

BEARING THE SUMMER HEAT IN URBAN OSAKA APARTMENTS: Analysis by age

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ABSTRACT

A questionnaire survey of urban Osaka apartment residents elicited data related to the use of air conditioners, portals, and electric fans as means of bearing summer heat. Those means' respective relationships to respondents' attributes, especially age, were investigated. Results show the following: 1) regarding electricity expense awareness, younger respondents (under 40 years old) save electricity more ($p<0.05$); 2) younger respondents' costs of air conditioning were lower ($p<0.01$); 3) younger respondents open windows more frequently when asleep ($p<0.02$); and 4) younger respondents use electric fans more frequently.

KEYWORDS

air conditioner use, natural ventilation, electric fan, questionnaire survey

1 INTRODUCTION

Against the background of global environmental concerns, reduced energy consumption is an urgent social objective. For that purpose, it is desirable to bear summer heat using natural ventilation while avoiding air conditioning. This study was undertaken to grasp apartment residents' actual situations of bearing summer heat. In addition, the reported means' relationships to respondents attributes, especially age, were investigated. For this study, bearing summer heat means the use of thermal controls: air conditioners, window opening and closing, and electric fans.

The survey was carried out in southern Osaka during autumn 2004 to elucidate bearing heat lifestyles, especially by natural cooling, without having to depend on air conditioners in summer. The survey was specifically administered to apartment dwellers, with contents related to 1) the thermal environment and thermal environment control use, 2) awareness of the environment, and 3) lifestyle. Factors that determine thermal environment control behavior were analyzed.

As reported previously, we analyzed the relationship between thermal environment control behavior, attributes of respondents, and attributes of dwelling units. Results of that study showed that 1) electric fan use is strongly related to age. Furthermore, awareness of electric fees is related to age. 2) Target temperatures of air conditioning are related strongly to residents' tolerance to cold. 3) Sleep conditions in summer are strongly affected by visibility from outside, dampness and odors in rooms, and summer heat in the dwelling units. The present study examines differences by age.

2 Methods

2.1 Investigation object

The survey was carried out in southern Osaka during 2004. Apartment buildings that had more than six floors and a hundred apartments facing south, west, and east were selected beforehand. Owned and rented, public and private buildings were almost equally selected. To residents in 24 apartment buildings, 1681 survey sheets were distributed. Responses were collected through postal services. In all, 290

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survey sheets were collected (17% collection rate).

2.2 Investigation items

The investigation items were grouped into seven categories: A: Dwelling unit attributes (9 items), B: Dwelling environment evaluation (16 items), C: Respondent attributes (15 items), D: Awareness and habits related to environmental problems (11 items), E: Electric fan use (2 items), F: Mechanical cooling use (9 items), and G: Window opening and closing (7 items).

2.3 Analysis method

To investigate factors related to thermal environment control behavior, Student's *t*-test was applied to the data. Results are shown in Table 1, Table 2, and Table 3. The items in rows of the tables were valued according to 3–6 categories and divided into two categories in the test. The left side of the tables shows evaluations of the better side, which is good for the environment. The right side is the opposite. Here 'good' means that the dwelling unit is new, large, and more healthy; moreover, the dwelling environment is better, environmental consciousness of the resident is higher, and the resident uses natural ventilation more than air conditioning.

Mean values of items shown in columns were compared between the left side and right side of the items shown in the row. In Tables 1–3, cell rows that intersect with columns show results of the comparison: ">" denotes that the mean value of the left side of the item shown in the row is larger than that of the right side. That is to say, the side with a smaller mean value is the side of good valuation. Furthermore, "-" indicates that no significant difference exists. Figures 1, 2 and 5 in those tables respectively represent significance levels of $p < 0.01$, $p < 0.02$, and $p < 0.05$.

