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The influence of sustainable design features on indoor environmental quality satisfaction in Turkish dwellings

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The aim of this paper is to explore the influence of sustainable design features on occupants' satisfaction levels with indoor environmental quality (IEQ) aspects in three types of dwellings. Satisfaction level was investigated through a field survey with 240 participants, in apartments, row and detached houses in Turkey. Satisfaction level was explored in terms of overall satisfaction with IEQ, with the efficiency of daily living activities and with sleeping quality. Satisfaction level was also investigated regarding the dwellings' thermal, ventilation, lighting, sound level and moisture qualities. The findings indicate that the existence of exterior insulation, a thermostat, light dimmers and control of daylighting systems through operable windows have high impacts on the satisfaction level of occupants living in all three types of dwellings.

Keywords: indoor environmental quality; lighting quality; occupant satisfaction and performance; sound quality; thermal quality

1. Introduction

Most people spend most of their time in their homes, where they conduct the main activities of daily living (ADL) and where they sleep. Therefore, it is important to investigate occupants' satisfaction levels with their indoor environment. Studies show that living in a sustainably designed housing environment leads to greater feelings of comfort, safety and satisfaction, and results in positive attitudes (Brower 2003; Kaplan 1985; Langdon 1988; Lipsetz 2000; Mesch and Manor 1998). Residential satisfaction also influences people's intentions. Although many studies address different aspects of dwelling satisfaction in different countries among different ethnic groups, the relationship between satisfaction and sustainability is rarely investigated. In addition, most of such research is conducted in Western countries; information on less-developed countries is lacking, but such countries also require sustainable practices so that people can achieve a better quality of life and a higher standard of living. Hence, more research is needed to explore the sustainable design features of indoor environmental quality (IEQ) that influence residential satisfaction.

Several studies consider residential satisfaction as multifaceted, comprising the home's interior and exterior, relationships with neighbours and the local physical environment. These studies focus especially on functionality (safety, presence of and access to services), aesthetics (appearance) and health features (air quality and pollution). 'Residential satisfaction' in most studies is interpreted as 'neighbourhood residential satisfaction' (Brower 2003; Kaplan 1985; Langdon 1988; Lipsetz 2000). While some of these studies measure the level of residential satisfaction by evaluating the physical and social features within that environment (Mesch and Manor 1998), other studies measure it in relation to a decision to move or stay (mobility facilities) (Brower 2003; Lee, Oropesa, and Kanan 1994; Newman and Duncan 1979). Hur and Morrow-Jones (2008) investigate neighbourhood factors that influence residential satisfaction and conclude that general interior appearance is the most significant factor affecting residential satisfaction. This result parallels the existing literature; Kaya and Erkip's (2001) study on satisfaction in dormitory buildings finds that occupants of noisy, dark and narrow dormitory rooms with low ceilings report low satisfaction levels with their indoor environment. Uzzell, Pol, and Badenas (2002) examined the effects of satisfaction along with place identity and social cohesion on attitudes to environmental sustainability and find a strong relationship between an occupant's levels of satisfaction and his or her behaviours with respect to environmental sustainability, such as recycling and household energy consumption. However, satisfaction is a complicated feeling;

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other studies correlate residential satisfaction to social concerns, such as having friends and relatives nearby (Brower 2003; Lipsetz 2000).

Many studies consider the significance of residential satisfaction at different levels of the environment, such as from the housing unit to the neighbourhood (Wiedemann and Anderson 1985). Amole's (2009) investigation of residential satisfaction at various environment levels supports the idea that people can experience different satisfaction levels between the bedroom and the neighbourhood. That study (Amole 2009) corroborates Canter and Rees's (1982) theoretical view that levels of environment are distinct, separate and hierarchical spheres of interaction. Similarly, Gifford (1997) and Oseland (1990) find that occupants' conceptualization and experience of a space can vary in different physical environments, even among different rooms within the same housing unit. McCrea, Stimson, and Western (2005) show that, depending on the context of the research and interest of the researcher, the level of environment (be it a housing unit, student dwelling or neighbourhood) affects one's perception. However, the influence of sustainable design features on IEQ satisfaction has not been examined extensively or empirically; therefore, there is little to no data about how occupants at different environment levels respond to sustainability features, such as enhanced thermal, visual and acoustic comfort, improved waste management, reduced CO_2 emissions and improved water and resource efficiency.

This study examines these issues in the context of available sustainability features in Turkish residential environments. In this study, different types of environment are represented by three dwelling types: apartment, detached and row houses, and characteristics of the residential environment refer to the available sustainability criteria. Different than previous studies, in this study, the authors analyse satisfaction with IEQ and relate this satisfaction to the availability of sustainability criteria in three types of dwellings.

