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The influence of tenure status on housing satisfaction and indoor environmental quality in Finnish apartment buildings

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ABSTRACT

Based on a previous nationwide housing and health questionnaire survey, we observed significant differences in many housing quality attributes by dwelling types and tenure status. Respondents living in apartment buildings and rental houses reported being less satisfied with their housing conditions than respondents living in owner-occupied apartments or houses in Finland. In this subsequent work, we aim to study the associations between tenure status and housing satisfaction among respondents living in apartment buildings (N = 397). Further, we used measurement data collected from 28 apartments in six buildings to determine if the differences in housing satisfaction could be related to objectively measured indoor environmental quality indicators: indoor temperature, relative humidity, and carbon dioxide concentrations. Based on the results, the respondents from rental flats were significantly more unlikely to be satisfied with their dwelling, and to report their dwellings to be suitably warm in winter than the respondents from owner-occupied flats. Based on the measurement data, small differences were observed in thermal conditions by tenure status; however, a large portion of all apartments appeared to be overheated, and only one apartment experienced room temperatures below 18 °C during winter. In conclusion, there were large differences between occupant self-reported satisfaction and thermal comfort by tenure status, but differences in measured parameters were relatively small. The results indicate that occupant characteristics are likely to explain a majority of differences by tenure status, which should be taken into account when assessing the overall relationships between housing and health.

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1. Introduction

Housing is an important area of research because people spend most of their time in residential environments [1], which can affect health [2]. Satisfaction with a dwelling is associated with physical and mental health, and health satisfaction [3]. Many housing and indoor environmental factors have been associated with occupant health. For example, too high room temperature can increase chemical emissions from interior materials and cause symptoms such as fatigue, as well as decrease the ability to concentrate [4,5]. Dampness and mould are well-known risk factors for asthma symptoms and other respiratory symptoms [6]. Evidence exists about noise exposure being associated with cardiovascular diseases and symptoms [7–9]. Environmental tobacco smoke causes many harmful effects including cardiac diseases and lung cancer for adults and respiratory tract infections and asthma for children [10]. Occupant density, behaviour of occupants, and season can affect indoor environmental quality (IEQ), for example opening windows is a more effective way to dilute high carbon dioxide (CO_2) concentrations and indoor air pollutants than infiltration of fresh air [11], but may also results in decreased indoor temperature.

According to our previous study utilising the same questionnaire data, self-reported general symptoms were associated with self-reported inadequate size of the residence, moisture or mould damage on interior wall, floor or ceiling surfaces, dissatisfaction with indoor air quality (IAQ), and neighbour noise disturbance [12]. In addition, dissatisfaction with IAQ, as well as moisture or mould damage on interior surfaces were associated with upper and lower respiratory track symptoms and respiratory tract infections. Moisture or mould damage was also associated with eye and skin symptoms, and daily neighbour noise disturbance with sleep disturbance [13].

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In addition to occupant reporting, information about IEQ can be collected by objective measurements. With respect to IEQ measurements, temperature (T) and relative humidity (RH) are commonly used as indicators of thermal comfort, and CO_2 is used as an indicator of occupancy (crowding), ventilation, and IAQ.

Socioeconomic and –demographic inequalities have been found to be strong determinants of environmental risks for example through exposure to environmental hazards [14]. These inequalities can be expressed in relation to factors such as income, education, employment, age, gender, race/ethnicity, and specific locations or settings. Tenure status has been used as an indicator of socioeconomic position, and has been associated with housing conditions, self-reported morbidity, and higher mortality rates [15–18].

In 2010, some 30% of Finnish households lived in rental flats [19]. Household-dwelling units in rental flats are mainly (85%) one or two person households. The young population especially lives in rental flats [20]. Average income level is lower in rental households than owner-occupied households. Differences in incomes between these two groups have been increasing: In 1989 the disposable income of rental households was 79% of disposable income of owner-occupied household, whereas in 2010 it was about 60% [19].

The aim of this study was to examine the associations between tenure status and housing satisfaction and IEQ-related factors in Finnish apartments. The null-hypothesis is that housing satisfaction and IEQ are independent of tenure status.

2. Materials and methods

Material consisted of a nationwide housing, health, and safety questionnaire data based on a random sample (N = 3000) of Finnish households collected in 2007 [21], and a separate sample of six apartment buildings with both measurement and questionnaire data (N = 65) collected in 2010–2012.

