersen et al, 2006), with varying results across studies and locations. Bickerstaff and Walker warn that methodologies used in air quality perception research are important as much of the existing literature is prone to *"uncertainties and contradictions"* (2001, p.135), and stress the importance of context, especially given the variance and complex interactions at play across different users, buildings and locations.

Perception studies specifically of office occupants are far less common. A large scale audit of office buildings in Europe, using a rigorous approach of both measurement and perception, evinced the possibility of a gap between user requirements and minimum standards (Bluyssen et al., 1996). Thus, it is important that more than simply measurements to minimum standards are performed in offices but also to comfort requirements. It has also been shown that many occupants are not aware of the benefits of optimal IAQ, for example reduced health risks or productivity improvements (Hamilton, Rackes, Gurian, & Waring, 2016). And when it comes to risk, even where occupants accept that they may be at risk of exposure to contaminated air, they nevertheless are irrationally optimistic in their belief that it will not be themselves that suffer any harm, only others (Wall, 1974; Billingsley, 1974/1975). This is known as an optimism bias. If this were to be commonplace, it may have implications on responsibility. A logical step to make is to assume that if office workers are aware of air quality risks but are reticent to acknowledge that it may harm them personally, they will be less inclined to be vigilant about air quality or raise the alarm about any concerns.

2.3 IAQ Productivity Effects

IAQ has significant economic effects, shown by a number of recent studies in this contemporary field. In the Netherlands, poor IAQ is estimated to cost employers €584 million

per year (EC, 2017). A key driver for businesses to ensure optimal air quality in offices is causal relationships between good air quality and productivity, with recorded increases of between 8% and 11% (Allen, 2016; Chang et al., 2016; MacNaughton et al., 2015; Williams, 2016). On top of output benefits, good air has been shown to lead to a reduction in sickness and related absences, maximising employee utilisation from a management perspective as well as improving health and wellbeing for employees and visitors (Milton et al., 2000; Clausen et al., 2011; MacNaughton et al., 2015).

Therefore, it would be expected that companies or managers would be active in ensuring optimal air quality for employees. It might also be asked whether a business could obtain a competitive advantage from clean air, in the form of productivity gains and employee wellbeing. The point on optimal IAQ as a competitive edge is furthered by Hamilton et al., who postulate that optimising IAQ to acquire health and productivity benefits is also cost-effective (2016). Beyond responsibility for employee wellbeing, it might even be argued that there is a responsibility towards business owners or stakeholders to optimise IAQ.

2.4 IAQ Responsibility

The potential risks and benefits related to indoor air quality are well documented. But who is responsible for deciding the level of air quality and who is responsible for maintaining it? These parties have a real impact on health, comfort and economic factors. A variety of issues around responsibility, some sparked by interviews as part of this research, have been raised in this paper. This section looks at the literature on responsibility for IAQ in more depth.

As well as being a legal question, the issue of responsibility touches on ownership and control: if air is a public good then should the provision and assurance of clean air in urban areas be firmly the responsibility of governments? Or is air in office spaces classed as a private good as soon it enters the building? A public good is widely accepted as having two identifying traits, although these traits differ across authors. Kotchen (2006) and Ostrom and Ostrom (1977) argue that public goods are non-rivalrous and also non-excludable. Reddy (2015) is more nuanced in his framing, citing traits of 'externality' (that bear some non-rivalrous nature) and also 'non-excludability'. As offices are the domain of, often, private companies or spaces to which access is limited, it can be said that indoor air in an office environment is not a public good – segments of society are excluded from its consumption. At the office level this may require a more nuanced view. Outdoor air, the source of ventilation, impacts indoor air quality and is a public good, the domain of the government (Kotchen 2006; Levinson, 2012). Thus, responsibility lies with the government for a clean source of air. If the source of air is not clean, it could be argued that office buildings should be responsible for ensuring that its occupants breathe good air. Such items are open to debate as these sort of issues do not appear explicitly

in regulations. As it stands, the Dutch government leaves much of the responsibility to the market. The WHO is no clearer on the matter, stating that because of the numerous components and influences involved, *"no single profession or authority has full responsibility for healthy indoor air"* (2000, p.2). The report is somewhat abstract is assigning responsibility or providing guidelines to this, mentioning only *"appropriate authorities"* (ibid). Thus, where responsibility should lie is very much open to interpretation.

The few papers that consider the question of IAQ responsibility corroborate this, by way of contrasting opinions. Den Hartog places architects at the highest point of responsibility: "the quality of the indoor climate of buildings is the result of design decisions that architects make" (p.5, 2004). Another academic, Levin, argues that the *"fundamental responsibility (and ability) of architects, engineers, and building operators to create indoor environments that are both habitable and environmentally responsible"* (1993, p.34). Applying ability denotes that those who have direct influence and control of air quality have greater responsibility. This line of thinking is adopted by Roulet et al. who conclude that *"the intentions of the building owner and of the designer have the greatest influence on the quality of the building"* (2006, p.10). Hasselaar and Morawska write about a "*paradigm of individual responsibility*" and place emphasis on the education of people on ventilation measures and how to use air conditioning and other machines (2003, p.7). Without this information and understanding there is a risk of "*conflict between manufacturers and consumers",* with user friendliness not always compatible with IAQ systems (ibid). Thus, the question 'where should responsibility lie?' is very much open.

2.5 Summary

Indoor Air Quality is, as noted, a complex field with many interconnected influences and interactions. It is also a field that has moved forward significantly, particularly with the emergence of private building certifications and the consideration given towards health, wellbeing and air quality. A variety of studies of perceptions have been conducted over the last 30 years. However, studies of perceptions within office environments compose only a fraction of this research. Some literature signifies that occupants may underestimate risks and be unaware of the benefits, additionally throwing up a number of questions and considerations in terms of responsibility. Responsibility in this narrow field is, as predicted, not a line of research that has much in the way of published papers. What does exist leaves questions about responsibility up to interpretation.

Chapter 3. Methodology

The methodological approach employed by this research is defined and explained in depth in this chapter, with explanations and justifications given behind methodological decisions. This begins with a reflection on the author's research paradigm to understand how this underpins the development of the research methodology. The author's acknowledgement of his own philosophical commitment provides the author with a better understanding of the subject of investigation and how best to approach it, and is intended to provide readers with the context on which the research is built and an understanding of assumptions or interpretations that this research makes (Johnson & Clark, 2006).

On the spectrum from positivism (the classic philosophy rooted view of the world deriving from natural science that what you observe is real and generalizable) (Remenyi et al., 1998) to constructivism (the more modern belief that laws are either indefinite or not real and emphasises differences between humans, their roles and their subjective understandings), the author would place himself towards the constructivist end of the scale. From an ontological viewpoint, while individuals have their own perspectives and opinions about good air quality, there is an objective reality when it comes to air pollution and what is deleterious to health, although this reality may not be absolutely understood. From an epistemological viewpoint, it can be argued that the air we breathe and feel on our skin is experienced through the various senses as interpreted by our brains; sensations are attainable but true and direct experience is beyond reach. Here I identify with Bhaskar (1989) in the sense that in order to comprehend phenomena one must understand social structures. Simultaneously, the constructivist concept of social actors is also applicable, in the way that each stakeholder interprets the roles of themselves and others (Saunders et al., 2008). In order to communicate on the same level and comprehend multiple or contending viewpoints, the author is empathetic towards each individual.

One limitation of a constructivist approach is that the focus is on depth rather than breadth and thus implies a relatively small population, which may be open to criticisms about generalizability. However, this can be countered with the argument of Marshall (1996) that the production of results about complex issues is more valid than being able to apply the results in other scenarios. Adding to that, depth is a quality all to itself, which has the possibility of bringing to light concepts or perspectives that otherwise fly under the radar (Macdonald et al., 2002).

Despite the author's in-built paradigms that might be the basis for which methodological tool is selected (Dash, 2005), I make a conscious effort to embrace a pragmatist mind-set – putting

the research question first and foremost. In this case there is an alignment between the two. Air quality itself is a real, measurable phenomenon with real, measurable impacts on health, productivity and the environment. In terms of responsibility, impact at the individual level and the ethics and assurance of its provision there is no absolute right way or single truth; it is all down to the subjective perspectives of individuals. Therefore, the recognition of subjectivity among individuals' stances and their interpretation of a phenomenon is useful in researching how stakeholders perceive office air quality and responsibility thereof.

3.1 Research Objectives Refinement

As set out in Chapter 1, this pilot study is centred on the phenomenon of office air quality and responsibility thereof. Chapter 2 exposed a dearth of literature relating to either multiple stakeholder perceptions of IAQ or theory about responsibility for office air quality, revealing opportunity to explore this field for clues in order to construct theory about this phenomenon. Office air quality is a complex picture when one thinks about the many sources of pollution, both internal and external, the number of variables among buildings, users and locations, and multiple stakeholders with different interactions and sensitivity. To address this, I consider perspective as key: an office worker may have a different opinion about the air quality, how important it is and who is responsible for it from their manager. And the manager, in turn, may well have a different interpretation from that of a policy-maker. Combining and contrasting opinions can lead to understandings of how responsibility is assigned, where any gaps exists or perhaps lead to new revelations or insights.

Thus, the aims of this research are two-fold. One is to explore office IAQ using the perspectives of multiple key stakeholders as a conduit. Two is to use multiple perspectives to explore how stakeholders perceive responsibility for attaining and ensuring good IAQ in offices. The intention is to produce views that can be analysed for convergence or divergence. In doing so, I aim to synthesise or aggregate the results to produce a picture of IAQ and responsibility in office settings and provoke the development of a theory. From this outcome I aim to catalyse a full-scale study and other derivative research into the area of office air quality, by deploying this theory as a testbed for further analysis. The longer-term contribution is the use of the outcomes (of derivative research) by companies and HR to understand and manage various opinions or tensions around air quality and wellbeing within organisations. A second contribution is to (for derivative research) to provide inputs to policy makers that operate with building codes and working condition regulations.

3.2 Research Design

As this research sets out to discover relatively uncharted territory and catalyse further research paths, this thesis is exploratory in nature (Blumberg et al.; 2008, Robson, 2002). Given the exploratory nature of the research, a qualitative approach is suitable, as qualitative methods are 'less reliant on existing theory' and studies (Neuman & Wiegand, 2000, p.21; Strauss & Corbin, 1997). They are suited to discovering new domains in which existing knowledge is thin (Blumberg et al., 2008; Eisenhardt 1989; Yin 2003). Under certain conditions, such as where the research topic has high complexity and many stakeholders, qualitative research can prevail over quantitative, through its strength in depth and meaning (Skinner et al., 2000). Qualitative studies can have an iterative nature, enabling fluidity in the incremental steps of the research and information to be more dynamically used, in turn providing a catalyst for rich outcomes (Eriksson & Kovalainen, 2008).

Any qualitative research undertaking risks being burdened by a number of potential limitations. Qualitative research has been criticised as being more complicated (Snape & Spencer, 2003) than quantitative research. Indeed, there are many forms of qualitative research and there is much room for variance in methodological approach and interpretation of data. Another drawback of qualitative research derives directly from the absence of quantitative measurements. Merriam (1995), among others, identifies validity and reliability as continuing legitimate concerns academics have about qualitative research. Validity can be maximised by a number of means, for example, the use of multiple tools and information sources (Saunders et al., 2003). A rigorous research approach can have a positive effect on validity and reliability. This research uses both semi-structured interviews and desk research and makes efforts to achieve scientific rigour, as described in the following sections.