3 Results

3.1 Ages of respondents

Ages of respondents are shown in Fig. 1. Respondents in their 30s–50s were the most numerous, accounting for 65%. Age was reported using seven categories: 20s ($n=11$), 30s (68), 40s (56), 50s (64), 60s (47), 70s (35), and 80s (7). For some analyses, respondent data were divided into two categories: under 40 ($n=79$) and 40 and over ($n=209$). Air-conditioner use has spread rapidly in Japanese homes since the mid-1970s: the saturation level was 17.2% in 1975 and 84.4% in 1999. Respondents under 40 years old are thought to be more familiar with air conditioning during childhood than other respondents. For comparison of younger generations under 40 and older generations 40 years old and older, mean values in two categories of items A–F (noted before) were used.

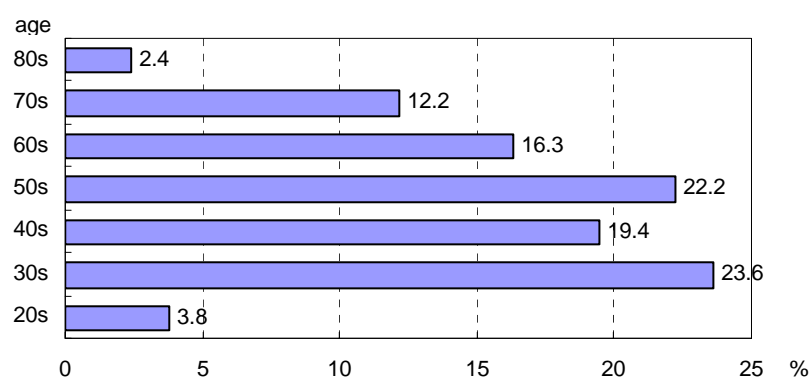


Fig. 1 Frequency distribution of respondent age

3.2 Differences of evaluation of other items by age

3.2.1 Attributes of dwelling units

As Table 1 shows, compared to respondents over 40, those under 40 have fewer years of residence ($p < 0.01$), fewer windows facing south ($p < 0.05$), more windows facing west ($p < 0.05$) and a higher rate of private ownership than public ownership of their dwelling ($p < 0.02$).

The floor number of the dwelling unit, dwelling floor area, age of the dwelling unit, ownership form

(own/rent), and degree of satisfaction with the dwelling environment show no difference by age.

3.2.2 Evaluation of dwelling environment

As Table 1 shows, compared to respondents over 40, respondents under 40 answered that ventilation is worse ($p < 0.01$), the air outside is more polluted ($p < 0.01$), condensation on windows or walls is generated more frequently ($p < 0.05$), mold forms on windows and walls more frequently ($p < 0.05$), and effectiveness of cooling is worse ($p < 0.01$).

Sunshine, the view from the balcony, visibility from outside, crime prevention, noise, dampness and room odors, insects' appearance indoors, solar heat in the summer, glare through windows, and summer heat in the dwelling unit show no differences according to respondents' age.

3.2.3 Attributes of respondents

As Table 2 shows, compared to respondents over 40, those under 40 are more likely to be female ($p < 0.01$), are more tolerant of heat ($p < 0.02$), and catch colds more easily ($p < 0.01$).

Tolerance to cold, regularity of living hours, pattern of living, regularity of meal times, breakfast habits, smoking habit, installation conditions of rattan, installation conditions of window shades, length of occupancy at home on weekdays, health condition, and sleep condition in the summer show no difference by age.

Figure 2 shows tolerance to heat by age bracket. It is common among all age brackets that the respondents that "ordinary" answers are most numerous. Respondents in their 20s or 30s answered "strong" more than "weak". Respondents over 40 answered "weak" more than "strong". As age increases, responses of "ordinary" decrease and those of "weak" increase. However, it is noteworthy that the respondents in 70s and 80s answered "strong" more than others do.