2. Sustainable residential environments and IEQ

The importance of occupant interactions with sustainable built environments and systems cannot be disregarded. A sustainable built environment must ensure the occupants' safety, health, comfort and satisfaction, 'while meeting the needs of the present without compromising the ability of future generations to meet their own needs' (United Nations Brundtland Commission 1987, 41). Due to its multifaceted character, sustainability in the built environment is difficult to define. The concept of sustainability has become an overarching principle in many national and international studies since the publication of the United Nations' Brundtland Report (1987) and the 1992 Rio Earth Summit, which put human beings at the centre of the concern for sustainable development and outlined the goal for humans to live healthy and productive lives in harmony with nature (Birkeland 2002). In this sense, sustainable design is a philosophy that aims to maximize the quality of the built environment while minimizing or eliminating the impact on the natural environment.

Although the essence of sustainable development lies at the interface of its three dimensions – environmental, economic and social – the social dimension has commonly been recognized as the weakest 'pillar' (Lehtonen 2004) because the interaction between the environmental and the social is still uncharted (Ljungquist 2003). Thus, in addition to accommodating physical environmental factors, understanding the level of human satisfaction with sustainable systems is a prerequisite for reducing buildings' environmental impacts, increasing IEQ and creating healthy built environments.

In the last decades, sustainable urban residential development has undergone extreme growth due to massive population mobility to cities all over the world, including developing Turkey. There has been great effort to move towards projects with low environmental impact, in the building sector. However, despite Turkish society's apparent interest in environmental and financial issues, a market for sustainable home has not yet been established. Construction of residential buildings and regeneration processes of residential urban environments are undertaken with inadequate involvement of relevant stakeholders and without integration environmental, economical and social dimensions of sustainability (Afacan and Afacan 2011). Since facilities with low environmental impact require additional costs, sustainable residential buildings are feasible only when consumers' willingness and ability to pay overcome the cost. A sustainable residential environment provides better sanitation (sewers and trash collection), better indoor air quality (IAQ) (daylighting, ventilation, heating and cooling), and better services, and with improved living standards, occupants are demanding such environments. Sustainable residential developments should not disregard human satisfaction, behaviour and interaction. For example, an architect or builder may consider sustainable building systems but if human satisfaction and comfort are not taken into account, the systems are unsustainable.

There is constant debate about the potential negative effects of poor environmental quality on health and quality of life. People spend on average 85–90% of their time in indoor environments (Ljungquist 2003; Robinson and Nelson 1995). IEQ affects user satisfaction, performance and productivity, and thus ensuring high IEQ requires a comprehensive approach towards lighting, acoustics, noise control, ventilation and thermal comfort. Creating a comfortable and healthy indoor environment is not only important for occupants but helps reduce the need for reconstruction and renovation. According to Leadership in Energy Environmental Design (LEED), a green building certification and rating programme in the USA, IAQ, thermal quality, lighting quality and acoustic quality are four aspects of IEQ affecting employee satisfaction and performance (U.S. Green Building Council 2000).

Good air quality in residential environments is a major concern regarding health and well-being (Bluyssen 2010). Complaints about IAQ range from simple criticism, such as air smelling odd, to complex situations that cause illness and loss of concentration as well as time spent trying to rectify such issues (Kang and Guerin 2009). Natural ventilation reduces internal air pollution and limits energy needed for a mechanical ventilation system (Kalz, Pfafferott, and Herkel 2010); therefore, a fresh air supply and appropriate humidity can be a good design outcome. In wet spaces (kitchens, bathrooms and toilets), dampness should be avoided through extraction. Low-emission building components and materials should be chosen to maintain good air quality. If ventilation systems are required, occupants should be able to control them.

Among the various types of buildings, residential buildings should especially have adequate thermal comfort to support the activities of its occupants (Hedge and Dorsey 2013; Hoof et al. 2010; ISO 7730). Moreover, the relationship between indoor climate and energy use is quite obvious (Park et al. 2013). According to a large 1991/1992 survey in Sweden concerning indoor climate in dwellings, between 600,000 and 900,000 people were estimated to be exposed to an indoor climate that negatively affected health and well-being (Norlén and Andersson 1993). Built environments should minimize overheating in summer and optimize temperatures in winter without unnecessary energy use. Where possible, natural ventilation should be used; if that is not possible, programmable controls for heating, ventilation and air-conditioning (HVAC) systems, adjustable thermostats or occupant-controlled temperature and ventilation systems should be used.