3.3 Grounded Theory

Grounded theory (GT), commonly used for qualitative research, is considered apt for this research and is thusly employed here. GT has been said to be especially applicable in streams where the potential for deeper research or for new perspectives on well-covered fields exists (Creswell, 1998; Milliken, 2010). The GT approach to qualitative research was developed by Glaser and Strauss in 1967 and, while divergent schools of thought have emerged, at its core is an iterative process of coding, memo writing and theoretical sampling to produce concepts and categories before transforming these into theory; hence theory is *grounded* in data (Ryan & Bernard, 2003).

Grounded theory deviates from other popular qualitative research methods that follow a sequential, linear data collection and analysis process. Unique is its *constant comparison* –

continuous alternation between data collection, coding and analysis. Coding of data is done in synchronization with the collection of data, in this case from interviews (Glaser and Holton, 2004). This results in new dimensions and concepts to be added into the mix for consideration in further interviews and theory development. Due to this iterative process, grounded theory is a more complex tool than it otherwise appears (Ryan & Bernard, 2003).

Kenny and Fourie (2015) identify three distinct schools of thought in grounded theory: Classic, Straussian and Constructivist. As various academics have cast Classic GT theory as rooted in positivism, (Charmaz, 2006; Jones & Alony, 2011) and the structured Straussian approach is also critiqued as positivist by Charmaz (2008), the Constructivist Grounded Theory approach developed by the latter appeals to the author's own epistemological and ontological value. This is in addition to its characteristics of flexibility, openness to interpretation and ambiguity tolerance (Kenny & Fourie, 2015). Thus, constructivist GT is selected as the methodological tool of choice. This selection has implications on the use of literature and on the way data is coded. While a classic grounded theory approach expels the use of any extant literature prior to the research (and even suggests trying to banish existing knowledge about the topic from one's mind) (Glaser & Holton, 2004), constructivist GT encourages the utilization throughout the research and using a literature review (Kenny & Fourie, 2015).

To mitigate against the risk of being overwhelmed by information and succumbing to bias, I followed Charmaz's (2006) suggestion not to wade into all literature until the process of data collection and analysis has begun. Before data collection I lacked background information about office air quality and its legislation in the Netherlands that I deemed valuable to begin the research process and to conduct interviews capably[4]. Therefore, literature and information in these areas was collected to fill out my understanding. Constructivist GT's flexibility towards literature fitted my research preferences, in comparison with stricter GT approaches. Coding implications are explained in the data analysis section.

In selecting constructivist GT, I must nevertheless acknowledge a number of criticisms that have been directed at it, although the purpose is not to defend constructivist GT from philosophical critiques posed by competing GT theorists, rather to look at methodological robustness. Robustness is in fact one of the positions it is attacked on, for constructivist GT's acute flexibility in coding. I prefer to have the opportunity for flexibility and creativity rather than be constrained by an overtly structured approach. A related risk here is noted by Suddaby (2006), who emphasises the need for the researcher to remain creative with the data and not fall into the trap of attempting to use logic and deduction to germinate a theory. Another risk

[4] It was essential to have a number of ideas, themes or directions to continue the flow of conversation and to have data or information to hand to respond to any questions.

that I must comprehend, perhaps in part to constructivist GT's more creative approach, is how obfuscated the process can be, requiring that I learn and understand what data I have.

Being more interpretative than descriptive (Glaser, 2002), constructivist GT has the potential to distort the data collected. In the constructivist approach it is the author who collects the various strands of information to form a narrative. In building this narrative, the author's agency changes from mere gatherer and identifier to creator.

Charmaz's GT conjects that there is not one single truth but rather multiple realities as individuals experience phenomena from different positions, construct subjective realities and assign meaning (Appleton & King, 2002). Thus, constructivist GT is apt in the study of multiple stakeholder perspectives, particularly as it seeks *"an interpretive understanding of subjects' meanings",* resulting in an image of how individuals interpret reality (Lincoln & Denzin, 2003, p.50; Suddaby, 2006). Such meanings are to be tested for validity and rigour (Miles & Huberman, 1994). Thus, with this constructivist GT method the research process will culminate in the development of a narrative that addresses *"categories, conditions, conceptual relationships, and consequences"* (Hallberg, 2006, p.147), arising from the realities of multiple stakeholders around the topic of office air quality, as I interpret them.

3.4 Data Collection

The collection of data in this research is shaped by the research choices made thus far. The exploratory nature of this research makes a strong case for the utilization of semi-structured interviews to collect primary data (Fylan, 2005). While grounded theory can use data collected from field research, content analysis or other methods, interviews tend to be the technique of choice (Suddaby, 2006; Kenny & Fourie, 2015).

3.4.1 Interviews

Interviews present a tool for researchers to *"gain insight into … social issues through understanding the experience of the individuals whose lives reflect those issues"* (Patton, 2005; Seidman, 2013; p.14). Therefore, interviewing the various stakeholders of office air quality would provide a representation of how the phenomena are viewed. In turn, the objective of interviews in this research is to collect the perspectives of each key stakeholder group towards IAQ in general and towards responsibility in the office environment, which can then be transcribed and coded to transform data into nominal variables (Ryan & Bernard, 2003). Semi-structured interviews are intended to develop an understanding of the views of a participant on the selected topic (Blumberg at al., 2008; Lee et al., 1999). They elicit rich opinions from participants (Eisenhardt & Graebner, 2007; Barriball & While, 1994), at the same time giving space for new strands of the topic to take root. This is an important capacity

given grounded theory's character of continuous exploration throughout the data collection and analysis process. The richness of interviews is valuable in exploratory research as it allows researchers to discover new unexplored directions and relationships (Tull & Hawkins, 1990). This richness has the added value of improving the validity of the research. Thus, semi-structured interviews as a primary data source are a suitable medium for this research. In this research the structure the questions are built around office air quality in general and around responsibility for ensuring good office air quality. This loose structure allows for flexibility in the questioning, timing and adjustments based on participant responses. The individuals interviewed are referred to as 'participants' in a conscious effort to reflect their active involvement that occurs in the long, conversational style interviews conducted (Seidman, 2013).

To ensure that data collected from participants would touch on the research dimensions and have congruence within each stakeholder group, an interview guide was developed in advance. This still leaves flexibility for further exploration in directions stemming from the core dimensions (Patton, 2005). To ensure a flow and retain a natural atmosphere, the questions were not held rigidly and were adjusted to the situation in phrasing, style, delivery and order, depending on the participant and the answers given in an adaptive approach (Rubin & Rubin, 2011). This is, alongside the ability to immediately address misunderstandings or request clarifications, one of the key advantages of face-to-face interviews that its proponents advertise (Barriball & While, 1994). However, the interviews are approached in an attempt to stay 'on-topic'; whilst giving the participant rein to introduce related ideas and strands, I attempted to guide the participant back to the overall topic when narrative became too tangential.

Semi-structured interview techniques are not without their drawbacks and limitations. Some of those mentioned in the literature are biases in both questioning and responses, and lack of accuracy as a result of limited recollective powers (Yin, 2003). The ways in which interviews will be conducted take into account these limitations. Participant bias was tackled by the approach taken to hold interviews, with venue, time and other variables considered while the confidentiality of participants was assured (Abdelnour & Laasonen, 2016). While inherent observer biases may be impossible to avoid, they may nevertheless may be mitigated by the constant of having one researcher conduct all interviews, as I did in this research, thereby negating any risk of differing approaches to the interview, the questioning and the way in which responses are received and interpreted (Cavana, Delahaye & Sekaran, 2001; Easterby-Smith et al., 2008). Throughout the interviews, I tried to remain neutral and not allow tone or questions filled with personal opinion sway the conversation. Admittedly, this can be extremely challenging and personal opinions do somewhat encroach on the neutrality of the interviews, although arguably not in a way that damages the research. Lack of accuracy is somewhat

limited by the use of an audio recorder to capture all spoken words, while gestures, facial expressions and other non-verbal forms of communications are not included in the data collection and analysis. As with most interviews, there exists the risk of participant error. The risk is that participants give different responses depending on the situation, or the state that the participant is in at the time of the interview.

Chenail (2011) comments that interviews require significant practice, something that can only be achieved by conducting interviews. A pilot run, recommended to iron out any issues in interviewing before the research proper begins, was not pursued for reasons of practicality. A major impediment on time was my inability track down willing participants. Thus, any pilot would potentially use participants who would otherwise participate in the actual research and result in the loss of a valuable source of data. To counteract this somewhat, in lieu of a pilot study I engaged in interview preparation with a fellow Master's student to test questions and to practice follow-ups and returning conversations to the main themes.

Following a preparatory phase, I approached potential participants with honesty and transparency as to the research objectives and interview purposes. As well as being the moral imperative, this can help establish a relationship of trust from the outset, particularly as the research is not a critical analysis of people's work or views. Communication with potential participants was polite, professional and sensitive towards the participant's post and field of work. Each participant's value to the research was emphasised and it was stated that the topic may lead to interesting insights for them. Participants were asked for their consent to the use of a recording device prior to the interview. Individual interviews were conducted to retain anonymity and to remove any potential for intra-group influencing. To prevent bias, I attempted to forge a rapport and develop trust with participants. Preference was given to references I received from stakeholders and university lecturers, as those parties with whom I had a common acquaintance were expected to have an elevated level of trust and willingness.

The audio of all interviews was recorded digitally and transcribed near-verbatim (changes were only made for brevity) shortly after the interview was held, to maximize the chances of recollection where needed and to provide a contingency in the case of poor audio quality or other technical difficulty. The author holds copies of the transcripts. Following transcription, the transcripts were then coded using the approach laid out in the data analysis section in this chapter. A coding example is presented in Appendix B: Coding Example: Coding Example. The basic Interview Protocol is presented in Appendix C: Interview Protocol.

Permissions

Informed consent was sought from each participant prior to his or her participation in the research. Permission was sought from each and every participant for the recording of the

interviews and the use of information provided and quotations within the publication of this paper. Participants' anonymity is protected through the use of codes, with a different code given to each stakeholder group, as shown in Table 1, Chapter 4.

3.4.2 Sample Design

In composing the sample members, a purposive approach was adopted in the view that it would have value in generating rich, relevant data leading to better outcomes (Kuzel, 1999). The criteria for individuals viable for participating in an interview vary between the stakeholder groups. For example, experience in their role was evaluated to be more important for an architect than for a user. No considerations were given towards age or gender in order to keep a wide net for participation. This research intended to conduct interviews with at least three persons from each key stakeholder group, as detailed in Chapter 1 (stakeholders). As it emerged, the number of relevant stakeholders expanded as the research process progressed and the requisite number of willing participants was not found within the timeframe. The selection of key stakeholders is displayed in section 1.2 Stakeholders.

For purposes of accessibility, stakeholders from a large commercial complex in Rotterdam, *Groot Handelsgebouw*, were targeted. This building consists of scores of office spaces leased to commercial tenants (and one residential tenant), making complete control over day-to-day activities challenging. This has to be considered in comparison to other buildings where a single company is the sole owner or renter. In this building, a building management department, consisting of a building project manager and a maintenance manager, oversee the operation of the building and its environment.