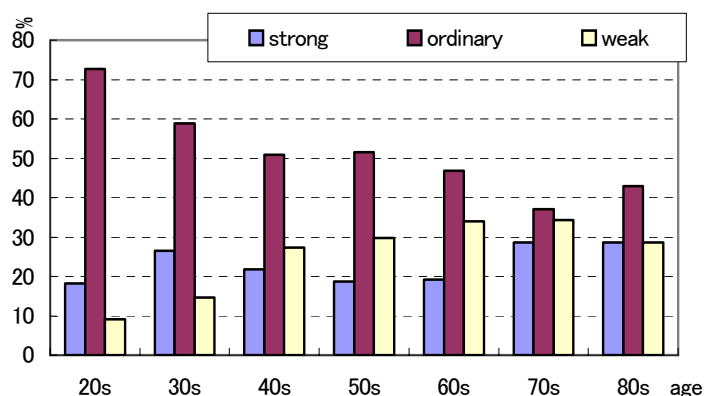


Fig. 2 Tolerance to heat by age bracket

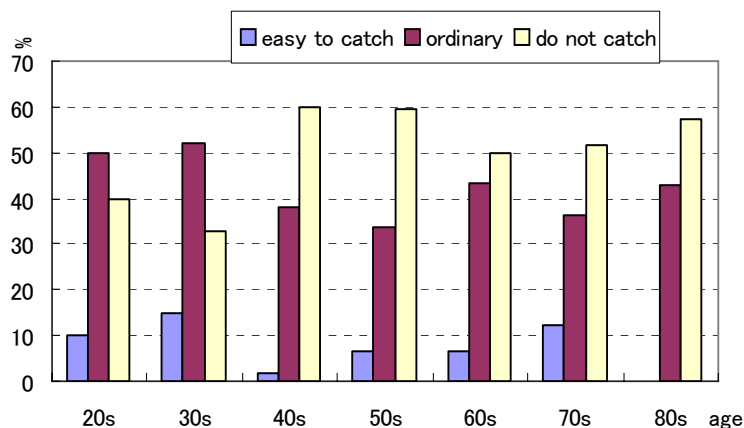


Fig. 3 Disposition to catching colds in the age bracket

Figure 3 shows the disposition to catching colds. More than 50% of respondents over 40 answered that

they “do not catch” colds. On the other hand, tolerance to cold shows no difference by age. It is notable that respondents over 70s more often answered that they are ‘strong’ to heat and ‘do not catch cold’.

3.2.4 Awareness and habits related to environmental problems

As Table 2 shows, compared to respondents over 40, those under 40 answered more that they “prefer natural cooling to mechanical cooling” ($p < 0.05$), report more that they “have a cold constitution.” ($p < 0.01$), less often “try to use environmentally friendly products such as detergents.” ($p < 0.02$), and are less “interested in the heat-island effect and global warming” ($p < 0.01$).

“Having sensitivity to heat and cold”, “frequently controlling temperature using clothes and bedclothes”, “preferring feeling connected to the outside, even in a room”, “having a desire to live in nature such as in a mountain cabin”, “trying to conserve water”, “trying to save electricity”, and “realizing the heat-island effect”, show no difference by age.

3.2.5 Air conditioner use

As Table 3 shows, compared to respondents over 40, respondents under 40 answered that their air conditioners are few ($p < 0.01$), the air conditioners are newer ($p < 0.01$), they are more likely to mind electric bill amounts ($p < 0.01$), do more to reduce electric bills ($p < 0.01$), and report a smaller difference between electric bills of August and May ($p < 0.01$).

Degree of use of air conditioners in the summer, degree of satisfaction with performance of air conditioners, cooling temperatures, use of air conditioners at bedtime, and attitudes toward use of mechanical cooling exhibit no significant difference by age.

