

Assessment of wellbeing in an indoor office environment

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ABSTRACT

Relationships between indoor building conditions and wellbeing of occupants are complex; many indoor stressors can exert their effects additively or through complex interactions. It has been shown that exposure to these stressors can cause both short-term and long-term effects. Relevant relations between measurements of chemical and physical indoor environmental parameters and effects have been difficult to make. To increase the chance on successful assessment of cause-effect relationships in future indoor environmental quality (IEQ) investigations, there seems to be a need to improve procedures applied to gather the relevant information. From different fields of expertise knowledge was retrieved on how and why people respond to external stressors, which factors, parameters or indicators can be used to explain these responses and how to assess those. No consensus exists on which physical, physiological, psychological or social indicators should be applied to explain these responses. However, several existing techniques are available and promising innovative techniques are being developed, of which the applicability needs to be explored. The review results in a better overview of which factors are important to consider in future studies.

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1. Introduction

Previous studies have shown that the relationships between indoor building conditions and wellbeing (health and comfort) of occupants are complex (e.g. [1–5]). There are many indoor stressors (e.g. thermal factors, lighting aspects, moisture, mould, noise and vibration, radiation, chemical compounds, particulates) that can cause their effects additively or through complex interactions (synergistic or antagonistic). It has been shown that exposure to these stressors can cause both short-term and long-term effects. In office buildings, a whole range of effects have been associated with these stressors such as Sick Building Syndrome (SBS), building related illnesses and productivity loss. More recent studies have indicated that indoor building conditions may also be associated with mental health effects [6], illnesses that take longer to manifest (e.g. cardiovascular disease [7,8]; a variety of asthma-related health outcomes [9]) or even obesity [5].

Although previous studies have shown associations between indoor stressors and comfort, health and productivity in an office environment [10–12], relevant relations between measurements of chemical and physical indoor environmental parameters and effects have been difficult to establish [13,14]. This may be explained by the following [15]:

- Many exposure-response relationships have not yet been (sufficiently) quantified;
- Little is known on the complex interactions between risk factors (or parameters) in the indoor environment and effects are not all known [16];
- Many risk factors may currently not even have been identified;
- Factors other than indoor environmental aspects (e.g. social and personal factors) may influence the effects;
- Exposure and response may be time dependent (e.g. daily, weekly and seasonal patterns);
- The needs and requirements of people are subject to change over time: Requirements and responses of people today differ from those people living 100 years ago;
- Previous exposures and circumstances are often unknown but may influence and therefore may be important to consider.

Basically, it may largely be brought back to the fact that insight into the mechanisms underlying the relationships between indoor environmental aspects and wellbeing is still limited, both at the receiver side (the exposed person) and at the sender side (sources of exposures/stimuli). Because we simply do not know all the interactions or mechanisms taking place between the sources that produce/cause the stimuli, among the stimuli, and between the stimuli and the exposed persons, in IEQ investigations *short-cuts* have been taken. In a short-cut, the building characteristics (such as having an HVAC system) or measures taken (such as a maintenance or cleaning schedule) are directly related to comfort or health

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responses of occupants. The term short-cut was previously introduced by Bluysen et al. [17]. The prerequisite for successfully performing such a short-cut or pattern recognition is however that the ‘right package’ information is gathered. Biological, chemical and physical monitoring of the parameters in the indoor office environment (stimuli) is not carried out as a first step in this approach. Measurements of biological, chemical or physical parameters may be taken as a second step.

Methods applied in IEQ investigations varied from an epidemiological approach, in which questionnaires and health/comfort data may be used either in combination or not with biomarker sample collection (e.g. blood, urine), field studies in which in general a smaller sample of persons is studied in combination with environmental inventories, to laboratory studies in which persons or animals are exposed to controlled environmental conditions [18–21]. Health and comfort data are then combined with information on characteristics of the indoor environment in order to find relations. However, other risk factors that may cause psychological or physiological stress (e.g. major life events), individual differences caused by personal factors (e.g. states and traits), or history and context can all affect the outcome that is being studied. These factors are taken into account only to a limited extent in current methods commonly applied to identify relationships between health and comfort of people and the physical and social environment.