Adequate lighting and daylighting in interiors provides many health benefits and positively influences mood and well-being (Hedge and Dorsey 2013; Hygge and Lofberg 1997). A good design should allow optimal daylight and reduce overall lighting energy consumption. The design of built environments should avoid glare and provide for occupant-controlled lighting. Some design features should be present for controlling sunlight in the summer. In addition to lighting for visual comfort, the reflectance and colour of floors, ceilings and walls should be considered.

An optimal acoustic environment positively affects occupants' well-being and efficiency (Hedge and Dorsey 2013). Built environments should be designed to minimize noise from the outside and to optimize the acoustic level inside by controlling system noise from ventilation or heating. In dwellings, sound insulation for facades to reduce noise levels from traffic and industry may be required. Internal insulation may be needed for adjacent houses or rooms to control interior noise and provide acoustic privacy. Designers are responsible for specifying finishes such as ceilings, floorings, carpet systems, wall coverings and paint for appropriate sound transmission, as well as window treatments and furniture.

There are common worldwide standards for the above-explained four IEQ criteria, such as those from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Green Seal Standards. However, there is no evidence that the indoor environment designed according to these standards is comfortable and productive for occupants (Lee and Guerin 2010). Moreover, although much research illustrates that homes with sustainable environmental features (i.e. thermal, visual and acoustic comfort) are preferable and highly appreciated by occupants, understanding human satisfaction with sustainable systems is a prerequisite for managing IEQ because such innovations have a profound influence on human behaviour and attitude (Sakhare and Ralegaonkar 2014). Hence, designing sustainable residential environments is about more than environmental attributes; such design is successful only if it leads to occupant satisfaction, stimulates social cohesion, supports social welfare and enhances personal, community and global health (Edward 2010).

The relationship between an occupant and a dwelling is multifaceted and of key importance to overall occupant satisfaction. Occupant satisfaction has a positive effect on the performance of domestic activities; occupant satisfaction levels decrease when performance of domestic activities is reduced (Steemers and Manchanda 2010). Domestic activities can be grouped into ADL and sleeping, with the former including basic activities (bathing, eating, dressing, functional mobility, personal hygiene, etc.) and instrumental activities (cooking, housekeeping, laundry, etc.). Recent studies show that

> individuals who reported poor sleep quality and short sleep duration were consistently lower in subjective well-being and also reported increased levels of negative affect and mood disturbances when compared to individuals who reported good sleep quality and/or 7–8 hours of sleep per night. (Lemola, Ledermann, and Friedman 2013, e71292)

Occupants therefore require high levels of IEQ for optimal well-being and performance of domestic activities.

In the current study, the authors explore the following research questions: (1) Is there any difference in satisfaction level with IEQ criteria in different dwelling types? (2) Is there any difference in the (i) overall satisfaction of IEQ, (ii) satisfaction level with the efficiency of daily living activities (ADL), (iii) satisfaction level with sleeping quality and (iv) importance level of sustainability issues for occupants in different dwelling types?

Occupant satisfaction was investigated through a field survey in three dwelling types: apartment, detached and row houses. The aim of the study is not to evaluate the building performance of different dwelling types or demonstrate well-known sustainable home features when designing environmentally friendly and energy-efficient residential environments, but to focus on how the availability of sustainable IEQ factors influences human satisfaction.

3. Methodology

3.1. Sample group

Study participants were chosen by stratified sampling among clusters in urban areas with the same income level in Ankara, Turkey. First, neighbourhoods in the Greater Municipality of Ankara were stratified according to occupant income level. Then dwelling clusters were identified in each medium- to high-level income stratum. The next step was a random sampling of the dwellings and occupants in each cluster. Two hundred and forty occupants from the 3 dwelling types (99 occupants from apartments, 75 occupants from detached houses and 66 occupants from row houses) participated in this four-week field study from mid-February to mid-March 2013. Demographic information about the occupants is given in Section 4.

3.2. Instrumentation and data collection

A self-assessment questionnaire was developed with an occupant focus group first and then tested and refined using the interviewing method. The questionnaire involved two sections: background information and occupants' IEQ evaluations. Questions regarding background information included two categories: occupant demographics and dwelling characteristics. The former included age, gender, education level and duration in the current dwelling. The latter involved issues related to control availability of natural and artificial lighting systems and thermal systems. The amount of insulation in the buildings' interiors and exteriors and its components were also investigated. Table 1 presents the measures used for the background information.