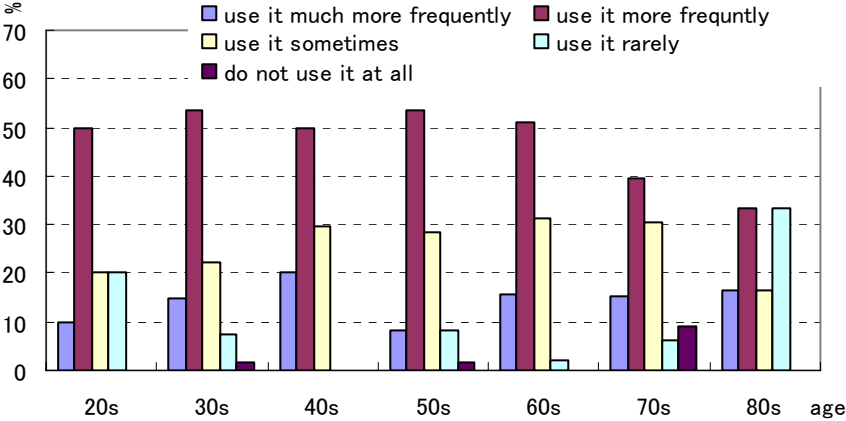


Fig. 4 Degree of use of mechanical cooling during summer by age

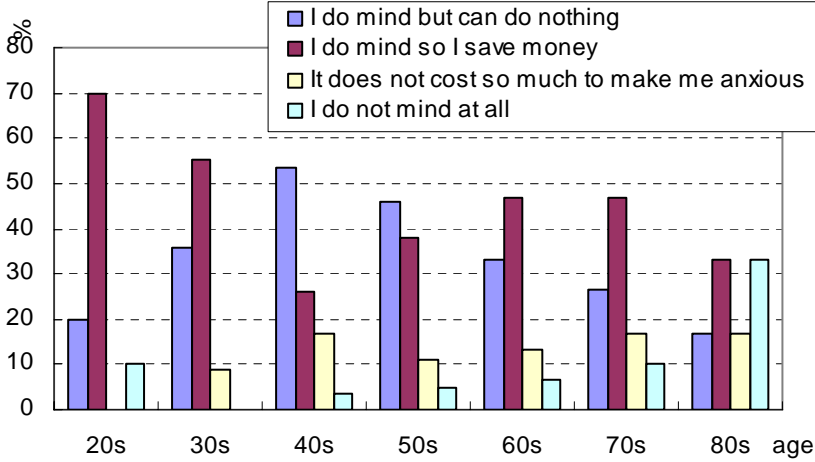


Fig. 5 Awareness of electric bill by age

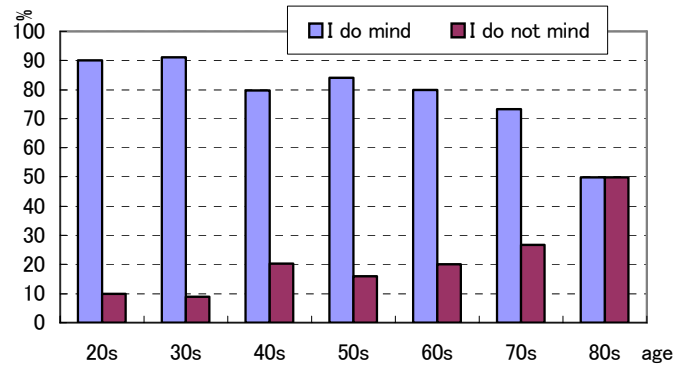


Fig. 6 Awareness of electric bill (I do mind/I do not mind) by age

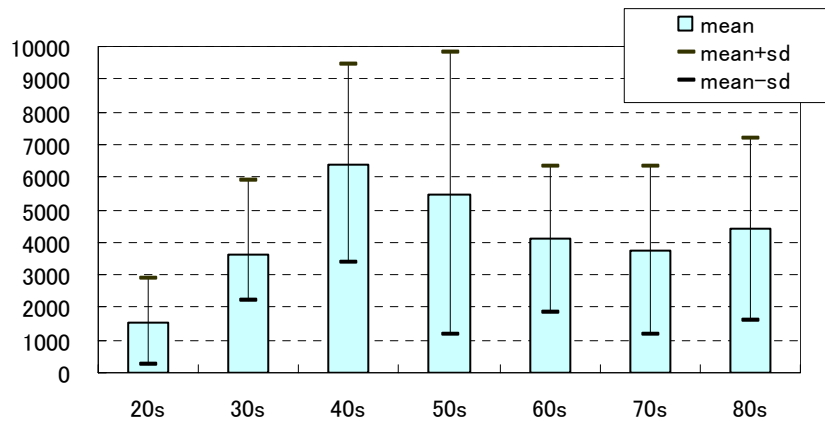


Fig. 7 Monthly cooling cost by age (Yen)

Figure 4 shows subjective degrees of air conditioner use in the summer. Respondents in their 70s and 80s answered “more frequently” less than others did.

