

## **Living environment survey along Hokuriku Shinkansen railway: Social survey conducted one year after opening**

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### **ABSTRACT**

We report the results of a social survey along the Hokuriku Shinkansen (high-speed) railway. This survey was conducted in November 2016, one year after the opening of the Hokuriku Shinkansen Line. Questionnaires were distributed to the inhabitants of 20s and the older living in detached houses along the railway in Ishikawa and Toyama prefectures by mailing method. We selected 1,980 households for survey cooperation and got about 1,000 responses. The main question items were as follows: housing and living environments, transportation facilities (including noise and vibration), lifestyle habits and individual factors. Since noise and vibration exposures for each house have not yet been estimated, we examine the relationship between the distance from the railway to each house and community response to each of noise and vibration. Furthermore, we conducted a social survey with similar questionnaires in 2007, the year before the opening of the Shinkansen Line. We also overview the changes in the evaluation of living environment including noise before and after the opening.

### **INTRODUCTION**

The Hokuriku Shinkansen high-speed railway began operating between Tokyo and Kanazawa, Japan in March 2015. The railway runs a 12-car set rolling stock and has a maximum speed of 260 km/h. In the future, the Hokuriku Shinkansen line will be extended to Shin-Osaka. The Shinkansen railway is convenient as a means of transportation, but noise and vibration caused by the passing trains can disturb residents living along the railway line. The effect of noise and vibration on the residential environment has been studied previously through social surveys of the local population [e.g. 1-3]. However, these most surveys were performed after the opening of the Shinkansen network, and only one study compares residential environment before and after the opening of the Kyushu Shinkansen railway, an older section of the Shinkansen railway network [4]. Morihara et al. [5] investigated the living environment before the opening of the Hokuriku Shinkansen line in Ishikawa, Japan. The results showed that there was a greater number of residents satisfied with their living environmental (37%) than those who were dissatisfied. Moreover, 61% of respondents gave a positive evaluation of their

residential environment. Noise annoyance caused by the conventional railway was more than that by road traffic in 50-60 dB ranges.

This study investigates the residential environment after the opening of the Hokuriku Shinkansen railway and compares the results with the previous social survey [5].

## **METHOD**

### **Survey site**

The survey sites are located in the residential area along the Hokuriku Shinkansen railway in the Ishikawa and Toyama prefectures in northern Japan. The Ishikawa site corresponds to the 2007 survey site, and the conventional railway line runs near many houses surveyed. Conversely, the Toyama survey site is a quiet residential area, and the conventional railway does not run near the site. The Shinkansen high-speed railway line is elevated above ground level at both sites. This study did not conduct noise and vibration measurements but had access to measurements taken by the prefecture [6,7]. Maximum noise levels of 70–81 dB and maximum vibration levels of 41–58dB, were measured on the ground in Ishikawa from September to December 2016 [6]. Maximum noise levels of 69–74 dB were investigated at the Toyama site. Vibration level data was not investigated for Toyama [7].

### **Social survey**

The target houses were all detached houses within 150 m of the Hokuriku Shinkansen railway. If there were no houses within 150 m, we targeted the first row of houses up to 210 m away from the railway line. Respondents were selected from commercial residential maps, and one person per household was selected using the nearest birthday principle. The questionnaire consisted of 43 questions and was distributed by mail and titled the “Living Environment Survey” (Table 1). The questions addressed housing, residential environment, environmental pollution and daily activity disturbance, lifestyle, and demographic variables. The questions on noise and vibration were prepared and a five-point verbal scale was used in combination with a 0 to 10 points numeric scale following the guidelines and recommendations of the ICBEN team 6 [8].

A total of 1025 people responded to the questionnaires, a response rate of 51.8%.