Accessibility was eased by the 'The Happy City Lab', a partnership between Rotterdam School of Management and businesses connected with the *Groot Handelsgebouw*. One consequence of this is that this narrows the sample base and the type of responses and opinions of stakeholders, given their experiential alignment related to ventilation systems, location attributes and other factors. Given the low sample, this research is to be a pilot study, from which a more comprehensive study using a refined approach can be undertaken.

This research employs nine participants in the sample: four users, one company manager, one building manager, two architects and one IAQ expert. Interviews were held between 26 May and 18 July 2017. Interviews lasted on average 40 minutes and 30 seconds. One interview contained 2 participants, creating a possible influencing effect. This was accepted on the basis that the second participant would likely not have another available slot and additionally the discussions generated between 2 participants has potential to avoid interviewer bias. A couple of limitations become apparent. First, according to Strauss and Corbin, a minimum of ten

interviews are required to enable the development of grounded theory (1997). While this does seem like an arbitrary number, this research aims to address that by ensuring the length of depth of interviews is enough to gather a rich dataset. I made extensive efforts to acquire participants from other stakeholder groups. Despite two-way communication with various engineering company representatives and government officials, no participant with availability was found. This is a drawback, considering the importance assigned in the stakeholder mapping.

3.4.3 Desk Research

Additional primary data was collected through email correspondence and communication with stakeholders connected to the topic of research as well as University lecturers and contacts who could assist, albeit not designed as a data source. The results and outputs of this research provide inputs to Chapter 1, in which the context is set.

Secondary data was collected from behind the desk in an explanatory capacity and to help build an understanding of the topic of office air quality, with focus on the Netherlands, including indoor air quality legislation in the Netherlands and relevant stakeholders. Data was collected mainly via internet research using (scientific) search engines to run keyword searches leading to journal articles, government websites and publications as well as news items. Validity of information is a common concern when it comes to dealing with information gleaned from websites, with biases inbuilt in many cases (company websites tend to accentuate the positive, for example) (van Tulder, 2007). Further, the author is subject to his own biases in the selection of what is seen as information relevant to this research (Yin, 2003). The risk of bias is something I acknowledge.

3.5 Data Analysis

As described earlier in this chapter, this research adopts a grounded theory methodology meaning that collected data undergoes a *"process of continual re-examination of data"* in an inductive approach to develop theory (Saunders et al., 2008, p. 123). Data is coded, meaning sections of the text that are interpreted by the researcher to be significant are assigned a short, symbolic word or phrase (Saldaña, 2010). 'Interpreted' is a potential limitation – on which criteria certain data belongs in which code category is subjective and down to the evaluation of the author, creating unavoidable bias.

The choices to be made in coding methods are many; Saldana (2009) lists 22 coding techniques and highlights the ongoing discourse in the academic community about what the best approach is which type of research and whether none, one or mixed techniques should be used. The reasonable outcome is that the choice is context dependant. In the case of Grounded Theory,

Charmaz (2006) provides a framework to follow as she sees it best for the development of constructivist GT, which Saldana (2009) also recommends adhering to. Therefore, I follow Charmaz's (2008) two-stage coding technique of initial coding (in this case, sentence-by-sentence) followed by refocused coding. Incorporating this, the data analysis process is the following:

1) As transcripts are produced they are read, analysed and coded in discrete ways for concerns, actions and theoretical cues
2) Codes are reviewed and recoded for accuracy and conceptual overlap (Saldana, 2009).
3) Codes that are frequently occurring or stand out as particularly pertinent to the phenomenon become draft theoretical categories that *"crystallize participants' experience"* (Charmaz, 2006, p.54)
4) Codes assigned to these categories are brought together using techniques of memo writing and theoretical sampling to produce theory.
5) Theory is reviewed against existing literature (Glaser & Holton, 2004)

As Charmaz (2008) proposes, *in vivo* coding is applied where practical, meaning that the language of participants is directly lifted from the transcribed interviews as codes. A coding example is shown in Appendix B, using a mix of in vivo and descriptive forms. Memo writing, mentioned in the fourth step, is the process of note-taking throughout the coding and theory development process to organise codes and develop paths; it is an integral component of grounded theory and is strongly encouraged by Charmaz (2008) in constructivist GT.

A Computer Assisted Qualitative Data Analysis (CASDAQ) software tool, 'ATLAS.ti', was used in the process of extracting themes from the data and in developing relational models. Transcripts were imported into the software where they were coded and where memo writing could take place. While academics such as Charmaz (2008) and Lincoln & Denzin (2003) argue that computer software fragments and discards data in a way that changes the researcher's understanding of the data, the power of software in breaking down the volume of data into more manageable fragments eases the path to interpret the data (Glaser & Strauss, 1967), important given time constraints. In this research, where some stakeholder groups have multiple members, software made it easier to collect and combine quotes and codes of all members within a group. The process of codes, categories and memo writing to construct theory is still very much a creative process in the hands of the author.

This concludes the selection of methodological tools and the explanations given for their selection and suitability for this research. Figure 3, below, condenses the research process into a simple stage-by-stage graphic.

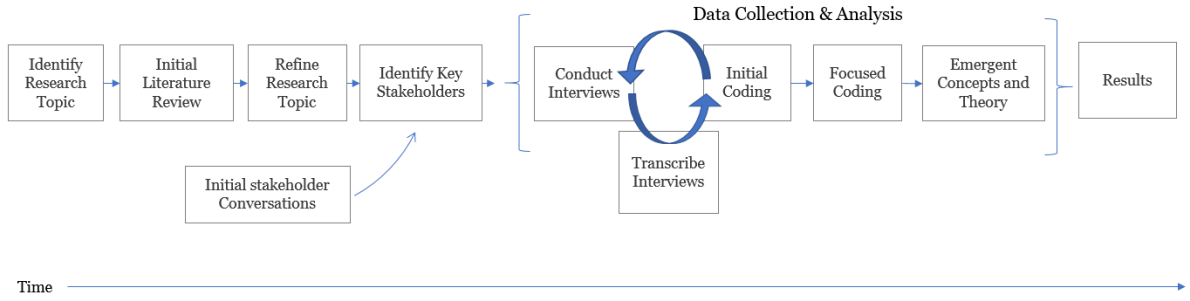

Figure 3: Research Process (Source: this research)

3.6 Reliability and Validity

The quality of scientific research weighs heavily upon the solidity of its reliability and validity, which are required to minimize the chances of coming to false results and conclusions (Saunders et al., 2008). As described in this chapter, a number of risks exist in the methodology. I acknowledge these risks and, where previously described, where possible made efforts to reduce risks across four main categories of reliability as formed by Robson (2002): participant error, participant bias, observer error and observer bias. Nevertheless, despite steps taken towards minimising bias, it is natural in this type of research for a dose of bias to remain. That must be considered in review of results, presented in the next chapter.

Chapter 4. Results

In all, eight semi-structured interviews were held with nine stakeholders (each given a reference key) from five key stakeholder groups as displayed in Table 1. These interviews yielded over 38,000 words of rich data. The data was analysed following the constructivist GT method as detailed in Chapter 3. This chapter presents the results of this analysis.

Key Stakeholder Groups	**Participant Key**
Office Users	User A
	User B
	User C
	User D
Company Manager	Manager
Building Manager	Building Manager
Architects	Architect A
	Architect B
IAQ Experts	IAQ Expert

Table 1: Participant Key and Key Stakeholder Groups

The semi-structured nature of interviews led the conversations down many diverse avenues of discussion. As per constructivist GT, selected lines of enquiry were removed or disconnected as a result of theoretical sampling. Thus, results are presented in line with the field of the exploratory focus: stakeholder perceptions of office air quality and of responsibility for good air quality.

The analysis is structured in five sections. Results corresponding to general perceptions of air quality are introduced in sections one to three. Results relating to responsibility are presented in section four. Within each section theoretical categories are proposed and explained. This analysis culminates in a synthesis of data and categories in section five, producing a theoretical construct.

1) Perception Construction
2) Primary Stakeholder Concerns
3) Awareness
4) Assignment of responsibility
5) Synthesis

4.1 Perception Construction

Before the topic of responsibility was broached, participants were openly asked about their views on office air quality and what they consider to be good air quality, how it relates to their role and so forth. While professionals working in the field of IAQ or connected to it have a relatively clear understanding of IAQ, people out-with the field are less knowledgeable with regards to pollutant sources, health impacts or economic effects. Nonetheless, as this research values perceptions, the views of those with less knowledge are equally as valid as those with more knowledge. How stakeholders construct views on IAQ varies among participants and stakeholder groups. In sharing how it concerns them, how they encountered it and what they consider as components of air quality, one main attribute was recurrent throughout interviews.

Recollecting negative sensory experiences

One category constructed encapsulates the common approach of participants in trying to identify what good air quality is. Ideas of IAQ often spread to recollections of negative experiences, based on human senses. Users' verbal and non-verbal responses indicate that IAQ is not a familiar topic to occupants. Participants relied on sensory experience to indicate whether air quality is good or bad. Conversations often centred around the effects on comfort perceived by users to be attributed to air quality, such as high temperatures or bad smells. This gives the indication that negative experiences are mainly used as a baseline against which air quality in the current environment is perceived.

"I once had an Airbnb in Washington, in the US, and there was the humidity, it was really low." (User B, Interview, 20 June 2017)

"the one thing is for sure; the air [in China] was very polluted, the air on the streets" (Architect B, Interview, 6 June 2017)

The use of benchmarking IAQ against positive experiences or associations was the exception: *"I can see that if I walk through this forest, the air is cleaner than on a sunny day in Amsterdam, of course I can experience that."* (Manager, Interview, 21 June 2017)

4.2 Primary Concerns

In responding to open questions about air quality, participants provided in indication of their main concerns, as expressed directly and as frequently occurring factors throughout the data. These belong to 4 main groups: Health & Wellbeing, Economics, Aesthetics, and Regulations.

4.2.1 Health & Wellbeing

Prioritising comfort

While health and wellbeing are generally grouped together in literature, first associations and the most commonly cited components of all stakeholders except the IAQ expert were related to wellbeing (comfort) and much less so health. Studies of the public have shown a degree of uncertainty of links between air quality and health (Bickerstaff & Walker, 2001). This could explain the lack of concern given towards health. The comfort factors that frequently emerged were those that relate to human sensory experiences of temperature, smell, noise, humidity and ventilation (oxygen levels and "stuffy" air):

"I'm thinking about air quality in my workspace, eh, in a way that you have the feeling that it is fresh" (User A, Interview, 8 June 2017).

"The right temperature, is often the first thing you notice. The smell. And I think there is also something like the oxygen level" (User B, Interview, 20 June 2017).

"it's more how you feel, and also depending on how many people are sitting in the office, if it's quite crowded you can feel it more getting hot and sticky" (User C, Interview, 22 June 2017)

"Air quality is when it's not too humid, not that warm etcetera, that's comfortable for me but I'm not sure if that's about the air quality" (Manager, Interview, 21 June 2017).