The second section, occupants' IEQ evaluations of the questionnaire, is related with indoor environment quality satisfaction levels. Participants were asked to rate their satisfaction level with the following five IEQ issues related to their dwelling's type on a seven point Likert-type scale, ranging from 'very dissatisfied' to 'very satisfied': (i) thermal quality; (ii) ventilation quality; (iii) lighting quality; (iv) sound level and (v) amount of moisture in the dwelling. Besides, they also rated their overall satisfaction with their dwelling and the overall effect of their dwelling on sleep quality and performance of ADL. Thermal quality was assessed as the occupant's level of satisfaction with heating in winter and cooling in summer as well as satisfaction with the extent of room temperature control in winter and summer. Ventilation quality was assessed as occupant satisfaction level with natural and mechanical ventilation as well with the extent of natural and mechanical ventilation control. Lighting quality was assessed as occupant satisfaction level with the amount of daylight, artificial light and control of each light type. Other items assessed included satisfaction level with the ability to control glare, satisfaction level with visual lighting comfort while conducting daily activities and satisfaction with the level of visual privacy in the dwelling. Sound quality satisfaction was measured as satisfaction level with speech privacy, background noises and the ability to understand desired sounds. Table 2 presents the questions and measures used for occupants' IEQ satisfaction levels.

3.3. Analysis

The data were analysed by descriptive statistics and Kruskal–Wallis H-test. Descriptive analysis explained the occupant demographics and dwelling characteristics by frequencies. The interviewers also recorded the comments of the participants related to the dwelling characteristics. These unstructured interviews are used to support the quantitative findings of the study. Kruskal–Wallis H-test is used to compare the satisfaction level with each IEQ in all three dwelling types, since it provides the alternative non-parametric procedure where more than two independent samples are to be compared against one dependent variable on the ordinal scale. This test is used to assess the null hypothesis that there is no difference among the median scores of satisfaction levels on the ordinal scale between the occupants of apartments, detached and row houses, regardless of the independent samples of uneven sizes. A pairwise comparison of the three dwelling type was also done to determine the average rank of each dwelling

Table 1. Measures for the demographics of the occupants and characteristics of the dwelling.

Characteristics	Issues	Measures
Occupants	Age	30 or under; 31–50; Over 50
	Gender	Female; male
	Education level	Elementary; high school; university
	Duration of stay	Less than 1 year; 1–5 years; 6–15 years; Over 15 years
Dwelling	Control of natural lighting systems	Window blinds and shades; operable window; balconies or terraces
	Control of artificial lighting systems	Light switch; light dimmer; task light
	Control of thermal systems	Thermostat; portable heater/fan; room air-conditioning; adjustable wall air vent; adjustable floor air vent
	Availability of insulation	Building exterior; building interior; building components

Table 2. Measures for IEQ environmental satisfaction levels of the occupants.

Indoor environmental quality	Measures for satisfaction level
Thermal quality	Heating in winter
	Cooling in summer
	Extent to which you can control room temperature in winter
	Extent to which you can control room temperature in summer
Ventilation quality	Natural ventilation
	Mechanical ventilation
	Extent to which you can control natural ventilation
	Extent to which you can control mechanical ventilation
Lighting quality	Amount of daylight
	Ability to control or block daylight
	Amount of artificial lighting
	Ability to control artificial lighting
	Ability to control glare
	Visual comfort of lighting in daily activities
	Level of visual privacy
Sound level quality	Level of speech privacy
	Background noises
	Ability to understand desired sounds
Moisture quality	Moisture amount
	Extent to which you can control moisture

type. If the null hypothesis is true, then all dwelling groups should have more or less the same average rank.

4. Findings

4.1. Descriptive analysis

Participants were asked to provide their demographic information and dwelling characteristics. In the apartments, the majority of occupants were younger than 31 years old (42.4%) and between 31 and 50 years old in the detached (49.3%) and row houses (42.4%). The percentage of female participants in the study was higher than male participants in all three dwelling types. More occupants than not in all three dwelling types had a university education. The highest percentage regarding duration in dwellings was 1–5 years in apartments (41.4%) and detached houses (38.7%) and was 6–15 years in row houses (39.4%). Table 3 presents the responses for each question on occupant demographics and dwelling characteristics.

The most frequently used natural lighting system controls were the balconies and terraces in the apartments (56.7%) and row houses (66.7%) and operable windows in the detached houses (65.3%). All female participants in the apartments noted that the presence of plants and fresh air in the balconies stimulated their performance of daily activities. Most of the participants (77%) in the detached houses stated that operable windows are not only important in terms of ensuring adequate daylight but also regarding their interaction with the built environment.

> I feel positive when there is daylight through terraces. (Participant 23)

> I prefer to have balconies to be connected with nature. (Participant 78)

> I am very satisfied when I could control the operability of glazed windows and doors. (Participant 2)

The most frequently used artificial lighting system control in all three dwelling types was the light switch. Task lighting use had the highest percentage in detached houses (42.6%), with row houses next (37.8%) and apartments last (33.4%). All the participants over 50 years old in the three types of dwelling highlighted the importance of task lighting. Most of the female participants (33 of 99 in apartments, 30 of 75 in detached houses and 23 of 66 in row houses) noted that light dimmer affects their ADL positively compared to the light switch.