## **RESULTS AND DISCUSSION**

### **Demographic factors**

The respondents were predominantly male (56%), the same value as in the previous survey [5] and 90% of the respondents were over 40 years old (Table 2). This result reflects the dominant demographic of people living in detached houses in regional towns and cities. Almost all the respondents tested insensitive to noise using the WNS-6B scale [9]. A cut-off point of 4/5 on the WNS-6B scale was used.

**Table 1:** Items of Questionnaire

Factors	Items
Housing	Ownership, Years of residence, Size of house, Structure, Window type, Satisfaction, Evaluation (Areas of house and garden, Comfort in summer and winter, Insulation, Ventilation, Sunshine, Soundproof, earthquake-resistant)
Residential environment	Preference, Natural environment, Townscape, View from house, Quietness, Cleanness, Conveniences (Medical facilities, Access to company or school, Access to post office, bank and shopping, Public transportation)
Environmental pollution and daily activity disturbance	Road traffic noise, Aircraft noise, Shinkansen railway noise, Conventional railway noise, Construction noise, Exhaust gas, Factory noise, Vibration (Road traffic, Shinkansen and Conventional railways), Noise and Vibration (Time, Season, Acceptance), Activity disturbances (Conversation, Telephone, TV/radio listening, Reading, Thinking, Falling asleep, Awakening, Window open, rattle, activities at garden)
Life style	Activities for saving energy, Sleeping condition, Number of awakening, Window opening (Sleeping and Relaxing), Usage frequency of transportations, Attitude of transportations, Safety image of transportations
Demographic variables	WNS-6B[9], Sensitivity (Coldness, Hotness, Vibration, Chemicals, Odor, Dust, powder, air pollution), Occupation, Staying time of residence, Number of family, Gender, Age

**Table 2:** Demographic attribute

Gender(%)	Age(%)	WNS-6B(%)
Male 573(56.3)	10s 10(1.0)	0 85(8.5)
Female 444(43.7)	20s 26(2.6)	1 283(28.3)
	30s 41(4.0)	2 390(39.0)
	40s 124(12.2)	3 149(14.9)
	50s 191(18.8)	4 87(8.7)
	60s 343(33.7)	5 4(0.4)
	70s or more 283(27.8)	6 1(0.1)

### Housing factors

Approximately 90% of respondents' houses were constructed from wood. Steel-framed buildings comprise 6% of respondents' houses, and both reinforced concrete construction and mixed material structures made up ~1% (Figure 1), which is similar to the values in the previous study [5]. Figure 2 shows the relationships between the type of living room window glazing and the number of years after house construction. In houses less than ten years old, 87% had double-glazed living room windows; in houses that were 10–20 years old, this is reduced to 64%. The relationship indicates that recently built houses in this survey area will likely have double-glazed windows. Aluminum window frames comprise 80–90% of the respondents, with plastic frames increasingly common in modern properties (Figure 3).

The number of respondents satisfied with their housing was greater than those dissatisfied (40%:10%) with no difference recorded between the 2016 and 2007 surveys (Figure 4). The comfort in summer was the most positive evaluation in the housing questions. It was sunshine, house ventilation, house size, and garden size that the positive evaluation was more than the negative evaluation. Conversely, it was earthquake-resistance, soundproofing, insulation, and the comfort in winter that the negative evaluation was more than the positive evaluation (Figure 5). The climate of the Hokuriku district directly influences the housing satisfaction results.