Regarding electric bill awareness (Fig. 5 and Fig. 6), the ratio of respondents choosing “I do mind” decreases with increased age. Income might be a reason: respondents in their 40s chose “I do mind so I save money” less than others and chose “I do mind but can do nothing” more than others.

Figure 7 depicts cooling costs by age bracket. Cooling costs of respondents in their 40s are highest. In addition, those of respondents in their 20s and 30s are lower than others.

3.2.6 Window opening and closing

As Table 3 shows, compared to respondents over 40, those under 40 report that they open the window more frequently at bedtime ($p < 0.05$), open the window to its full width usually ($p < 0.05$), seldom open the front door for natural cooling ($p < 0.02$), and do not have screen front doors installed ($p < 0.05$).

Window opening during waking hours in summer, frequency of window opening during autumn, and the width of window opening during autumn show no difference by age.

Figure 8 presents data for window opening at bedtime during summer. Respondents in their 20s answered “frequently open” more than 50%. For respondents in their 20s to 50s, the ratio of “frequently close” increases with age. More than 40% of respondents in their 60s chose it.

With respect to the degree of window opening during summer, younger people more often open a window fully. The respective ratios of respondents choosing “half-open” and “one third open” increase with age. “Fully open” increase from 50s to 80s. On the other hand, “half-open” increases from respondents’ 50s to 80s. Regarding the use of the front door for natural cooling, most respondents in their 50s chose “frequently open”; the ratio of “do not open it at all” of 50s is also high. For those other than respondents in their 50s, the ratio of “do not open it at all” is the highest.

Regarding installation of front screen doors, it is common for all ages that the ratio of “not installed” is the

highest. In fact, 100% of the respondents in their 20s chose “not installed”. Rates of installation increase as age increases. The ratio of “use frequently” also increases with age.

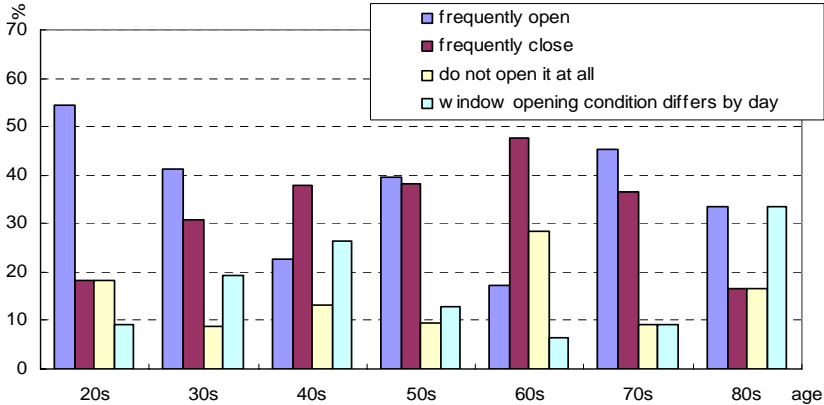


Fig. 8 Window opening condition at bedtime in the summer in the age bracket

3.2.7 Use of electric fans

As Table 3 shows, compared to respondents over 40, those under 40 report fewer electric fans used ($p<0.01$); the frequency of electric fan use during summer is indicated by the response of “use it” ($p<0.01$).