> Artificial lighting system should be easily controllable, such dimmer. (Participant 45)

> While my children get to sleep, I prefer to lower the brightness of the light through dimmer. (Participant 178)

There were many similarities among thermal system controls. In all dwelling types, the most frequently used thermal system control was the thermostat and, in decreasing percentages, a portable heater/fan, air-conditioning and adjustable wall and floor air vents, respectively. According to 87 participants (43 of 99 in apartments, 25 of 75 in detached houses and 19 of 66 in row houses), lack of adjustable thermal control systems and floor air vents are major barriers to thermal comfort and causes heating problems in summers and cooling problems in winter. Insulation within building components had the highest percentage in all three dwelling types, with insulation on exterior walls second and interior insulation third (see Table 3).

> If the temperature is very high in winters, I feel uncomfortable and get sleepy. (Participant 2)

> I would like to have wall and air vents in my house to maintain a healthy environment for my children. (Participant 141)

> I have rheumatism; so thermal comfort and moisture levels are very important for me. I wish to have control on moisture and indoor temperature of each room. (Participant 89)

4.2. Analysis of satisfaction levels

4.2.1. Satisfaction with dwelling

For overall occupant satisfaction levels in the three dwelling types, the Kruskal–Wallis test found that there

Table 3. Demographic information about the residents and the characteristics of the three-residence type.

		Residence type		
		Apartment (%)	Detached house (%)	Row house (%)
Age in years	Less than 31	42.4	30.7	31.8
	31–50	29.3	49.3	42.4
	Over 50	28.3	20.0	25.8
Gender	Female	53.5	56.0	63.6
	Male	46.5	44.0	36.4
Education	Elementary	3.1	2.8	6.3
	High school	25.0	12.7	17.5
	University	71.9	84.5	76.2
Duration of stay	Less than 1 year	9.1	8.0	12.1
	1–5 years	41.4	38.7	24.2
	6–15 years	32.3	34.7	39.4
	Over 15 years	17.2	18.7	24.2
Control of natural lighting systems	Window blinds and shades	37.5	46.6	54.5
	Operable window	48.5	65.3	34.9
	Balconies or terraces	56.7	50.7	66.7
	None	4.0	5.3	0.0
Control of artificial lighting systems	Light switch	96.0	91.3	95.4
	Light dimmer	4.0	27.9	10.6
	Task light	33.4	42.6	37.8
	None	2.0	5.3	3.0
Control of thermal systems	Thermostat	61.5	48.2	66.6
	Portable heater/fan	25.2	26.6	24.2
	Room air-conditioning	17.2	26.6	21.2
	Adjustable wall air vent	14.1	11.9	12.0
	Adjustable floor air vent	2.0	3.9	1.5
	None	13.1	12.0	12.1
Availability of insulation	Building exterior	57.7	77.3	69.2
	Building interior	44.8	64.4	56.3
	Building components	60.4	79.5	72.1

was a significant difference among the dwelling types (H (2) = 7.52, two tailed $\rho = 0.023$). The pairwise comparisons found that apartments (mean rank = 104.81) were significantly different than detached houses (mean rank = 130.76). There was no significant difference in overall occupant satisfaction levels between detached and row houses or between apartments and row houses (Figure 1).

For occupantsatisfaction levels with sleep quality in the three dwelling types, the Kruskal–Wallis test found that there was a significant difference among the dwelling types (H (2) = 18.69, two tailed $\rho = 0.001$). The pairwise comparisons found that apartments (mean rank = 100.78) were significantly different than detached houses (mean rank = 143.90). There was no significant difference in overall occupant satisfaction levels regarding sleep quality between detached and row houses or between apartments and row houses (Figure 2).

For occupant satisfaction levels with ADL performance in the three dwelling types, the Kruskal–Wallis test found that there was a significant difference among the dwelling types (H (2) = 22.04, two tailed $\rho = 0.001$). The pairwise comparisons found that apartments (mean rank = 99.95) were significantly different than detached (mean rank = 147.06) and row houses (mean rank = 117.89). There was no significant difference in occupant satisfaction levels with ADL performance between apartments and row houses (Figure 3).