The weighted concern of employees towards comfort is also exemplified by the perceptions of Architect B: *"there's a lot of complaining about the quality of the comfort. And, eh, that results in the fact that people in offices, they rent it for 5 years, they want to leave there, as it cannot be solved. It's so very important for the employees"* (Interview, 6 June 2017). The architect is also of the perception that *"good air quality is very important for wellbeing"* (ibid).

One user expressed ambivalence towards the potential health effects but made frequent references to comfort aspects such as heat and smell. *"I live near a highway in this area, I always breathe this air so maybe I live a year shorter but it's not really a concern*" (User D, Interview, 22 June 2017)

Contrasting with the clear user concern for comfort is the objective of the building manager to achieve an air quality that conforms to scientific measurements and regulations as opposed to how it is perceived by occupants as an impact on their comfort: *"[IAQ] for me, as a project manager, and as building maintenance, it has a higher priority than the people using it. They want to have a comfort area."* (Building Manager, Interview, 19 June 2017) This contrasts

with the IAQ Expert, who perceives peoples' needs as the priority: *"And I think that the people perspective is more important than the installer perspective"* (IAQ Expert, Interview, 21 June 2017).

Judging by user perception, the window is at the centre of comfort. By expressing their concerns and how they are resolved, the opportunity of users to open windows and doors to the outside emerged as a vital component of their comfort. Windows were also considered by the manager as the most important aspect of employee comfort. Architects also view windows as an important factor for occupants. The IAQ expert supported this: *"Eh, the most important aspect are our windows. You want for air quality that you can open the windows actually"* (IAQ Expert, Interview, 21 June 2017)

The importance of windows should be considered in line with concerns of cost perceived to be held by the building manager and building owner. There is an understanding that building owners see energy savings as a way to reduce operating costs and may opt for buildings in which windows cannot be opened (Torcellini et al., 2006). Given perceived comfort importance, this perhaps should be a consideration for embedding rules about openable windows into building codes; a government responsibility.

Managing Different Peoples' Needs

Modern office spaces are often a combination of open and private spaces, meaning people with different health and comfort needs work together in a shared space. Thus, co-workers must manage the needs of those around them. This creates a potentially difficult coming together of needs, especially in consideration of the notion that people want and benefit from control of the micro-environment around them – something that can't be done when others are influencing it (Lee & Brand, 2005).

"[…] there are some people more – like Eveline - she has the allergy and yeah, she feels it more if [the carpet is] not really good cleaned" (User C, Interview, 22 June 2017)

The fact that IAQ is subjective in terms of comfort can create mismatches of needs: *"And some people feel this but others don't, so it's not an objective, it's not a thing you can measure it's more of a feeling, a perspective, yeah. I'm sitting on my desk with another girl that does sports a lot, she's really active and she is hot quickly, so she wants to open everything and I don't"* (User D, Interview, 22 June 2017)

4.2.2 Economics

"Money is main" (Building Manager, Interview, 19 June 2017)

IAQ and attainment of optimal levels of clean air were often related back to thoughts and issues of cost, especially among architects and the building manager, as well as being perceived as the driving rationale of the building owner.

Balancing Trade-offs

The cost of investment in IAQ results in perceptions of trade-offs between money and air quality. There are perceptions that IAQ and ventilation is very costly: *"It's ridiculous to see sometimes how much money we spent on ventilation in buildings"* (Architect B, Interview, 6 June 2017). The view that ventilation is very expensive appears to conflict with the findings of Hamilton et al. (2016) and MacNaughton et al. (2015), who separately show that high standard ventilation costs are below $40 per annum. Perhaps the initial investment is what is perceived as outrageous.

As perceptions show, architects provide advice to the building owner, therefore their opinion on cost is a significant factor in consideration of the view that building owners put money first. *"And the people who own this building, who are the people who don't want to pay for it, but want to have a return on investment. And that's the drive."* (Building Manager, Interview, 19 June 2017). Further, decisions are taken based on economic returns, not the health of occupants: *"And it's hard to realise it's driven by money, it's not driven by personal health"* (ibid). As MacNaughton et al. testify, economics often takes a front seat in the concerns of decision makers in buildings: *"the cost of energy is often prioritized over IAQ and minimum required ventilation rates are met*" (2015, p.14711).

4.2.3 Aesthetics

Compromising IAQ performance for aesthetics

Architecture is a field that combines disciplines of maths, material science, wellbeing and other areas. It is also synonymous with design and can be considered as having a strong aesthetics aspect to it. The importance of aesthetics to architects is evident in the prevalence of the word 'ugly' in the data and responses such as: *"It's really like, listen guys, you have to make sure that the air quality, or the temperature or whatever, is within the requirements of the law. And then we think OK. The only thing we try to do is "that's ugly, we want it somewhere else"* (User D, Interview, 22 June 2017).

As well as architects having strong concerns about aesthetics, a municipal planning board (a committee set up by the government and composed largely of architects that gives approval to

building projects) is greatly focused on aesthetics and maintaining cultural heritage. Their remit also covers approval of technical installations (i.e. mechanical ventilation) that is housed externally and therefore impacts the building appearance. Therefore, the government has an objective in compromising certain building aspects, such as IEQ, in the name of aesthetics and culture. Thus, the government controls two separate bodies, one for working conditions and one for aesthetics, which can have conflicting stances.

4.2.4 Regulations

Architects and stakeholders must pay a great deal of attention to regulations, with codes related to regulations a frequent occurrence throughout interview dialogues. From the data it can be said that regulations have a major impact on the way in which architects and building managers fulfil their roles, applying not only rules but also experiencing certain constraints when it comes to IAQ.

Feeling constrained by regulations

Linking aesthetics and regulations, the abovementioned planning regulations are perceived by the building manager and architects to be a constraint, As well as interfering with design, the planning office issues commands about the (re)location or appearance of technical installations which architects say can have a negative effect on air quality. Regulations are seen by the Building Manager as a primary concern - *"And me as a local project manager, em, have to look into all kinds of regulations, regulations on the building and also on the installations"* - but also as counter-active to guidelines - *"The regulations and the guidelines; they don't match to each other"*. This is pronounced in criticism of regulations issued by the aesthetics body of the municipal planning office (referred to as 'monuments' in the dialogue*)*: *"It's not a very good choice that they made [about the installation location] but it was one to please the people from the monuments."* (Building Manager, Interview, 19 June 2017). Thus, a less than ideal situation for the location of the ventilation equipment is a result, a genuine concern.

Perceptions of conflict with regulations arose in the way that architects and the building manager experienced fire-proofing regulations and air quality regulations. *"it's even more complicated, because it's also because of fire regulations … you know if you have windows you can open that affects fire safety"* (Architect B, Interview, 6 June 2017). In the design phase architects aim to put wellbeing first, with windows a key element of that, but regulations can be limiting. It is thus a complex responsibility for architects to balance fire safety issues against longer-term wellbeing.

One standout excerpt concerns the interaction between the regulations and guidelines, in the resulting decisions taken about air quality. There is a perception that guidelines constrain

optimal IAQ, as the *"minimum is always the maximum"* (Architect A, Interview, 26 May 2017). Architects and the building manager give the impression that even though they could provide advice on IAQ, building owners or decision-makers would generally revert to the minimum regulations, for cost reasons. This indicates that while green buildings do exist in the Netherlands, they are the exception, or even that air quality is given low importance there. And in offices, air is most likely to be at the minimum regulation or worse, depending on maintenance quality. It also indicates that the market cannot yet adequately self-govern IAQ and demand for higher quality, especially while awareness among stakeholders appears to lack.

Somewhat inconsistent with the perception that regulations could be higher, simultaneously there exists concern that regulations cause issues because they are strict, exerting constraints in the reverse direction. This is a challenge for the building owners and managers:

"What the government does now is say "Listen, if you don't renew that, or improve that, then you're not allowed to have an office there anymore". So they might have to take away the whole building. So that's gonna be quite a big problem, well not a problem, a challenge" (Architect B, Interview, 6 June 2017).

4.3. Awareness

"What is actually happening?!" (User B, Interview, 20 June 2017)

Despite a claim by Bernstein (2008) that awareness among the public regarding IAQ in the office environment is on the rise, this was not evident in this research. Rather, a lack of awareness emerged in the results as a central category. Users, managers and architects expressed a lack of personal awareness in various forms, often focusing on the current environment:

"We also have no clue about [ventilation], how it actually works" (User C, Interview, 22 June 2017)

"I have no idea how big the problem [of indoor air pollution] is" (Manager, Interview, 21 June 2017)

Looking beyond themselves, stakeholders who lack awareness also perceive others as having a lack awareness of IAQ. An example of this is from the interview with Architect B: *"I think a person is not able to know "OK, this is good or bad air quality". I've no idea. Maybe we are with awful air quality and we die within 2 weeks. I've no idea"* (6 June 2017).

The perception that people in general have limited awareness is consistent with a study by MacNaughton et al. who found that building managers and building owners in the U.S. "believe that tenants do not consider indoor air quality (IAQ) when leasing a space" (2015, p.14711). This implies that there is little motivation for building managers and building owners to go beyond the minimum regulations. The reason to do so then must come from a strategic hedge against tightening regulations or a place of moral reasoning.

"I want to meet [regulations], I want to [exceed] them because the regulations are getting stronger and stronger every year, or harder and harder every year" (Building Manager, Interview, 19 June 2017).

As well as direct expressions of a lack of awareness among participants, there were multiple related expressions support and add further explanation to this category:

Perceiving ambivalence

A broad impression among participants is that people in general have no interest in the topic of IAQ in the office: *"nobody cares"* (Architect A, Interview, 26 May 2017). This *in vivo* code can be said to be associated with the importance level: if importance was high it is logical that interest would be high. Unimportance is attributed to views of multiple stakeholders.

Sensory limitations

It should be appreciated that humans have sensory limitations and without access to electronic sensor data are not able to accurately identify air quality. The following excerpt also shows how comparative situations are required in order for sensory appreciation. *"But, I would say, the moment when I came back in Holland, and the airplane door opened and I walked in the gate, the tube… The first thing I noticed was how fresh the air was! But I only experienced that difference because it was not the other way around. It was not that I was in China and I was thinking "oh, the air is very polluted", it's just the moment I got back I realised how fresh the air is here. I think that is really a difficult issue of what is good or bad air quality"* (Architect B, Interview, 6 June 2017).

Identifying as low priority

Users and Managers widely acknowledge that IAQ is not a high priority in the office: *"We are not really busy with the air quality in this office"* (User C, Interview, 22 June 2017).

The same view is held by Architect A. If there was demand for higher IAQ then that would indicate a higher level of priority: *"you have the possibility … to make it even cleaner or bring it up to standards which would be acceptable for hospitals, for instance. Anti-allergic and… You could do that but there's no demand at all"* (Architect A, Interview, 26 May 2017).

Perceiving IAQ risks and benefits as abstract

One notable outcome is the perception of IAQ as an abstract concept. An example refers back to the excerpt of the manager in Section 4.1, in which the experience of good air quality is understood. Occupants do not seem capable of perceiving, or noticing, when air quality is particularly high.

In some cases, physical symptoms might create a link but generally the connection is limited, especially when the benefits of good IAQ that emerge from the literature are discussed, such as productivity: *"And I think 2% or whatsoever [of productivity gains] is just too vague, too abstract for [businesses]"* (Manager, Interview, 21 June 2017).