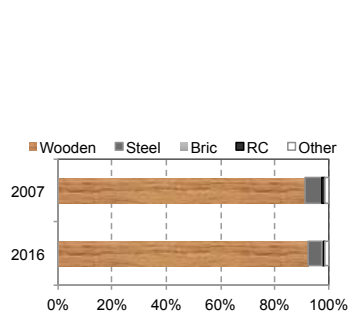


Figure 1: House structures

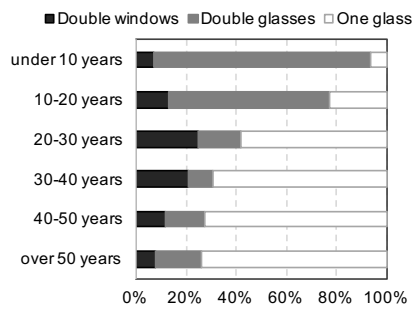


Figure 2: Window glasses

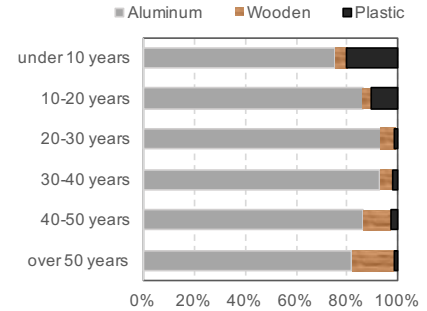


Figure 3: Sash types

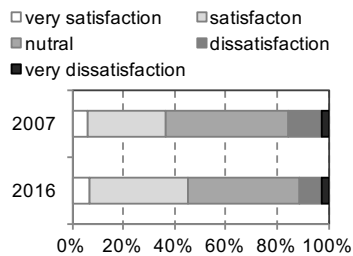


Figure 4: Satisfactions for house

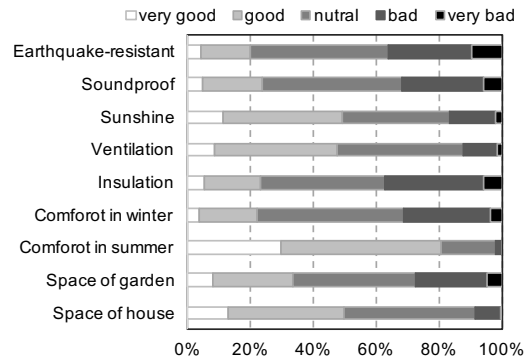


Figure 5: Evaluations for house

### Residential environment factors

Approximately 70% of the respondents living in Ishikawa and Toyama are content with their residential environment (Figure 6). The natural environment, cleanliness, public transportation, plus access to medical facilities, place of work, and post office, were evaluated as good by ~40% of respondents, 36% answered quite good and 20% thought these factors were unsatisfactory (Figure 7). The evaluation of quietness is related to the distance from the Shinkansen line (Figure 8).