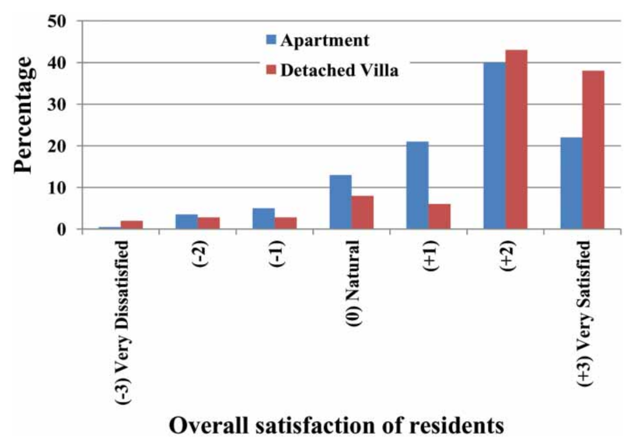

Figure 1. Overall satisfaction levels of occupants among the occupant types.

All participants were asked the level of importance they placed on sustainability in design issues. The authors found no significant difference among occupants in the three types of dwellings for this issue (H (2) = 5.62, two

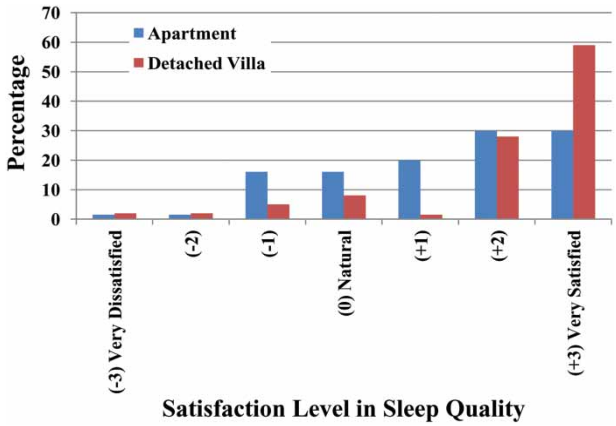

Figure 2. Satisfaction level in sleep quality of occupants among the occupant types.

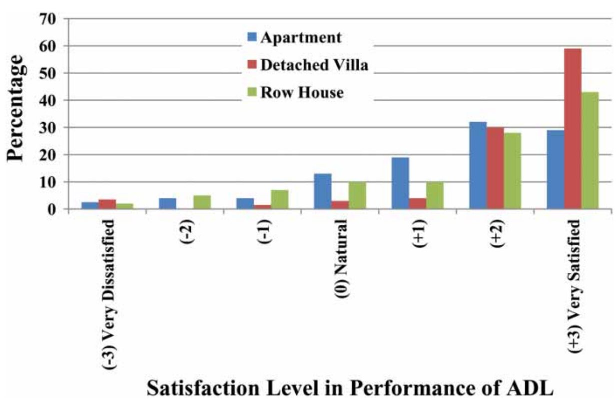

Figure 3. Satisfaction level in performance of ADL of occupants among the occupant types.

tailed $\rho = 0.06$). Neither was any significant association found among age, gender, education level and duration in the dwelling, nor between the demographic factors and overall satisfaction with the dwelling, overall effect of the dwelling on sleep quality or on ADL performance.

4.2.2. Satisfaction with IEQ

Regarding satisfaction levels with thermal quality in the three dwelling types, the Kruskal–Wallis test found that satisfaction level related to cooling in summer and the summer room temperature control in the three dwelling types differed significantly (H (2) = 9. 64, two tailed $\rho = 0.008$; H (2) = 17.90, two tailed $\rho = 0.001$, respectively). This test was followed by further tests to determine which configuration of dwelling types differed and in what direction. The pairwise comparison found that apartments were significantly different than detached houses in their satisfaction levels both for cooling in summer (apartment mean rank = 103.61; detached house mean rank = 133.45) and summer room temperature control (apartment mean rank = 95.27; detached house mean rank = 138.41). There was no significant difference among the three dwelling types in the satisfaction levels of thermal quality related to heating in winter and winter room temperature control.

For satisfaction levels of ventilation quality in the three dwelling types, the Kruskal–Wallis test found that satisfaction level related to natural ventilation, natural ventilation control and mechanical ventilation differed significantly, (H (2) = 19. 77, two tailed $\rho = 0.001$; H (2) = 11.44, two tailed $\rho = 0.003$; H (2) = 7.12, two tailed $\rho = 0.028$, respectively). The pairwise comparisons found that apartments dwellers were significantly different than row house and detached house dwellers regarding their satisfaction level both with natural ventilation (apartment mean rank = 96.33; row houses mean rank = 135.78 and detached house mean rank = 134.27), natural ventilation control (apartment mean rank = 98.09; row houses mean rank = 125.38 and detached house mean rank = 128.80) and mechanical ventilation (apartment mean rank = 106.02; row houses mean rank = 133.30 and detached house mean rank = 123.49). There was no significant difference among the three dwelling types in satisfaction levels of ventilation quality related to mechanical ventilation control.