Even physical symptoms that may derive from poor air quality are present, it is perceived as hard for users to make the connection between cause and consequence: *"If you know where the complaints come from, CO2, other different qualities of air, that makes you have a feeling of sickness. But they cannot put their finger on it, unless you know"* (Manager, Interview, 21 June 2017).

A consequence of the abstract nature of IAQ is the issue of personal bias – linking air quality to personal effects is difficult and, much like smoking, there is a perception that people are optimistic in their own changes: *"It's hard to show that it affects you personally – it's a public health issue. On the long term, well if you live in Rotterdam well in general you live one year shorter than people who live on the countryside but you never know if YOU are a year shorter!"* (IAQ Expert, Interview, 21 June 2017). This quote serves to accentuate the complexity of IAQ and its effects.

4.3.1 Desiring Information

Two key consequences emerge from stakeholders' perceived lack of awareness. The chief consequence is the desire for information and data around IAQ, expressions that are heavily grounded in the data and lead to a new theoretical category: 'Desiring IAQ Information'.

Essentially, users expressed a lack of awareness supported by other factors such as feelings that air quality as abstract and feeling uninformed in their current environment. This gained further support from expressions of ambivalence, as in the view of Architect A: *"Nobody wants to know, everybody wants to block it out as long as possible"* (Interview, 26 May 2017).

It appears that the lack of weight or importance assigned to IAQ at the user and manager level results in a disconnect between office occupants and potential impacts of IAQ on health and productivity (see e.g. Hamilton et al., 2016). When the topic of health, productivity etc. were broached in interviews, users expressed desires of wanting access to IAQ data for their offices,

proof of OAQ effects, proof of concepts of betterment measures, and measures that would allow for experiential comparison: *"So, it would be nice to have a thing, like [she] said, where you can measure and I could tell her 'no, the air is still good'"* (User D, Interview, 22 June 2017).

Users wish to be informed about air quality statistics and measurements carried out in the building, to understand the quality of the environment in which they work in: *"if they would do a measurement it would be nice if they could send them around"* (User C, Interview, 22 June 2017).

This desire for data extends to ideas about electronic devices that would provide office occupants with valuable data about the air quality, providing awareness: *"I can imagine that you have some kind of sensor, within the wall, and then you can measure the air quality or whatsoever. Really a thing that you can hang it everywhere so that people are aware of the air quality, or can compare it with something because, I don't know what's good or what's not good. You know sometimes if you cannot smell it, or experience it, so maybe you need a sensor to be aware of that"* (Manager, Interview, 21 June 2017).

The government is held partly responsible for raising awareness around IAQ: *"I think [the government] can give us more awareness about what the air actually consists of because if I think back to my education I never got information about that and also when I get [letters] from the municipality there's no [letter] about air quality but about all other kinds of things."* (User B, Interview, 20 June 2017) This is offset by perceptions that people do not do enough to become involved in the discourse: *"People need to stand up and get aware of the fact that they are working a lot of the time and that it is not measured and that it is a very important part of how healthy you are."* (User A, Interview, 8 June 2017).

One caveat of heightened awareness and access to air quality data and information is that data is useless or even frustrating for users if channels or mechanisms for improvement exist: *"if you know it's not healthy then there should also be something to do about it."* (User D, Interview, 22 June 2017)

Figure 4, below, displays the relations between explanations of lack of awareness and the consequence of desiring IAQ information and evidence of impacts, as the network was created in the Atlas.ti coding software.

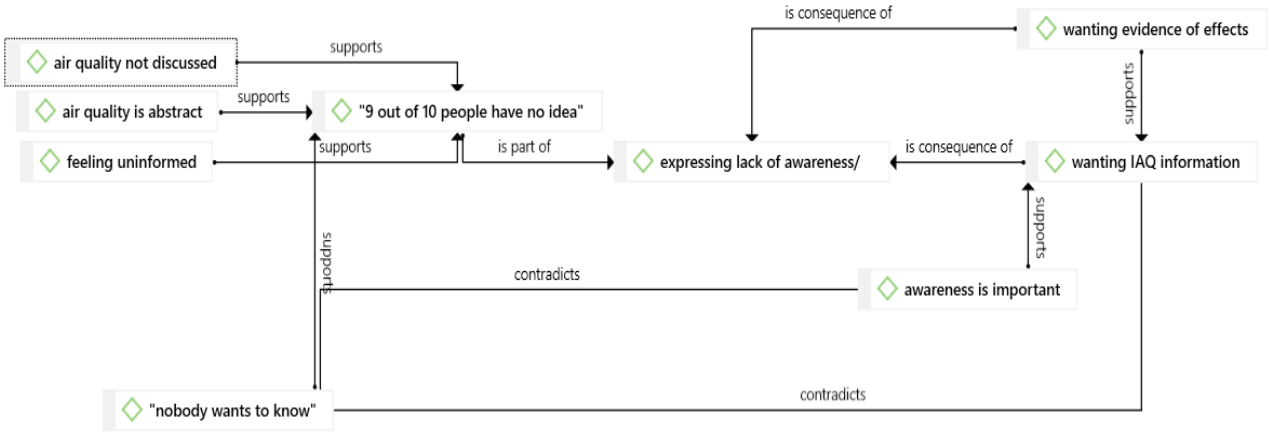

Figure 4: Network linking lack of awareness to IAQ information (Source: this research)

The secondary consequence that can be linked to a lack of awareness is the perception among users in particular that they have no agency to deal with issues of IAQ. Reasons for this are twofold. One could be related to how large organisations or offices operate and the range of issues that managers deal with. Users perceive that an individual is unlikely to be listened to without the support of colleagues.

"I think if I on my own am coughing a lot at my work and then I send an email it won't mean that they'll take action" (User B, Interview, 20 June 2017)

The second reason, closely entwined with this argument, is that in their views on making complaints users frequently reflected on the potential to have data to support them or be informed. Without any data about the connection between symptoms and cause, about the levels of CO2 or pollutants in the air, or information about the system, office occupants have little in way of evidence and thus bargaining power when it comes to resolving potential issues:

"If there are specific regulations everyone knows about, you can just go to the manager and say 'those are the regulations you are not fulfilling them so please do that!'" (User C, Interview, 22 June 2017)

Thus, it is posited that knowledge, following awareness, can create agency for occupants in IAQ recourse.

Figure 5, below, expresses in graphical form the relationship between a lack of awareness and the desire for information, the former augmented by stakeholder concerns explained previously. Lack of agency, solved by availability of information, is also incorporated. The complex networks around 'Expressing lack of IAQ Awareness' are simplified in comparison with Figure 4. The supporting and explanatory coded components of the category 'Expressing lack of IAQ awareness', such as the abstract nature, are grouped into 'Factors that provide explanations for a lack of awareness'. The multiple coded components that support the desire for information are grouped as 'Components that support a desire for IAQ information'.

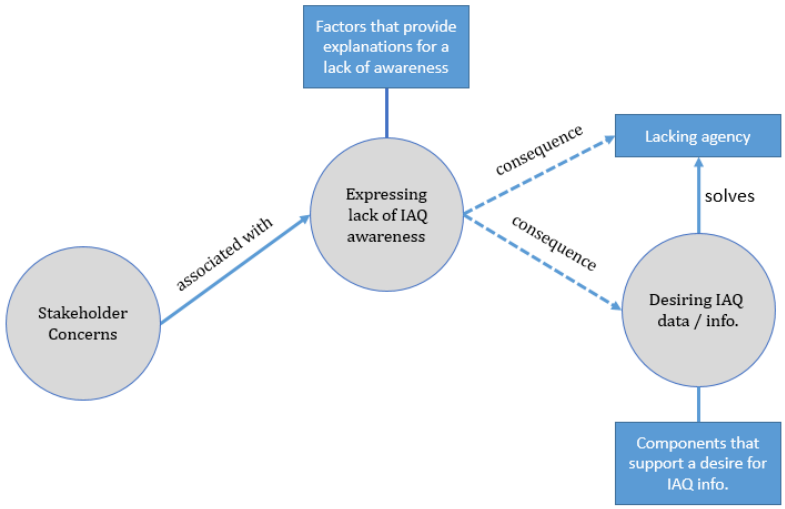

Figure 5: Graphic displaying the consequences of lack of awareness (Source: this research)

4.4 Assignment of Responsibility

Understanding views towards responsibility among multiple stakeholders may give way to insights about where misunderstandings could occur or about gaps in responsibility, if opposing views persist.

4.4.1 Difficulty assigning responsibility

"Eh… it's a difficult question." (User B, Interview, 20 June 2017)

Participants perceived assigning responsibility for IAQ as a difficult undertaking, with responses aligning towards the 'it depends' type as opposed to the identification of one single authority whom is held collectively responsible. This outcome is in line with the WHO's statement on responsibility that no one profession or authority is solely responsible for IAQ (2002). This does have its drawbacks though, especially when it comes to rectifying air quality issues in the office. As the IAQ Expert pointed out, *"there's not a special place where you can*

go to and say 'well [the air's] not good enough'" (Interview, 21 June 2017) Equally, there are feelings of uncertainty about the ability of markets to improve and regulate air quality: *"Well when you're looking for the impact, and the responsibilities, and as I told you I do not believe that the responsibilities will be taken by economical mechanisms"* (User A, Interview, 8 June 2017). Therefore, the hierarchy from office users to government in the Netherlands must identify who is responsible and find how to ensure that this responsibility is upheld. Perceptions collected in this research reveal no consensus as to responsibility but do reveal a number of factors impacting responsibility.

Perceptions of the other stakeholders' knowledge, expertise and decision-making power are important in the assignment of responsibility, with the party holding the most knowledge or decision-making power related to a specific scenario assigned responsibility. Primary stakeholder concerns, detailed in the previous section, are often a modifying factor on assignment. This is because they tend to correspond to the area of most concern to the participant, such as comfort.

4.4.2 Regulations and Responsibility

Responsibility is also 'passed on' by some parties. For example, building owners are seen to be intrinsically driven by money. This attitude seems to be accepted, thus putting the onus of responsibility on government to regulate effectively. There is a clear perception of the stakeholder groups that the Dutch government holds responsibility towards IAQ through regulatory measures:

"I don't think it's the responsibility for an architect for example. Although you might think "yeah, he designs this building", it's almost I think a responsibility for the government." (Architect B, Interview, 6 June 2017).

Yet, there is a mixed view on whether the current set of government regulations goes far enough in ensuring good air quality: *"the liberal government of Holland skipped a lot of rules regarding quality, in favour of investors that want to maximise their profits"* (Architect A, Interview, 26 May 2017).

Part of the reason for this can be assigned to the view that some responsibility, or at least flexibility, is given to the marketplace:

"The Dutch government they think it's important to have as [few] rules as possible, they don't want directly do anything they always say 'well, the market has to arrange this by themselves" (IAQ Expert, Interview, 21 June 2017)

In review, it may come down to different philosophies. The government, while bearing some of the responsibility, is also responsible for maintaining a working economy. The question of responsibility could again be debated. No government legislator could be tracked down to participate to provide corroborating or contrasting views.