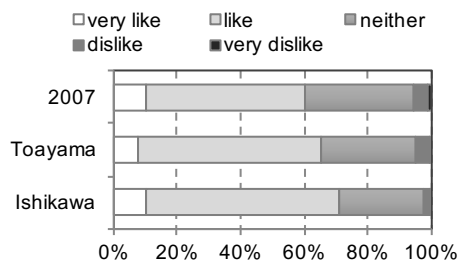


Figure 6: Satisfactions for house

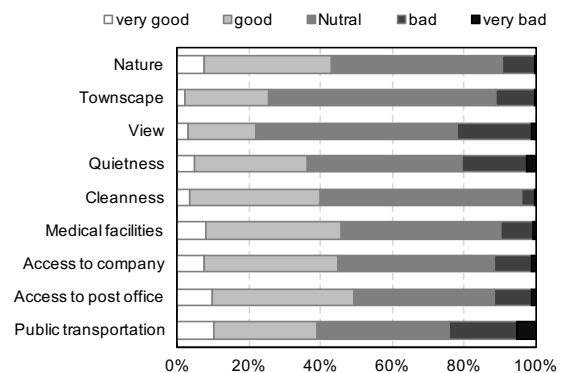


Figure 7: Evaluations for house

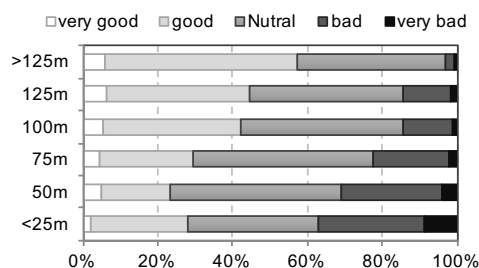


Figure 8: Relationships between quietness and the distance

## Lifestyle factors

The most frequent means of transportation was by car (Table 3). There is almost no use of the Shinkansen railway at present, and only ~1% of the respondents answered “Very” or “Extremely” likely to use the high-speed railway. Over half of the respondents answered that conventional railway and bus should be used and motorbikes should not be used. Half of the respondents agreed that the Shinkansen railway should be used. Conversely, ~4% of the respondents answered that it should not be used. Regarding the safety image of transportation types, it was shown that perceived safety of the conventional railway and the Shinkansen railway exceeded 80%, and that rail travel was safer than traveling by car.

**Table 3:** Number of consciousness to transportations

	Car	Conventional railway	Shinkansen railway	Motorbike	Bus	Aircraft	Bicycle
<b>Usage frequency</b>							
Not at all	55(5.5)	337(34.5)	518(53.5)	912(94.7)	410(41.8)	708(73.3)	411(41.3)
Slightly	36(3.6)	390(39.9)	327(33.7)	20(2.1)	295(30.1)	205(21.2)	167(16.8)
moderately	101(10.0)	197(20.2)	113(11.7)	14(1.5)	207(21.1)	50(5.2)	226(22.7)
Very	211(21.0)	34(3.5)	6(0.6)	12(1.2)	44(4.5)	2(0.2)	92(9.3)
Extremely	603(59.9)	19(1.9)	5(0.5)	5(0.5)	25(2.5)	1(0.1)	98(9.9)
<b>Attitude</b>							
Should be used frequently	88(8.9)	131(13.2)	106(10.8)	14(1.4)	144(14.7)	42(4.4)	297(29.8)
Should be used preferably	161(16.3)	559(56.4)	360(36.8)	64(6.6)	532(54.2)	147(15.2)	416(41.8)
Neither	545(55.1)	287(28.9)	472(48.2)	506(52.1)	279(28.4)	691(71.6)	225(22.6)
Should be seldom used	191(19.3)	8(0.8)	23(2.3)	256(26.4)	17(1.7)	52(5.4)	38(3.8)
Should not be used at all	4(0.4)	7(0.7)	18(1.8)	131(13.5)	9(0.9)	33(3.4)	20(2.0)
<b>Safety image</b>							
Extremely safe	13(1.3)	321(32.2)	405(40.9)	1(0.1)	88(8.9)	129(13.1)	296(29.9)
Rather safe	256(25.5)	529(53.0)	435(43.9)	20(2.0)	546(55)	374(37.9)	414(41.8)
Neither safe nor dangerous	439(43.7)	140(14.0)	141(14.2)	193(19.6)	332(33.4)	395(40.1)	225(22.7)
Rather dangerous	263(26.2)	8(0.8)	7(0.7)	520(52.7)	26(2.6)	71(7.2)	38(3.8)
Extremely dangerous	33(3.3)	0(0)	2(0.2)	252(25.6)	1(0.1)	17(1.7)	18(1.8)

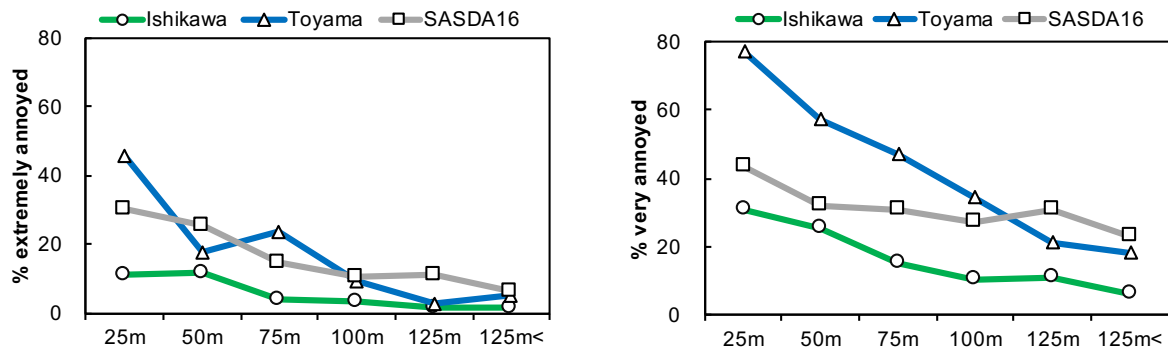
## Effect of distance from the Shinkansen line on responses

