Towards a new procedure for identifying causes of health and comfort problems in office buildings

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SUMMARY
In the European project OFFICAIR a procedure has been prepared for the inventory and identification of associations between possible characteristics of European modern offices (building, sources and events) and health and comfort of office workers, via a questionnaire and a checklist including environmental, physiological, psychological and social aspects. This procedure was applied in circa 160 office buildings in eight European countries (Portugal, Spain, Italy, Greece, France, Hungary, The Netherlands and Finland) during the winter of 2011-2012.

KEYWORDS
Office buildings, indoor environment, health, comfort

1 INTRODUCTION

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 that is needed (Bluyssen et al. 2011a). In a recent overview it was shown that all potential stressors and factors, whether of psychological, physiological, social or environmental nature, that can have an influence on the health and comfort of people may be relevant to include (Bluyssen et al., 2011b).

Methods applied in IEQ investigations varied from an epidemiological approach, in which questionnaires and health/comfort data may be used in combination or not with biomarker sample collection (e.g. blood, urine); field studies, that allow to study biological and physiological markers in smaller samples of participants, in combination with environmental inventories and exposure monitoring; to in vitro and in vivo toxicological studies, making use of controlled exposure conditions. Health and comfort data are then combined with information on characteristics of the indoor environment in order to find relations. In all this studies, the associations between the characteristics of the indoor environment and health and comfort are investigated. However, other risk factors related to psychological or physiological stress (e.g. major life events), individual differences (e.g. states and traits), or history and context can affect the investigated outcome (Bluyssen et al., 2011b).

Epidemiological studies in Europe and US have addressed indoor air quality (IAQ) and associated exposure source related symptoms in office workers using questionnaire surveys (e.g. Bluyssen et al., 1996; Brightman et al., 2008; Reijula et al., 2004; Jaakkola et al., 2007). The investigated symptoms traditionally included mucosal irritation (eyes, nose and throat) and general symptoms, such as tiredness and headache: generally eye irritation and tiredness are among top-two reported symptoms, e.g. (Brightman et al. 2008). The results from recent studies on this topic suggest that indoor air pollutants could be also related to effects on the cardiovascular system (de Oliveira Fernandes et al., 2008). Moreover, psychosocial stress has been hypothesized to make individuals more susceptible to environmental exposures (Gee and Payne-Sturges 2004), and its role as a potential effect modifier need to be further investigated. Psychosocial stressors comprise of stressors in the social environment (e.g. social disorganization), individual psychosocial stressors (e.g. socio-economic status and working conditions) and major life events (e.g. job loss or a death in the family). Advantageous and disadvantageous events could move individuals away from their personal baselines. This shift seems not be always temporarily, caused by major neurobiological mechanisms capable of creating physiological and psychological responses (changes in pro-inflammatory cytokines, behavioural and somatic responses). This may lead to unconscious behavioural conditioning and sometimes unwanted learning effects (psychological and physiological) and symptom misattribution (Riether et al., 2008; Bulsing et al., 2009).

2. THE EU OFFICAIR PROJECT

OFFICAIR is a European collaborative project, co-funded by the European Union, in the 7th Framework Program (FPF-ENV-2010). The project, which comprises of 15 partners from 11 countries, has officially started on November 1st 2010 and will run for 3 years (see www.officair-project.eu).

The overall objective of the OFFICAIR project is twofold. First, to establish a framework that will provide new knowledge in terms of databases, modelling tools and assessment methods towards an integrated approach in health risk assessment of indoor air pollution, focusing on modern office buildings. Second, to support current EU policies, such as, the Thematic Strategy on Air Pollution and the European Environment and Health Strategy and Action Plan.

Among others, OFFCAIR aims to inventory and identify stressors that have been appointed as possibly related to IAQ problems in European modern offices, via a field investigation (through questionnaires, checklists and IAQ monitoring). This includes, on the emitting side, the building/workspace characterisation, the assessment of the physical, chemical and biological parameters and, on the occupant's side, the subsequent exposures and health effects of the time spent indoors.

For this purpose, a procedure with a questionnaire and a checklist was prepared for the survey of 160 office buildings in the winter of 2011-2012. In each of 8 countries (Greece, Italy, Spain, Portugal, France, Hungary, The Netherlands and Finland) 20 buildings were selected. From these 20 investigated buildings, 3-5 buildings per country will be selected for detailed measurements, including environmental monitoring and medical examination. In a last step, in 1-2 building(s) per country (from the 3-5), an intervention will be performed to improve the indoor environmental quality. The procedure for the first step, the survey, is reported here.

3. PROCEDURE SURVEY

The procedure of the survey of the 160 buildings comprises: the selection and gathering of the buildings, the survey in the buildings, and the data management.

Selection of buildings

The selection of the buildings started in April 2011 and took until the survey itself. The following criteria were used for the selection of 20 modern office buildings per country:

- New or modernised buildings (use of modern equipment and access to internet)
- Assuming a 70% response rate, at least 860 workers should be investigated in each country (based on a singulary calculated sample size of 600), resulting in: 10 buildings with at least 70 workers and 10 buildings with at least 30 workers. (More workers were preferred though).
- Access to basic information on building fabric, services, HVAC systems (if applicable), cleaning practices, smoking polices, etc.
- Buildings should have been operating in their current form for a minimum of 1 year prior to the start of the study (preferable 2 years).
- No major renovation planned before the autumn of 2012.
- Access to Internet for digital questionnaires.
- Clear point of contact.

Desirable, but not mandatory, selection criteria for the whole sample included a mix of locations (urban, suburban, rural), HVAC types (incl. natural ventilation), public and private buildings, open and cellular office spaces and various types of activities (e.g. banking, insurance, calling centre, researchers). In any case, the collection of enough buildings was the first priority.