A gap exists between occupants and those stakeholders who were better able to express opinions about responsibility. This could be related to how rights of ownership of indoor air are difficult to assign (Stefan & Paul, 2008), making responsibility problematic. It can also be associated with trust: *"But if we mistrust everyone then the world won't be a better place. So, I hope [the owner is providing good air quality]"* (User C).

4.4.3 Managing Different Peoples' Needs Part 2.

As stated previously, users want of control of personal space and talk about managing the needs of others. This brings into question who is responsible for whom and why. For example, is a user who feels too warm resistant to open a window by way of empathy towards a co-worker with pollen allergies in the height of summer? This would involve a dive into moral philosophy, pitting for example a deontological view about maximising societal benefit against a consequentialist philosophy prioritising the final outcome. For example, is the vulnerable individual to be prioritised or the comfort of the many? And who is responsible? Again, questions of responsibility are not straightforward. In any case, it can be argued that there is an implicit onus on office users to bear some responsibility towards the wellbeing of others, understanding for example allergic sensitivities, not just themselves. An understanding of the effects of poor air on the vulnerable may assist in this issue.

4.4.4 Health versus Comfort Trade-off

The health effects of poor indoor air quality are well documented (see for example Bernstein et al., 2008; EC, 2017; HEI, 1995; Koistinen, 2008; SCHER, 2007) thus it is no surprise that the IAQ Expert views health as more important than comfort: *"health is more important than maybe comfort"*. However, given the significance of cost in the equation and the focus on occupant comfort, it can be surmised that a trade-off exists between health (or air quality) and other factors. This is supported by the perception of the same by Architect 2, comparing a new building with the old building he works from: *"But, like I said … I'm quite sure the air must be perfect or must be good. New machines, new technique etcetera. So I think the air quality in the offices over there is, if you read about it, if you read how their air quality is, it's probably twice as good as it is in here. But that chance that I feel much better in my office than the guy over there is quite big."* These trade-offs complicate the tasks of stakeholders and add fog to responsibility. Consequentially, this begs the question, should stakeholders put comfort first or health?

While the answer may appear obvious, perceptions among office managers are that complaints arise primarily from comfort effects, thus have a motivation to maximise comfort. Some users do perceives comfort as more important than air quality: *"If outside it's very warm and it's still cool inside well in the office of one year ago we experienced a lot of too hot days that you are sweating and that you're above the level of a very old office building, so it was not relaxed to work there, very hot. But I think that's more important than air quality"* (Interview, 8 June 2017). It could be argued that if users were fully aware of the health risks, however, that this perspective may change.

4.4.5 Fluid and contextually evolving nature of responsibility

Taking the collective views of stakeholders, different responsibility assignations were applied depending on the context. For example, compare a new building in the design phase versus an existing building. In a new building, the owner/property developer and architect are perceived to be key decision makers in the first instance and thus hold responsibility. Architects see themselves as decision-makers: *"technical advisors came in and there's really a point where we say "this is what we want" and they start calculating, organising"* (Architect B, Interview, 6 June 2017). Indeed, building owners and architects are shown by the literature to have prime responsibility in creating the IEQ, encompassing IAQ. (Levin, 1993; Roulet et al., 2006) However, once a building is completed, the architect's position as a key stakeholder and decision-maker fades.

"I think architects are the ones that are initiating it. Potentially the people who are paying for it and making decisions about it, maybe the architects as well but they work for them and if they say 'well it costs like even more', so then the people who are paying for it should decide. Maybe, the terms after they are already in the building; maybe the facility manager, or maybe the HR." (Manager, Interview, 21 June 2017)

The perceived view is that in existing buildings it is the office manager and building manager responsible for solving issues, with the building owner held accountable for any major issues that occur, at least hypothetically. Thus, responsibility depends on the scale of the issues, the age of the building and the stage of the building. Responsibility was also applied to the employee, in selection of the company that they work for, with some organisations perceived to be more concerned about employee health and wellbeing than others. In contrast, the IAQ expert views the company as a major holder of responsibility: *"if you're working in a building and you do not feel well, maybe if you go to your boss and mention the problem, you're a complainer. If it goes top-down, we are improving the indoor air quality in this building because it's better for you and it's better for us as a company, it's better for the human*

resources, it's a different approach. And I think we should work on that. I see indoor air quality as part of the human resources management." (IAQ Expert, Interview, 21 June 2017)

Further, questions about responsibility resulted not always in its assignment to a particular party or stakeholder but rather in discussion and wishes for more information about the topic. Therefore, more understanding is needed to be able to willingly assign responsibility.

4.5 Synthesis

"The thing is if you know then they have to do something about it!" (User C, Interview, 22 June 2017).

The research results presented in the previous two sections appear to present a number of interrelations between theoretical categories that are brought together in this synthesis. As the data revealed, there is a perceived lack of awareness. Separately, there is a perceived difficulty in assigning responsibility. It is argued that these categories are connected: some of the difficulty in users and managers discussing responsibility and assigning definitive holders of responsibility is in some part reflective of the general lack of awareness of IAQ. This is encapsulated neatly in the above insight of User C.

"I think that has to be again the theme for responsibility: awareness, creating awareness." (User A, Interview, 8 June 2017)

It is conceptualised that empowering employees and managers with IAQ data and information would close the gap in knowledge and support employees in rectifying IAQ situations. This in turn would tighten the implicit loop of responsibility attainment and maintenance, with users able to equalize pressure from the bottom up, rather than a continuous top-down arrangement. This includes involving decision-makers in IAQ issues, which is not currently the case in the building studied in this research. In this scenario, responsibility is arguably more dispersed, as users take a more active role in enforcement while direct influencers or decisions makers remaining active in the role of attainment. This concept is visualised below in Figure 6.

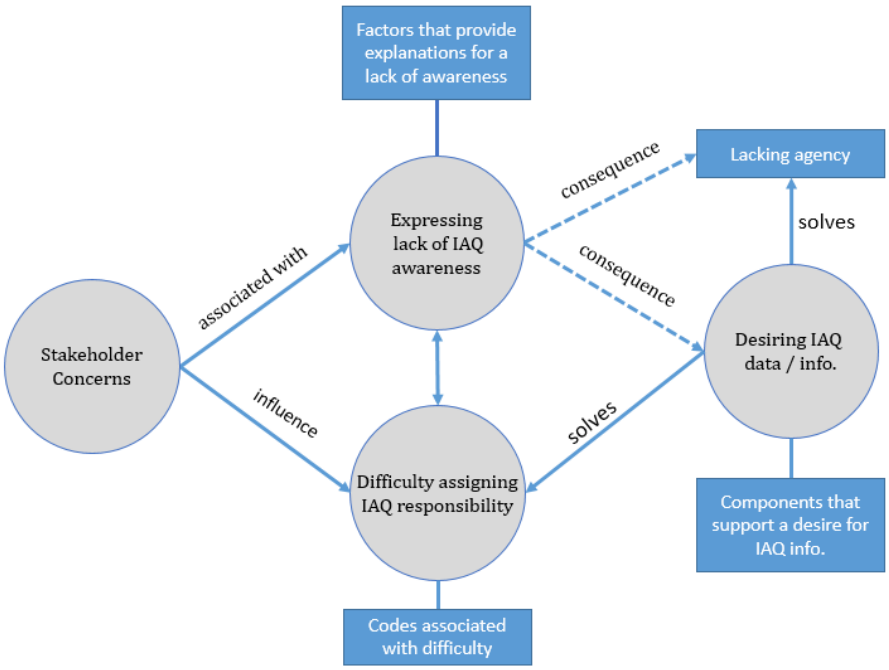

Figure 6: Lack of awareness curtailing responsibility fulfilment (Source: this research)

This concept can also be visualised with regards to the stakeholders involved at different points of the model, as perceived by stakeholders. This is shown below, in Figure 7: Awareness and Responsibility Stakeholders (Source: this research).

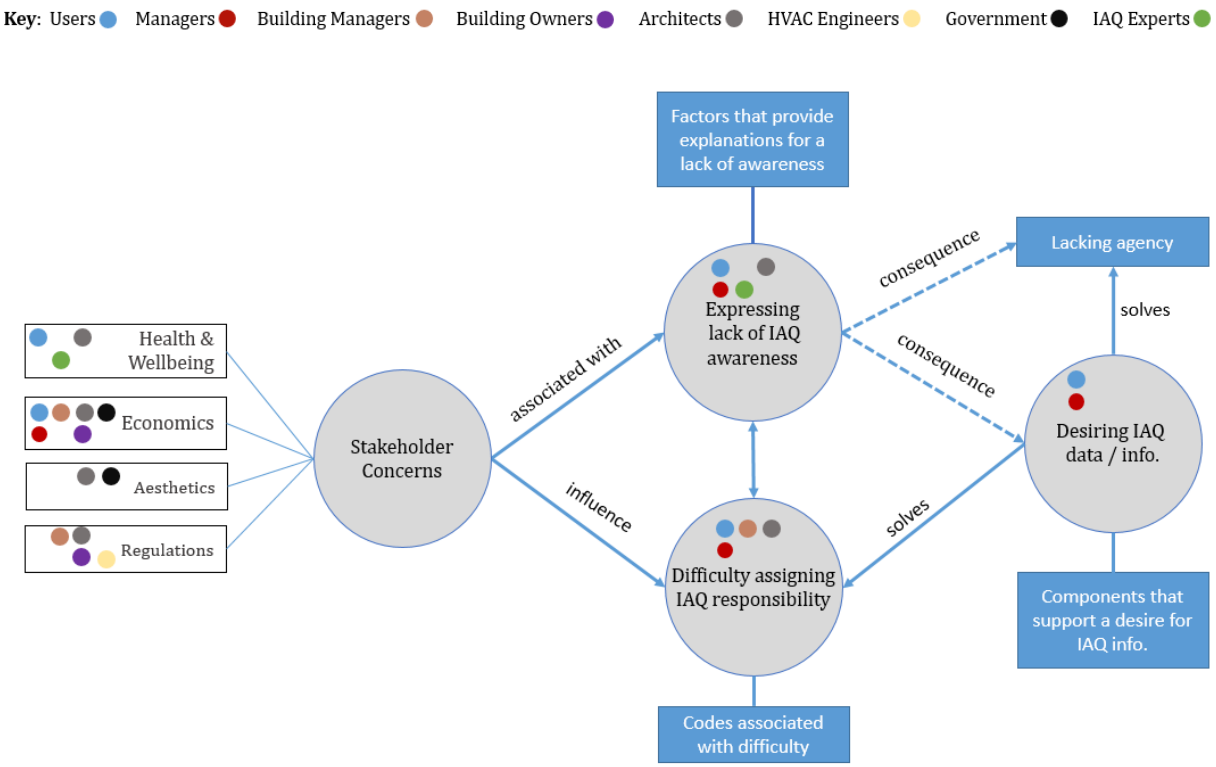

Figure 7: Awareness and Responsibility Stakeholders (Source: this research)

Chapter 5. Discussion

This research has explored perceptions held by multiple stakeholders towards IAQ and towards responsibility for good IAQ in offices. The results presented in the previous chapter are embellished and discussed.