The national survey was conducted by sending invitation letters and paper questionnaires by mail. The respondents (one 18–75 year old respondent per household) could complete and return the paper questionnaire by regular mail or complete the same questionnaire via the internet. The response rate was 44% (N = 1308), and responses comprised a representative sample of households in Finland. Tenure status was originally categorised as 1) owner-occupied flat, 2) rental flat in a housing association building, and 3) rental flat in tenement building. This study focuses on rental and owner-occupied flats in apartment buildings (N = 397).

First, questionnaire responses were cross tabulated by tenure status, including selected socio-demographic variables (e.g. gender, age, marital status) and housing quality attributes, such as satisfaction with dwelling, dwelling perceived to be large enough, satisfaction with IAQ, ventilation, trickle vents in bedroom(s), satisfaction with temperature conditions of the dwelling, airing by hood and opening windows, unpleasant odour in the dwelling (general stuffiness), and moisture or mould damage on interior surfaces. The chi-square test was used to test differences for categorical variables, and the Kruskal–Wallis test was used for continuous variables (e.g. age of the responders).

Where significant differences were observed by tenure status, multiple logistic regression analyses were performed. These analyses were performed for satisfaction with dwelling, dwelling perceived to be large enough, dwelling suitably warm in winter, and too dwelling cold in winter. Independent variables were added to the models stepwise. First, tenure status was included in the models by the method “enter”. The second step employed three socio-demographic variables (i.e. gender, age, marital status) by the method “enter”. In addition, a third step included additional variables that could be associated with socioeconomic status and/or the dependent variables: proportion of gross income used for living costs, education, and occupation, by the “forward conditional” method. For level of statistical significance we chose $p < 0.05$. Missing data were excluded from the analyses. These analyses were performed with PASW Statistics 18.0 Release 18.0.0.

In addition on the national survey data, a separate sample of six apartment buildings located in Eastern Finland was studied more thoroughly. Measurement data were collected from a total of 28 apartments who volunteered to participate: nine apartments in three buildings were owner-occupied and 19 apartments in the other three buildings were rental. A heating season with more stable indoor thermal conditions was targeted in order to minimize the impact of other factors (e.g., opening windows). One building was studied in 2010, four buildings in 2011, and one in 2012.

Measurements included two months of continuous monitoring of T, RH, and CO_2, recorded in two locations from each apartment (i.e., bedroom, kitchen or living room) every ten seconds using a wireless building monitoring system developed by the research group of Environmental Informatics at the University of Eastern Finland [22]. The monitoring system has been previously utilised in several studies [23–26]. Sensors were installed approximately 1.4–1.8 m above the floor level, and far from ventilation ducts, windows and doorways. The reliability of the measurements was tested in a few randomly selected dwellings with TSI's IAQ-CalcTM Indoor Air Quality Meter 7525. No significant difference was observed between the TSI and the installed sensors, and the reliability was within the manufacturer's specifications [27]. Contemporary outdoor T and RH data from local monitoring stations were obtained from the Finnish Meteorological Institute for comparative purposes.

The 10-s resolution data during a 2-month monitoring period was averaged to 1-h resolution. Descriptive statistics such as frequencies, means, and variances were calculated and compared for quality assurance checks. Normality assumptions of continuous variables were examined and outliers identified. Correlation coefficients were calculated for continuous variables. We used multilevel modelling (SAS-program's proc mixed procedure) for indoor T, RH, and CO_2 levels, where interaction of month and year was used as a random effect, and outdoor T, RH, and the tenure status were used as fixed effects. The main goal of the modelling was to evaluate possible differences between owner-occupied and rental buildings.

Temperature data from five apartments were omitted from the analysis: three apartments were unoccupied during the measurement period, and two apartments had an error in the equipment settings. Three rental apartments had missing data due to equipment error. The final sample with valid measurements included nine apartments from owner-occupied buildings and 16 apartments from rental buildings (Table S1).

The occupants of these six buildings were also asked to complete the questionnaires, but due to the small sample size and low response rate, only a group-level descriptive analysis was conducted by cross tabulating selected housing quality attributes (i.e. satisfaction with dwelling, dwelling perceived to be large enough, satisfaction with IAQ and temperature conditions of the dwelling, and unpleasant odour caused by general stuffiness) by tenure status.

3. Results and discussion

3.1. Bivariate analyses of questionnaire data

Table 1 shows socio-demographic variables by tenure status based on national survey data. Respondents living in owner-

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