In satisfaction levels of lighting quality in the three dwelling types, the Kruskal–Wallis test found that satisfaction level related to glare control and visual comfort in ADL differed significantly (H (2) = 7.46, two tailed $\rho = 0.024$; H (2) = 6.01, two tailed $\rho = 0.050$, respectively). The pairwise comparison found that apartments were significantly different than row houses in glare control (apartment mean rank = 106.02; row houses mean rank = 133.30) and that apartments were significantly different than detached houses in visual comfort in ADL (apartment mean rank = 108.42; detached house mean rank = 132.70). There was no significant difference among the three dwelling types in satisfaction levels of lighting quality related to the amount and control of daylight or the amount and control of artificial light. When a Bonferroni correction was made to adjust the multiple comparisons, there was a significant difference among the three dwelling types in visual privacy level (H (2) = 3.90, two tailed $\rho = 0.142/3 = 0.473$).

For satisfaction levels regarding sound quality in the three dwelling types, the Kruskal–Wallis test found that satisfaction levels related to speech privacy, background noises and understanding desired sounds differed significantly (H (2) = 20.48, two tailed $\rho = 0.001$; H (2) = 10.64, two tailed $\rho = 0.005$, H (2) = 9.98 and two tailed $\rho = 0.007$, respectively). The pairwise comparison for speech privacy level found that apartments (mean rank = 100.53) were significantly different than detached houses (mean rank = 146.00) and that row houses (mean rank = 110.16) were significantly different than detached house (mean rank = 146.00).

The pairwise comparison for background noise found that apartments (mean rank = 100.05) were significantly different than detached houses (mean rank = 133.17). For understanding desired sounds, apartments (mean rank = 104.76) were significantly different than detached houses (mean rank = 137.05). For all three measures related to sound quality, there was a significant difference among the three dwelling types. There was no significant difference among the three dwelling types in satisfaction levels of moisture quality related to the amount of moisture and the extent of moisture control possible.

5. Discussion and conclusion

The results of this study show that there is no significant difference in the level of importance given to sustainable design issues among the occupants of apartments, detached and row houses. However, the findings demonstrate that satisfaction levels for apartment occupants are significantly different than for the occupants of detached and row houses for the following IEQ criteria related to ventilation quality: natural ventilation, natural ventilation control and mechanical ventilation (see Table 4). Natural air circulation in buildings can be achieved by cross ventilation through operable windows; 91.2% of occupants in detached houses and 90.5% of occupants in row houses who had operable windows were satisfied with that natural ventilation. However, occupant satisfaction level was lower in apartments (62.8%). As noted above, ASHRAE (2004) provides ventilation standards for the built environment, but as Lee and Guerin (2010) state, there is no evidence (until now) that occupants of a built environment feel more comfortable, are more productive in ADL or have better sleep quality when such standards have been met. The studies indicate that building characteristics such as heating and ventilation systems have an impact on occupants' satisfaction (Hedge and Dorsey 2013; Kang and Guerin 2009), but the ventilation figures in the literature are mostly based on occupant *point of view* (i.e. subjective data), but which described as satisfaction level with the built environment. A subjective assessment of ventilation is often conflated with thermal conditions, as occupants tend to associate cool and dry conditions with high IAQ (REHVA 2011). In Table 4, the pairwise comparisons of occupant satisfaction levels are described in terms of dwelling types and IEQ issues.

Taking the above information into account, this study shows that physical conditions of apartments depending on the construction year, availability of sustainable features and types of heating and cooling systems (local or central) appear to have an impact on occupant satisfaction levels (Zalejska-Jonsson and Wilhelmsson 2013). In the above-noted Zalejska-Jonsson and Wilhelmsson study (2013), the authors show that there is a significant difference in occupants' general IEQ satisfaction levels depending on the age of the dwelling. These differences are mostly due to the existence of sustainable design features, which itself is due to the building's construction year. In Turkey, the legislative framework for energy performance efficiency and sustainability management in residential buildings was only amended in 2000 (General Directorate of Vocational Services of Environment and City Ministry 2014), and the most-often observed problem with IEQ in Turkish apartments is the lack of sustainable features in buildings constructed before 2000. All the apartments in the current study were constructed before 2000; however, all the detached and row houses were constructed after 2000. As stated in the Findings section and depicted in Figure 1, the overall satisfaction levels of people living in apartments is significantly lower than those of people living in detached and row houses. There was no significant difference in overall occupant satisfaction levels between detached and row houses. Hence, the effects of sustainable design features (insulation, thermal systems, lighting control systems, visual comfort and glare control) were examined as important aspects of IEQ satisfaction.

Table 4. Pairwise difference in comparison of the occupant satisfaction in dwelling types and IEQ issues.