The literature showed that significant motivations exist for offices to ensure that occupants receive optimal air quality. Yet, in line with Hamilton et al. (2016), it is apparent that this topic is still not given much importance or thought by managers and employees, despite weight given to it by research and WHO (2015). Lack of awareness on the side of management and lack of action on the issue could mean that building management are not pressured to ensure good IAQ beyond the minimum. It is argued here that the lack of awareness on the occupant side, and limited pressure for IAQ from the regulatory side, means that the responsibility for attaining and maintaining good IAQ lies with a few key decision-makers: the building manager, the building owner and the architects. However, as both building managers and owners are focused on costs, according to perceptions, there is a lack of incentive for them to pursue the highest levels of air quality. At the same time, the architect here is constrained by demand for optimal air quality by the clients and by regulations, as appeared in the results. As monuments

are exempt from the latest, tighter regulations, there is little pressure from the regulatory side to bring up air quality standards.

Regulations are certainly at the centre of many issues and the results seem to align with findings there exists a general *"abiding faith in minimum requirements set by standards"* (Hamilton et al., 2016, p.329). The trade-offs and economic factors involved in the constant reversion to the minimum are a concern not only for society but also for the economy, with both shown in the literature to be net losers from poor IAQ (EC, 2017). In addition, given the importance of openable windows as a component of comfort as expressed by participants, it could be argued that the government is responsible for ensuring that this need is met through building regulations, and in consideration of interrelated regulations such as fire-safety. In addition, in a pre-existing building with openable windows, the building manager is assigned the responsibility to inform users about outdoor air quality (IAQ Expert, Interview, 21 June 2017). It also indicates a need for government, companies and building designers to work together in ensuring a suitable location for office buildings. Further regulatory responsibility for the government is partly due to perceptions that market forces do not properly value or encompass IAQ. Therefore, an argument could be made to provide tax breaks to companies or building owners that ensure optimal IAQ, seeing as it is in the benefit of the economy and society as a whole (WHO, 2015; EC, 2017).

Awareness and understanding of air quality is perceived in literature to be poor partly because of the technical terminology prevalent such as personal exposure rates. Also, IAQ is at the nexus of building design and epidemiology research. Thus, information is isolated within silos. This is a problem to the extent that van der Zee et al. have developed a calculation to understand risks in more understandable terms – cigarette smoke equivalence (2016). It is suggested that the same approach is applied in offices in sharing IAQ information with employees. Desires for transparency and data about their local environment were a strong theme for users. The data was clear in displaying that office users want to be informed about IAQ. The issue may be slowly gathering pace, thus a proactive take towards including occupants in IAQ or the broader IEQ discourse and decisions around it, may be beneficial to an organisation. While HR departments may be aware of the benefits of good air quality, as shown in extant literature (Allen, 2016; Chang et al., 2016; MacNaughton et al., 2015), they could take note of user desire in having access to IAQ information or data. A proactive approach to employee wellbeing would see information shared with users and employees included in decisions about air quality. This could have potential benefits for employee satisfaction and company reputation. Or perhaps if users are given the feeling of control that will suffice. *"So I think that good air quality does have a strong effect on people's wellbeing but the psychological fact that they have an opportunity to adjust the direct environment,*

that's even more important" (Interview, Architect B). Systems compatibility with occupant preference is needed, for example the ability to open windows or operate air conditioning. What is not clear is whether organisations or building managers or architects want building occupants to be more informed or more active in the discussion.

The literature, in its assignment of responsibility, was either conflicting or vague (Den Hartog. 2004; Hasselaar & Morawska, 2003). While the results stop short of providing an easy framework for assigning responsibility, they do provide an understanding of who is responsible at different stages, which is one step further than the vague terminology used by the WHO. It also reduces the abstraction of the US EPA that responsibility for IAQ is shared. Rather, it is argued that different stakeholders all have different points of responsibility, at different situations and contexts. Responsibility is not shared in the sense that more than one party is responsible for the same element. As one participant mentioned: *"if two are responsible then no-one is responsible"* (Interview, User B). To be able to lineate responsibility according to the context could be useful in establishing not only liability, but where solutions to any problems exist.

This research identifies prioritisation of and responsibility for IAQ as hinging on awareness. Therefore, the urgency in raising awareness is underlined. Awareness is also expected to have a modifying effect on responsibility, empowering occupants in 'fighting for rights to clean indoor air'. This research stresses the centrality of occupant awareness in balancing out knowledge and supporting the recognition and assignment of responsibility for both attaining and maintaining clean office air. It encourages the provision of local IAQ data and information to building occupants and the creation of formal feedback loops for sharing information and accessing IAQ recourse. Better communication within buildings, between building managers and occupants, may facilitate understandings of health factors versus comfort among occupants, supporting decision-making. However, it emerges that access to recourse is important once awareness is place, in the form of technical solutions and, potentially, a clearly defined body of responsibility. If IAQ awareness were to grow, it is postulated that there would be a ready market for IAQ solutions, especially stop-gap. Thus, while responsibility still lies with the party with decision-making power related to a specific scenario, the widespread awareness and understanding should promote decisions in favour of a better outcome for all, modified by the multiple stakeholder concerns and not only the decision-maker. Involving a wider spread of stakeholders in a more democratic form of decision-making may also have positive outcomes. After all, a balanced outcome where responsibilities towards all there components of the triple bottom line is upheld could result in higher rewards (Elkington, 1998).

5.1 Conclusion

This paper contributes to the discourse of indoor air perceptions in offices. This research explores a number of themes, most significantly responsibility for attaining and maintaining optimal IAQ in office environment. Being exploratory, it introduces new theories and ideas, as well as opening up further avenues for research.

The research conducted and presented in this paper marks a first step towards understanding the concerns of different stakeholders and balancing the views of responsibility. The perceptions of multiple stakeholders invoked theories around a relationship between awareness, the availability of IAQ information in the hands of stakeholders and responsibility. The research theorises that prioritisation of and responsibility for good office air quality hinges on awareness. Further, responsibility is shown to be characteristically fluid and contextually evolving. This paper supposes that awareness would assist in ensuring that a dispersed form of responsibility would be upheld, supported by empowerment, particularly at the occupant level. It is conceived that understandings of IAQ and its risks and benefits amongst stakeholders would ease responsibility and also the path towards optimal IAQ. The research proposes regulatory improvements to facilitate this, for example addressing interrelations between regulations to avoid conflicts. Nevertheless, it is clear that more in-depth research with a refined methodology would better expose understandings of responsibility and any linkages between awareness, optimisation of IAQ and responsibilities pursued.

The research produces some learning outcomes for various stakeholders. Managers may learn from this research that employees would like to be better informed about air quality in the office environment, which could in turn support productivity. HR managers may take into account that individuals perceive air quality quite differently, meaning each complaint should be handled individually. Building managers can also make use of user desires for IAQ awareness. It could be beneficial to be transparent with building occupants about IAQ and to educate them about the various systems in place. Architects may accept that they are influential on IAQ in the building design stage and that minimum levels are not necessarily enough. Building owners may understand the extent of their responsibility not only to occupants but to society, and adopt a more sustainable way of thinking and return on investment.

Chapter 6. Limitations and Future Research

This paper explored perceptions of IAQ and responsibility for IAQ in office environments using a grounded theory approach. As a pilot study, the methodology and overall approach does have a number of limitations, described in this chapter. As a piece of exploratory research that aimed to uncover new insights and lines of research, recommendations are provided as to future research.

6.1 Limitations

Chapter 3 described a number of methodological limitations that this research is subject to. Research of a qualitative nature is commonly exposed to biases, as the collection and analysis of data is based on opinions and interpretations. As grounded theory relies on the author's interpretation of data and creativity in constructing concepts, there is undoubtedly bias in the way that results are constructed (Saldana, 2009). The interviews with participants may have yielded data subject to participant bias, either in the form of the mental outlook of participants at the time of the interview or perceptions of the air at that moment. In addition, some answers provided may have been framed in a way that aligned with professional duties, rather than own opinion. Although the research was focused on understanding a complex phenomenon and not generalizability, the location of the research has an effect. All users, managers and architects had offices located in the same building as each other. Perceptions of stakeholders from other buildings, particularly in one with many complaints, may have produced very different results.

Observer bias may also be an issue. I am not an experienced or expert interviewer, thus, biases show up in the questions I asked participants during the interviews, impacting the rigour of this research (Allan, 2003). Although neutrality was kept in mind and the intention was to hold open dialogues, I found it challenging not to project my own opinion onto the questions or prompts.

As I knew little about the research area, I undertook a review of relevant literature in advance of the data collection process, which I believe was essential to have the requisite knowledge to conduct interviews. Although this may not have constrained the research (McGhee et al., 2007), some GT practitioners may view it as a biasing influence (Glaser & Holton, 2004).

The small sample size, as a result of time constraints and participant unavailability, stands out as a significant limitation: participants represented not all identified key stakeholder groups. This produces obvious gaps in the research when opinions are aggregated or contrasted throughout the stakeholder groups, impacting validity. The stakeholder groups were also unequally weighted, reducing the ability to generalize within a group or to compare across

groups. The value of the data and results is negatively affected by the omission and imbalance of stakeholders. Validity is also limited by the single data collection method – augmenting the research with observational or survey questionnaire data in order to triangulate data would facilitate further analysis and stronger results (Yin, 2003; Saunders et al., 2003). In addition, the sample size has implications on the ability to fully embrace constructivist grounded theory principles, specifically in theoretical sampling (Charmaz, 2008).

Another limitation emerges from a basic misalignment between research expectations of participant understanding and the reality. Full understanding of IAQ and how it is managed and controlled in the office environment was generally lacking among participants, possibly impinging on the ability of participants to appropriately place responsibility. While the interviews held were of good length, only a small portion of interview time was attributed to discussions of responsibility, with participants less inclined to have strong opinions or begin narratives about responsibility. Although contributing to the results, this can also be said to be a limitation.

6.2 Future Research

This exploratory research is intended to pave the way for future research. The first recommendation is to build on this pilot study, in consideration of the methodology and limitations that this research exposed. The most important consideration is to ensure the participation of a valid number of key stakeholder group participants. It emerged late on in this research that equipment manufacturers may also be a worthy stakeholder group that could participate. Questions of triangulation also hold weight. While individual interviews are a good source of narrative and personal opinion, focus groups with multiple stakeholder groups may be a valuable addition, to enable discussion of issues and conflicts amongst participants that could lead to debates on responsibility or reveal other insights.

Further research could be conducted into the theory that broader awareness of IAQ among stakeholders could close knowledge gaps and act as a driver for responsibility. For example, does empowering employees with sensor data, transparency and educational courses have a ripple effect on responsibility? It would also be useful to get a societal perspective of the extent that health or comfort should be prioritised over the other, aiding understandings of responsibility bearings.

Given the number of variants in location and buildings and the importance of context in air quality perception studies, more comprehensive research is required (Bickerstaff & Walker, 2001). Changes in settings could lead to different outcomes, for example selecting participants from across multiple office buildings, or intentionally selecting both monuments and new office buildings to make comparisons. Conducting multiple interviews with a group of

stakeholders across different seasons may also influence results. Another twist on the research is to study occupant perceptions of IAQ before and after IAQ data and information is supplied to occupants to evaluate changes in perception. One caveat for further perception research is the low level of occupant awareness of IAQ and its risks and benefits (Hamilton et al., 2016).