Figure 9 presents the electric fan use frequency. For all ages, the respondents who answered “frequently” were the most numerous: about 40%. Furthermore, among respondents under 40, those who answered “use it very often” and “use it often” were more numerous. Electric fan use apparently declines as age rises when “much frequently” and “frequently” were classified into the good side, and “use it sometimes”, “rarely”, “not at all” were classified into the bad side. From respondents in their 20s to 50s, “very frequently” decreases rapidly: in 50s it is the lowest. “Sometimes” responses increased with age. Among respondents who answered “rarely” and “not at all”, respondents in their 50s were the most numerous. “Very frequently” shows an opposite tendency.

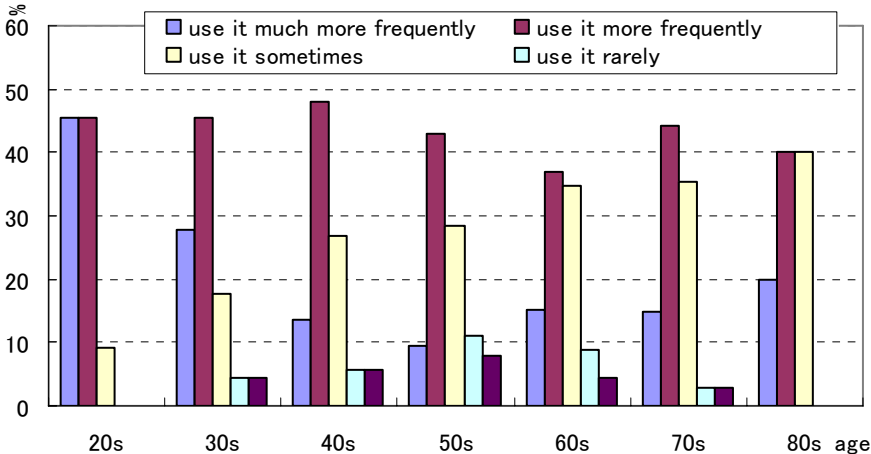


Fig. 9 Use of electric fans by age

4 Discussion

Respondents’ tolerance of heat and disposition to catching colds differ by age. Health condition, tolerance to cold, and sleep conditions show no difference by age.

Respondents under 40 claim to be more resistant to heat than those over 40. Subjective evaluation indicates that they are more conscious of electric bills and open the window more frequently at bedtime

and do more use electric fans during summertime. These might be related to the following facts: 1) younger respondents are stronger to heat than the older respondents; 2) younger respondents are more conscious of electric bills; and 3) have greater awareness of environmental problems, the younger respondents prefer natural cooling to mechanical cooling during summer. Furthermore, they are not interested in the heat-island effects and global warming. Respondents of the generation that was born after the diffusion of air conditioners (30s or 20s) do not always have a lifestyle of bearing heat using air conditioners. They use electric fans and window opening more than the older respondents. Comparing respondents under 40 and those over 40, no differences are apparent in the subjective degree of use of air conditioners by age. However, cooling costs differ by age. Regarding awareness of electric bills, respondents in their 40s and 50s chose "I do mind but can do nothing" more than others. In addition, cooling costs of the 40s and 50s are higher than those of others. Respondents in their 40s and 50s do less about reducing electric bills, although they are conscious of them. Respondents in their 40s and 50s are at their working prime, have high incomes, and have many family members, which might also be related to their responses.

5 CONCLUSIONS

A questionnaire survey was administered to elicit data about apartment residents' use of air conditioners, portals, and electric fans. Differences of the relations with other items were analyzed. The results are as follows.

- 1) Compared to respondents over 40, tolerance to heat of the respondents under 40 is stronger, but they more easily catch a cold. Regarding tolerance to heat, respondents over 40 years old answered "weak" more than "strong". As age rises, "ordinary" decreases and "weak" increases.
- 2) Respondents under 40 have awareness and habits related to environmental problems; they more often answered that they "prefer natural cooling than mechanical cooling in the summer."
- 3) Regarding awareness of electricity costs, the ratio of "do mind" decreases with increasing age. Compared to respondents over 40, those under 40 answered that the degree of electric fan use during summer is higher and that they are more conscious of electric bills. Younger respondents use electric fans to save electricity.
- 4) Subjective degrees of air conditioner use, cooling temperature, use of conditioners at bedtime, and attitudes toward air conditioner use show no differences by age.
- 5) For window opening at bedtime during the summer, more than 50% of respondents in their 20s answered "frequently open." From the 20s to 50s, the ratio of "frequently close" increases. More than 40% of respondents in their 60s chose that response.