	Differences in satisfaction		Apartment	Row house
Row house	Dwelling		Performance of ADL	
	IEQ issue	Ventilation quality	Natural ventilation	
		Lighting quality	Natural ventilation control	
			Mechanical ventilation	
			Ability to control glare	
Detached house	Dwelling		Overall satisfaction	
	Sleep quality			
	Performance of ADL			
	IEQ issue	Thermal quality	Cooling in summer	Speech privacy level
		Ventilation quality	Summer room temperature control	
		Lighting quality	Natural ventilation	
		Sound level quality	Natural ventilation control	
			Mechanical ventilation	
			Visual comfort in ADL	
			Speech privacy level	
			Background noise	
			Understanding desired sound	

In thermal quality, it was found that apartments were significantly different than detached houses regarding occupant satisfaction level both with summer cooling and summer room temperature control (as seen in Table 4). Regarding the percentages of occupants satisfied with the insulation level, for apartment dwellers exterior insulation increased their satisfaction with winter heating from 63.4% to 80.4%, whereas this difference was higher in detached (from 31.3% to 91.2%) and row houses (from 40% to 84.4%). However, the existence or level of interior insulation has no significant impact on occupant satisfaction in all three types of buildings neither for winter heating nor summer cooling. Regarding the availability of thermal systems, the most significant difference was found in row houses in terms of winter heating. The availability of thermostats and vents increased occupant satisfaction in row houses from 43.8% to 77.3% compared to the availability of fans.

For lighting quality satisfaction, apartments were found to be significantly different than row houses regarding glare control. Apartments were also significantly different than detached houses regarding visual comfort for ADL (see Table 4). Regarding the availability of lighting control systems, operable windows in detached houses increased occupant satisfaction with the control of daylight systems from 77.3% to 91.3%. However, the availability of artificial lighting control systems did not have a significant impact on occupant satisfaction in all three types of dwellings. Regarding the percentages of occupants satisfied with visual comfort and glare control, the availability of light dimmers and task lighting increased occupant satisfaction in apartments for the former from 80.7% to 100%, and for the latter from 62.2% to 100% compared to the availability of light switches. However, the availability of light dimmers and task lighting did not have a significant impact on occupant lighting satisfaction in detached and row houses.

For satisfaction with sound level, the level of speech privacy in apartments was significantly different than in detached houses and the level in row houses was significantly different than in detached houses. Zalejska-Jonsson and Wilhelmsson (2013, 137) find that ‘sound has a significant impact on overall satisfaction’, and add that sound quality has increased as sustainable features have been incorporated into buildings in recent years. As Beaman (2005) states, background noise has a negative effect on cognitive activities, which results in a decrease in performance. For sound quality, both in background noise and in understanding desired sounds, the current study found that the satisfaction level of apartment dwellers was significantly different than of people living in detached houses (see Table 4). These differences could be the result of overall different satisfaction levels, different satisfaction levels with ADL performance or with sleep quality between occupants in apartments and detached houses.

The above findings support earlier studies and suggest that the availability of sustainable IEQ features is a major factor affecting occupant satisfaction. As previously described in detail, the level of exterior insulation, thermostats, operable windows and light dimmers have high impacts on the satisfaction levels of occupants living in all three types of dwellings.

In that sense, it would be beneficial to compare these results with the ASHRAE standards, since Turkey has not developed IEQ standards and a green design guide yet. Although ASHRAE introduces fundamental IEQ concepts that are used by designers to make complex decisions about many more than simply keeping temperatures comfortable (ASHRAE 2004), the results of this study showed that sustainable IEQ solutions should go hand in hand with a drive for a more user-centred design. Because user adjustability is a key concern for a sustainable indoor environment (Afacan 2015), IEQ issues should be evaluated based on the cultural differences of users, as in this Turkish study they showed significant satisfaction differences depending on physical conditions of interiors. The results of this study help us understand that involving residents in the design process and understanding their needs, expectations, demands and experiences with innovative building systems is beneficial to architects, designers, policy-makers and government bodies. While designing sustainable interiors in addition to ASHRAE standards, it is inevitable to focus on which holistic and ergonomic approaches require new concepts (such as controllability) to improve residents’ IEQ satisfaction and ADL performance in residential environments.

In a future study, the authors will analyse occupants’ behaviour according to gender and lifestyle and their effects on overall satisfaction. Further studies with a much larger sample size could focus on post-occupancy evaluation protocols of different dwelling types categorized according to construction year. Moreover, since the current study is based on a nationally representative sample (i.e. how occupants live in three Turkish dwelling types), future studies could also explore cultural differences in terms of satisfaction levels and dwelling types.

Disclosure statement

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