In tangential lines of research, a couple of areas appear ripe for investigation. For example, costs of IAQ are still perceived to be high. Research into building costs and triple-bottom-line return-on-investment could yield results that would influence decision-making in building and maintenance. In another example, parallel research into deeper philosophical questions about where responsibility *should* lie ethically versus where it currently lies would be insightful and helpful in building policy and processes to ensure that responsibility is placed where society as a whole sees fit.

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Appendices

Appendix A: Dutch Legislation on Air Quality

This appendix contains relevant Dutch legislation that could be found on indoor air quality pertaining to office buildings. Legislation outlined here is not an exhaustive list, only what could be found through web-based research. These include translated extracts from the building codes and the working conditions decree. The other source of regulations, the collective contract conditions, are numerous, contextual and difficult to access.

Dutch Building Codes (Bouwbesluit)

The Dutch building codes are accessible at https://rijksoverheid.bouwbesluit.com (Rijksoverheid, 2017).

use function	Members apply																										limits
	air recreational area, lounge, toilet and bath room							thermal comfort	controllability			ventilation remaining spaces							Instead of the opening			Air Quality									construction		temporary construction	capacity per person
article	3:29							3:30	3:31			3:32							3:33			3:34									3:35		3:36	3:29
member	1	2	3	4	5	6	7	*	1	2	3	1	2	3	4	5	6	7	1	2	3	1	2	3	4	5	6	7	8	9	1	2	*	3 [dm 3 / s per person]
1 Useful Function	1	2	-	4	5	6	7	*	1	2	3	1	2	3	4	-	-	-	1	2	3	1	2	3	4	5	-	7	8	-	1	2	*	-
2 meeting function																																		
a childcare	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	*	6.5
b Another meeting function	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	4
3 cell function	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	
a cell																																		12
b another dwelling																																		6.5
4 healthcare Job	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	
a bed region																																		12
b another dwelling																																		6.5
5 industry Position	-	-	3	4	-	6	7	-	-	-	-	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	6.5
6 office Job	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	6.5
7 Bed Feature																																		
a. in an accommodation building	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	2	-	4	5	-	7	8	-	1	2	-	12
b. other accommodation function	-	-	3	4	5	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	2	-	4	5	-	7	8	-	1	2	-	12
8 teaching Job	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	*	8.5
9 Sports Feature	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	6.5
10 Store Function	-	-	3	4	-	6	7	*	1	2	3	-	2	3	4	-	-	-	1	2	3	1	-	-	4	5	-	7	8	-	1	2	-	4

Figure 8: Building codes (Source: Rijksoverheid, 2017)

The above figure shows that Air Quality regulations are contained in Article 3.34. Clauses related to offices, appear in points 1, 4, 5, 7 and 8, shown in the following translation:

Article 3.34 from Building Codes 2012, from the Dutch Government.

1. The supply in Article 3:29 [related to capacity] takes place outside direct fresh air to a residential quantity provided.

4. The supply of fresh air to a shaft for an elevator will directly from the exterior location, or through the elevator machine room from the outside. Disposal of indoor air from such a space is made directly to the outside instead, or the elevator machine room outside.

5. The supply of fresh air to a storage space for household waste takes place directly from the exterior, and the outlet of indoor air directly to the outside.

7. At least 21 dm / s capacity of the discharge of indoor air from a dwelling or residence space in which a space for a cooker, under Article 3:29, fourth paragraph, there is discharged directly to the outside.

8. The discharge of an indoor toilet or bathing area will find out directly instead.

Dutch Working Conditions Decree

The Dutch Working Conditions Decree is a set of universal employment regulations that includes articles related to the indoor air quality. They can be accessed, in Dutch, online at http://wetten.overheid.nl. Articles relating to indoor air quality primarily concern ventilation and certain pollutants and are translated below. This list is non-exhaustive due to translation limitations and lack of clarity amongst regulations. Not shown are asbestos limits (covered in article 4.4) and VOC rules (Section 7)

Article 6.2 Ventilation

1 At the workplace there is sufficient uncontaminated air present.

2 Ventilation systems are always ready for operation.

3 Air-conditioning systems operate in such a way that workers are not exposed to disturbing voyage.

4 Air-conditioning systems have a control system that signals faults in the installation as far as necessary for the health of the employees.

5 The first paragraph does not apply to workplaces in a building as referred to in article 1, subsection 1 of the Housing Act.

6 A workplace in a building as referred to in article 1, paragraph 1, of the Housing Act shall be used only if the building complies with the regulations prescribed by or pursuant to the Building Decree 2012 regarding the applicable use function within the meaning of that decision.

Article 4.5. Ventilation

1 If contaminated air is discharged, simultaneous supply of uncontaminated air is ensured.

2 It is forbidden to recycle air containing a hazardous substance to a place where the substance in question is not present.

3 It is forbidden to bring the air containing a substance as referred to in paragraph 4 back into the same place of work unless the employer shows that the concentration of a substance

referred to in paragraph 4 in the air supplied to that Workplace does not exceed one tenth of the limit laid down for that substance.

4 This article applies to the following substances:

A. Carcinogenic and mutagenic substances as referred to in Article 4.11, b and d;

B. A substance released from a carcinogenic process as referred to in Article 4.11, part c;

C. A substance that complies with the following hazard designation as referred to in the EC Regulation, classification, labeling and packaging of substances and mixtures: H phrase 334.

Artikel 4.46. Limit values

1 The concentration of asbestos fibers of the chrysotile type does not exceed the limit of 2,000 fibers per cubic meter, calculated over a reference period of eight hours a day.

2 The concentration of amphibious asbestos fibers actinolite, amosite, anthophyllite, tremolite and crocidolite does not exceed the limit of 10,000 fibers per cubic meter, calculated over a reference period of eight hours a day.

4.62 covers the Prohibition of benzene and chlorinated hydrocarbons

1 The use of benzene or a product whose benzene content is more than 1% by volume as a solvent, cleaning or diluent is not permitted unless done in a closed system or in another way which provides protection for exposure to at least the same extent Offered to it.

2 If benzene or a product as referred to in the first paragraph is used other than solvent, cleaning or diluent, this is carried out as much as possible in a closed system.

3 The first and second paragraphs shall apply mutatis mutandis to carbon tetrachloride, pentachloroethane and 1,1,2,2-tetrachloroethane as well as to a product whose content exceeds 1% by volume of one of the aforesaid substances.

Appendix B: Coding Example

To provide the reader with an impression of the coding process I employed, I have provided below an excerpt of an interview transcript as produced for this research. Alongside are the codes that I applied during the data analysis.

Transcript	**Codes**
And, at this moment, I really have no idea if you and I have good air quality or not, you know. But do I care? Yeah, I do care. Yeah, well, it's really… as long as I don't feel it, or smell it, or hear it, then I think OK, this is OK. I can open a window. It has become very specific, very technical, very specialised field in the total design of the building. It's really like, listen guys, you have to make sure that the air quality, or the temperature or whatever, is within the requirements of the law. And then we think OK. The only thing we try to do is "that's ugly, we want it somewhere else" or… It's very present you know. Look at ceiling in public spaces for example: I hate it, it's horrible.	"I really have no idea" Expressing lack of awareness Prioritising comfort Windows facilitate comfort "within the requirements of the law" Defining concerns: aesthetics

A screenshot of the software used in the coding is shown below. This image displays the list of code groups developed on the left and some of the codes from within the Health & Wellbeing group on the right.

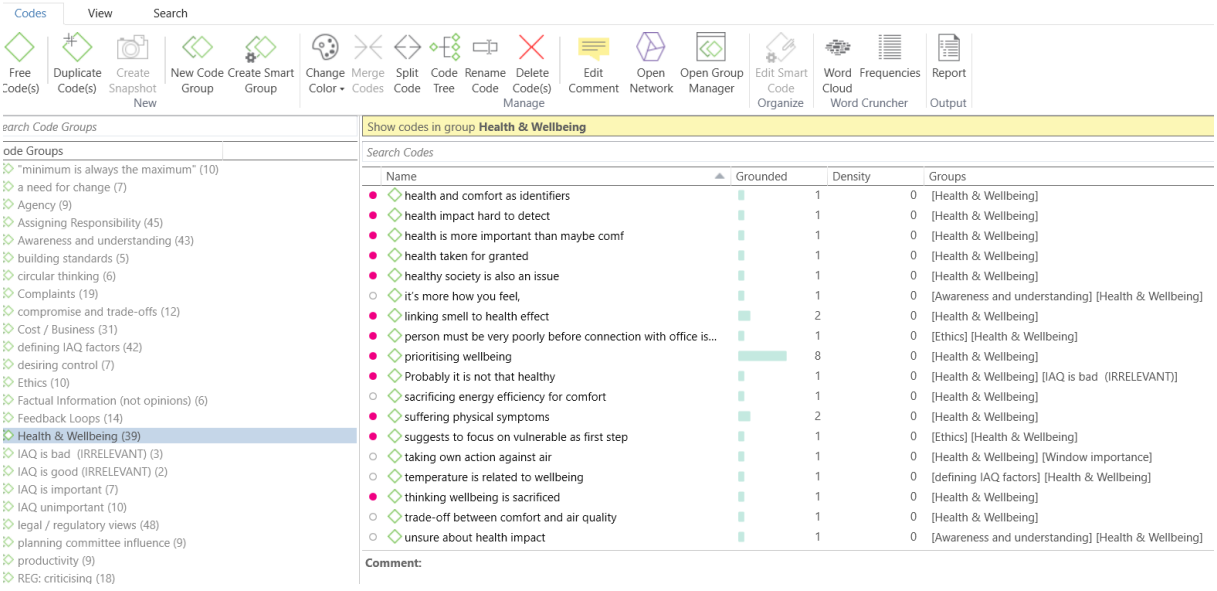

Figure 9: Codes in atlas.ti (Source: this research)

Appendix C: Interview Protocol

The approach I adopted to conduct interviews is based on the book of Rubin & Rubin (2011). As outlined the methodology chapter, semi-structured interviews were based on questions themes, with questions varying based on which stakeholder group the participant being interviewed belonged to. Their proposed *responsive interviewing* technique is adopted, engaging in conversation in reciprocal manner. This lies within the natural-constructionist mentality, accepting vagueness, the influence of both interviewer and interviewee on the conversation, and persistent flexibility.

Before the interview formally began, I attempted to engage in casual conversation to create a relaxed atmosphere and build a feeling of trust.

The interview formally began at the point I received an affirmative answer upon asking whether I could record the interview.

All stakeholders were asked common introductory questions similar to the following:

- What is your role?
- How does office air quality affect you in your role?
- What is good air quality to you?

Depending on the stakeholder being interviewed, later questions reverted to the themes:

- Responsibility in general and in hypothetical scenarios
- The roles of other stakeholders e.g. government, employer
- Knowledge of IAQ in their office environment
- Issues experienced.

Participants were given scope to talk openly about related topics as they came to mind. I tried to maintain any narratives with gestures and verbal cues.

Interviews always ended by requests for 'anything I missed or forgot?' and by requests for any other contacts that may be of interest to my research.

Interviews were often followed by informal conversations, after which I took memos of to record any details I could recollect.