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# UNDERSTANDING THE INDOOR ENVIRONMENT, ITS OCCUPANTS, INTERACTIONS, AND EFFECTS

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## ABSTRACT

Indoor environmental quality is still described with quantitative dose-related indicators, expressed in number and/or ranges of numbers for each of the factors (indoor air, lighting, acoustics, and thermal aspects). Interactions of stressors and effects at and between human and environment level are ignored. Individual differences in needs and preferences of occupants (over time) are not accounted for. We need a more complex research model and other indicators than the dose-related indicators used in our guidelines: building-related and occupant-related indicators.

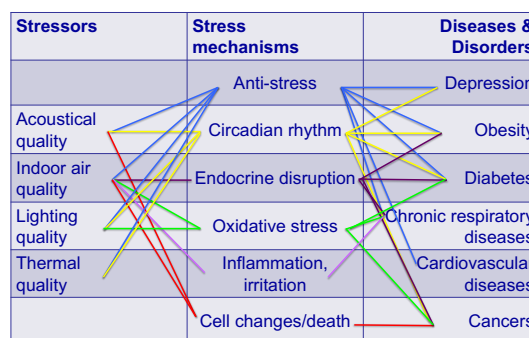
**Keywords:** *indoor environmental quality, diseases and disorders, interactions, preferences and needs, stressors.*

## 1. INTRODUCTION

We are confronted with diseases and disorders related to indoor environmental quality such as mental illnesses, obesity and illnesses that take longer to manifest, among which cardiovascular and chronic respiratory diseases and cancer, and very recently, COVID-19. Except for these health effects, the effects of the retrofitting measures we take to reduce energy consumption on health and comfort indoors, is also an emerging concern. Research has shown that, even though the conditions seem to comply with current standards for indoor environmental quality, staying indoors is not good for our health [1]. Reasons for this discrepancy might be the

fact that these guidelines are mostly based on single-dose response relationships to prevent negative effects, and that the criteria are determined for an average adult person [2]. The human body has several stress mechanisms available to cope with different stressors. Research in different fields shows that the relations between the stressors, those mechanisms that take place in the human body causing the diseases and disorders, are very complex [1] (Figure 1). Therefore, except for health threatening exposures, complexity, number of indoor environmental parameters and lack of knowledge, make a performance assessment using only threshold levels for the single parameters difficult and even meaningless.

### Human level



**Figure 1.** Possible interactions between stressors, mechanisms and diseases and disorders at human level (from [1]).

Besides interactions at human level, interactions occur in the environment over time, making it even more complex. Interactions in the environment can cause additional unwanted effects or even interfere with the primary effect. Increasing ventilation by opening a window can introduce

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noise from outdoors, and can introduce cold air during wintertime, and warm air in the summer. But also, in situations with a mechanical ventilation system, problems with noise from the increased airflow in the ducts, the so-called rustle of the air, can increase, when systems are put on their max possible airflow for as much ventilation as possible. Not to speak about the drafts this can cause.

## 2. 'NEW' RESEARCH MODEL

Therefore, a more complex model that accounts for all stressors, both positive and negative (so-called patterns of stressors), interactions, and preferences and needs of the individual for different scenarios and situations (expressed in profiles) was introduced (Figure 2) [3].

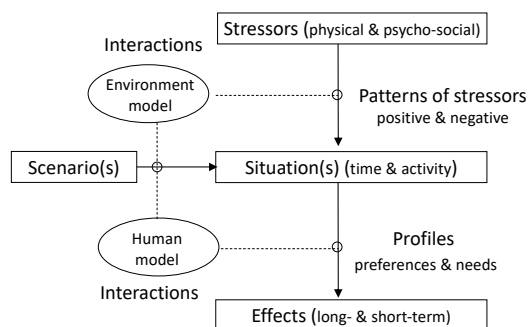


Figure 1. New model [3].

To validate this 'new' model, patterns of stressors and profiles of people for different scenarios (office workers and their workplace, students and their homes, primary children and their classrooms, employees of outpatient areas in hospitals) were determined in several field studies [4]. The outcome showed that people differ in their preferences and needs, and it is possible to distribute them into clusters based on TwoSteps cluster analysis of preferences and needs acquired through a questionnaire. Moreover, it is possible to determine pattern of stressors for different scenario's based on multivariate regression analysis of a survey of occupants and the buildings they are occupying.

## 3. NEED FOR OTHER INDICATORS

Next to this 'new' research model, it is important to consider other indicators that can be related to health and comfort of occupants to turn the negative effect around into

a positive experience. According to the standards a healthy building is a building that complies with the existing standards and guidelines for mainly the environmental or dose-related indicators. However, from previous studies it is clear for assessing whether a building is healthy, more is needed. A 'healthy' building should be a building that has the means to support the physical, psychological, and physiological health and comfort of its occupants over time. A 'healthy' building can influence health and comfort of its occupants through the thermal, lighting, acoustical and indoor air quality of the indoor environment. Therefore, indicators focused only on the control of single environmental factors with the so-called dose or environmental indicators, are not enough. We have two other categories of indicators that can be used: the so-called occupant-related indicators (such as preferences and needs, activity level, health status) and the building-related indicators (such as characteristics of a building and its components and certain measures taken) ([1-4]).

## 4. CONCLUSIONS

New ways of creating and maintaining healthy and comfortable indoor spaces for different occupants in different situations, require better understanding of the indoor environment, its occupants, and interactions. We need a more complex research model as well as other indicators than the dose-related indicators used in our guidelines: building-related and occupant-related indicators.

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