Survey in buildings

The survey of the buildings comprised of a digital questionnaire and a walk-through using a checklist. The procedure was based on a three weeks pattern in each building:

1. Information (Monday 1st week): A week before the survey took place, an email was sent out preferably by the management, or contact person, in the company, explaining the purposes and the contents of the survey (that is: a questionnaire will be executed via Internet and the investigating team will visit the building to perform an inspection).
2. Invitation letter (Monday 2nd week): Each worker received an official invitation e-mail in his/her own language containing again a brief explanation of the purposes of the survey, the identification code of the building and the deadline for questionnaire filling in and a link to the digital questionnaire in the countries main language.
3. Questionnaire: In principal all workers of a building received a questionnaire. In buildings with more than 100 workers, a part of the building (one or two floors or if the office buildings comprises of several separated buildings, one or more of those) could have been selected. The workers were asked to give an informed consent and the need for a positive answer to further fill in the questionnaire was clearly explained. The worker had the opportunity to select a different language for the questionnaire. In order to maintain confidentiality of data after 90 minutes the answers were erased from the cache and should be restarted from the beginning. Participant could save the survey at any time and resume it later.
4. Walk-through with checklist (preferable Tuesday or Thursday in 2nd or 3rd week): Most information was obtained by a walk-through the building, including plant rooms and circulation areas, as well as offices. This walk-through was in many cases accompanied by a facility manager or equivalent, who could supply some of the information orally.

Furthermore, further documentation was obtained (before or after the walkthrough) to complete relevant parts of the checklist (such as maintenance records, cleaning schedules, settings of installations and layout of building).

5. Reminder (Wednesday 3rd week): A reminder to fill in the questionnaires was sent on Wednesday morning of the 3rd week to all workers.
6. End of the survey (Saturday 3rd week): the deadline of filling in the questionnaire.

Checklist

The contents of the checklist was mainly based on the checklist for office buildings applied in the former European project HOPE focused on the indoor and built environment and deleting information about energy efficiency (Bluyssen et al. 2011a) and the suggested components in Bluyssen et al. 2011b (see Table 1). The information on the psychosocial environment e.g. features such as organisational structure, working hours and social working conditions were not included, since they were covered by the questionnaire and are not the main purpose of the investigation.

Table 1. Suggested components and sub-components of a checklist in an IEQ field investigation (Bluyssen et al. 2011b).

Components	Sub-components
The indoor and built environment:	
Characteristics of building, systems and rooms	i.e. (openable) windows, type of HVAC system, lighting system, control system, etc.
Characteristics of the built environment	i.e. busy road, rural/ surroundings, etc.
Processes to maintain and operate the building and its activities	e.g. maintenance of HVAC system, cleaning activities/schedule, renovation and retrofitting activities.
The psycho-social environment:	
Working environment	e.g. organisational structure, working hours and social working conditions
Neighbourhood	e.g. neighbourhood quality of office building

Questionnaire

Based on a literature review (Bluyssen et al. 2011b) and expert's consensus, the questionnaire was defined through a compilation and integration of existing questionnaires including the categories presented in Table 2. The questionnaire was voluntary and anonymous. Participants were able to skip any question they would not feel comfortable with. There was an automatic check of completeness, and missing answers were signalled to the participant at the end of the survey, in order to decrease involuntary missing answers. To maintain confidentiality, the questionnaire needed to be filled in consecutively, in less than 90 minutes. After 90 minutes, the answers were automatically erased; it was possible to start again from the beginning. One could also save the answers at any time and start again later (without the limit of 90 minutes).

Data management

All data, from the questionnaire as well as the checklist, were digitally completed and stored in the secure database provided by the University of Milano via a web-link.

Table 2 Components and existing questionnaires in the OFFICAIR questionnaire.

Components	Sub-components	Existing questionnaires
Personal data (demographic)	Age, sex, family status, smoking, education , commuting	Several
Work data	Office, job position, work seniority, full/part-time, working hours, type of work, VDU use, daily activities	Several
Psycho-social environment	Work-related stress	ERI-over commitment (Siegrist et al. 2004)
Psychological characteristics	Model of affect as one indicator	PANAS short version (10 items) (Thompson et al. 2007) Emocards
Events	Recently special positive event(s) Recently special negative event(s)	
Physical state	Psycho-physical health Indoor effects and physical environment perception	Adapted from HOPE (Roulet et al.2006)

NEXT STEPS

Data analysis

After completion of the survey, the data will be analyzed in two steps. In the first step, percentage of symptoms and complaints related to both physical and psycho-social environment for each building will be calculated, in order to select 3-5 buildings to be further investigated in the detailed study (and later in the intervention study). The second step will include among others a data reduction followed by the analysis of association between exposure and health and psycho-social outcomes, applying mixed-effects models with random intercepts.

Detailed study and intervention

It is planned to perform the detailed investigation twice: in summer 2012 and winter 2012-2013. The intervention study will be performed in the winter of 2012-2013. Both studies will comprise of chemical/physical measurements of the indoor environment, a checklist and questionnaire similar to the general survey, and a time-activity diary for 20-30 selected workers per building. Additionally, in the intervention study innovative measurements with fine dust, other particles and radicals, medical tests (e.g. lung function assessment, blood pressure and oxidative stress markers in urine, cortisol) and specific measurements for modelling purposes will be performed.

Framework

The statistical analysis for source characterization and health and comfort outcomes will contribute to the envisaged framework of short-cuts and other information that can assist with creating and maintaining a healthy and comfortable indoor environment (see also Bluyssen, 2012). The relative importance of the physical and psycho-social environment will be studied.

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