To be more successful in determining the health and comfort effects of certain indoor environmental aspects there seems a need to improve procedures applied in IEQ investigations. First, it is essential to understand the mechanisms behind how and why people respond to external stressors. The next step is then to determine which parameters or indicators can be used to explain these responses and how to assess those. Only when the picture is more clear, procedures can be improved in such a way that the chances to successfully assess the effects caused by different stressors (or combination of stressors) increase. The following questions seem thus important to discuss in order to get a better picture:

- *Human model*: How and why do people respond to external stressors?
- *Information*: Which parameters or indicators can be used to explain these responses?
- *Assessment*: Which methods/techniques can be applied to measure the responses?

In the underlying review an attempt was made to answer these questions, using information from previous studies and available information from different disciplines. Wellbeing is the overall term used for health and comfort throughout the publication.

2. Human model

Depending on how the body and mind cope with acute or chronic stress, stressors (both psychosocial and physical) may cause an imbalance of the human systems (body-brain connection) [22], which immediately or over time may cause physiological, physical and psychological changes. Personal factors, such as state and traits, but also previous exposures and circumstances and other factors may influence the perception of, coping with and responses to those stressors. In Fig. 1 a schematic overview is presented of this body and mind model, including stressors, factors of influence and responses, which will be explained hereafter.

2.1. Human systems

Human exposure to external stressors (physical and psychosocial) occurs mainly through the senses (recognised or not

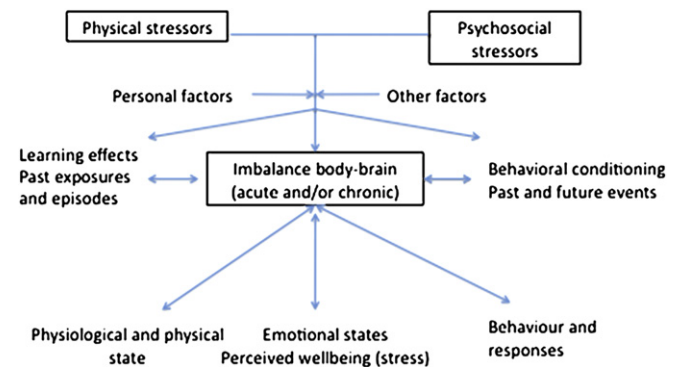


Fig. 1. Imbalance of the human systems: stressors, factors of influence and responses.

recognised). Receptors in our nervous system receive sensory information as sensations via the eyes, ears, nose and skin, enhanced by bodily processes such as inhalation, ingestion and skin contacts. External stress factors can influence all three control systems of the human body (the nervous system, the immune system and the endocrine system) and can result in both mental and physical effects [23,24]. Our emotions and evaluations are controlled by our limbic system (part of central nervous system) and other parts of the brain, and the autonomic nervous system keeps the parasympathetic and sympathetic activity in balance. The defence of our human body against (potential) disease (e.g. irritation, allergy, infection, toxicity) caused by stimuli from the environment are controlled (or better fought against) by the immune system that produces cytokines, which are transported by the lymphoid system. The endocrine system receives and sends information via blood vessels to endocrine glands that produce specific hormones, and provides boundary conditions for “control” of environmental stimuli by our immune as well as our limbic system. These systems are thus pretty much intertwined.

Interactions may occur between stressors in complex, real-life exposure situations as well as between various body responses to exposure(s). Our senses perceive individually, but interpretation occurs together. To truly evaluate the effect of an indoor environmental situation, therefore all routes of exposure (both physiological and psychological) and all interactions between and in the human systems can in principal be worth considering.

2.2. Responses

Most of us are familiar with several reactions of the human body to certain stimuli such as sweating when warm; closing/narrowing your eyes with a sharp light, temporarily stop breathing with a bad smell, allergic reactions to pollen, certain inflammation and infection defence mechanisms of the immune system upon an injury of the epithelium (the “skin” of an organ) or even chronic reactions (e.g. asthma). For all of these reactions can be said that external stressors (mainly physical) cause an imbalance in one of the bodily systems characterised by changes in production of hormones and cytokines and other physiological processes to restore the balance. Gee and Payne-Sturges [25] define “stress” as a state of activation of physical and psychological readiness to act in order to help an organism survive external threats. Stressors causing a response may on the long-term produce illness by weakening the body’s ability to defend against external challenges.

External stressors (physical or psychosocial) causing stress, can on the short-term cause the adrenal medulla to produce epinephrine (adrenaline) and to prepare the body for action (fight-or-flight) (through the sympathetic nervous system by producing norepinephrine). If the stressor is limited in time and perceived intensity, in

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