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Table 1 Relationship between age and each item of A, Attributes of dwelling units, and B, Evaluation of respondents

			A:Attributes of dwelling units								B:Evaluation of respondents																			
item	evaluation(good side)		A1	A2	A3	A4	A5	A6	A7	A8	A9	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	evaluation(bad side)		
age	under 40	N=79	>1	-	<5	>5	-	-	>2	-	-	<1	-	-	-	<1	-	-	-	<5	<5	-	-	-	-	-	<1	-	N=209	40 & over
			Years of residence	Floor number of the dwelling unit	With or without windows facing south	With or without windows facing west	Dwelling floor area	Age of the dwelling unit	Ownership form (Private/ Public)	Ownership form (Sale/ Rent)	Degree of satisfaction with the dwelling environment	Ventilation	Sunshine	View from the balcony	Glances from outside	Air outside	Crime prevention	Noise outside	Noise from upper/lower floors and from next door	Condensation on windows, walls, etc.	Dampness and odors in rooms	Mold on windows, walls, etc.	Insects such as fruit flies	Indoor insulation heat in the summer	Insulation through windows	Effectiveness of cooling	Summer heat in the dwelling unit			

Table 2 Relationship between age and each item of C, Attributes of respondents, and D, Awareness and habits

			C:Attributes of respondents												D:Awareness and habits															
item	evaluation(good side)		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	evaluation(bad side)	
age	under 40	N=79	>1	>2	<1	-	-	-	-	-	-	-	-	-	-	-	>5	>5	-	-	<1	-	-	<2	-	-	<1	-	N=209	40 & over
			Age	Sex	Tolerance to hotness	Tolerance to coldness	Disposition to catching colds	Regularity of living hours	Pattern of living	Regularity of meal times	Situation of having breakfast	Smoking habit (Smoking/ Non-smoking)	Installation conditions of rattan blinds	Installation conditions of window shades	Staying home situation on weekdays	Health condition	Sleep condition in the summer	prefer to natural cooling than mechanical cooling	having sensitivity to heat and cold	frequently controlling the temperature using clothes and bedclothes	having cold constitution	preferring feeling connected to the outside, even in a room	having a longing to live in nature such as in a mountain cabin	trying to use environmentally friendly products such as detergents.	trying to conserve water	trying to save on electricity	realizing the heat-island effect	being interested in the heat-island effect and global warming.		

Table 3 Relationship between age and items: E, Use of electric fans; F, Use of artificial cooling; and G, Window opening and closing

			E:Use of electric fans		F:Use of artificial cooling								G:Window opening and closing										
item	evaluation(good side)		E1	E2	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	G1	G2	G3	G4	G5	G6	G7	evaluation(bad side)	
age	under 40	N=79	>1	>1	<1	>1	-	-	>1	>1	<1	-	-	-	-	>5	>5	<2	<5	-	-	N=209	40 & over
			Number of electric fans used	Degree of electric fan use during summer	Number of air conditioners used	Purchasing time of the air conditioners	Degree of use of artificial cooling in the summer	Degree of satisfaction with performance of artificial cooling	Awareness of electric bill (I do not mind/ I do not mind)	Awareness of electric bill(I save money / I do not save)	Differential between electric bill in August and that in May	Temperature setting of artificial cooling	Use of artificial cooling at bedtime	Attitude toward use of artificial cooling	Window opening condition during waking hours in the summer	Window opening condition at bedtime in the summer	Width of window opening in the summer	With or without leaving the front door open	Installation condition of screen doors at the front door in the summer	Frequency of window opening in the autumn	Width of window opening in the autumn		