Figure 9 shows the relationship between noise annoyance and distance of the respondent’s property from the Shinkansen line. “% extremely” and “% very” mean that the percentage of respondents who selected “extremely” and “extremely” or “very” out of 5-point verbal scale within the distance range, respectively. The SASDA16 line is from the social survey data archive in Japan [10]. This study used the Shinkansen dataset (4219 data points) from the archive.

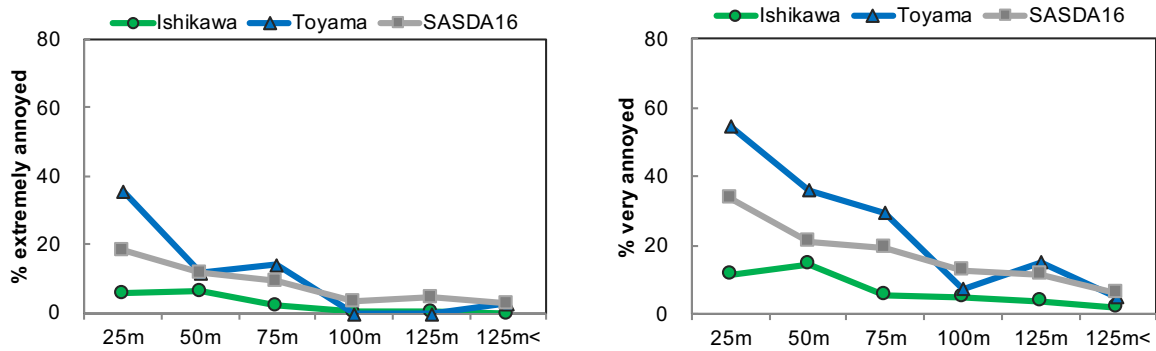
Noise annoyance in Ishikawa was lower than in the Toyama and SASDA16 survey results. In Toyama, high noise annoyance near to the Shinkansen line is identified. The difference in noise annoyance between sites suggests that residential noise conditions (e.g., background noise) may also have an effect. Vibration annoyance, shown in Figure 10, is found to be similar to noise annoyance close to the railway line, and overall the vibration annoyance was slightly smaller than the noise annoyance at a greater distance from the line.

The relationship between the distance and rest, rattling, and listening disturbances is shown in Figure 11. LD means the reaction of the larger one of the telephone and TV/radio listening disturbances. A higher disturbance of listening, rest, and rattling is identified in the SASDA16

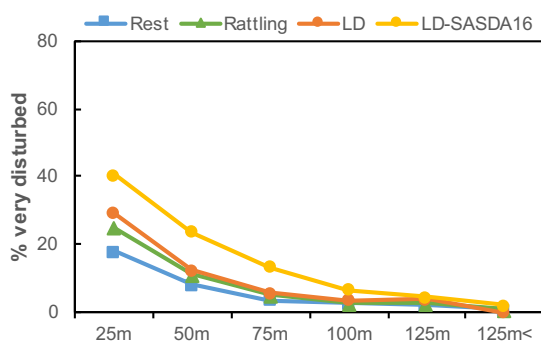
data compared to this study. Figure 12 shows that sleeping disturbances of respondents 25 m from the Shinkansen railway was slightly higher in our study than in the SASDA16 data.



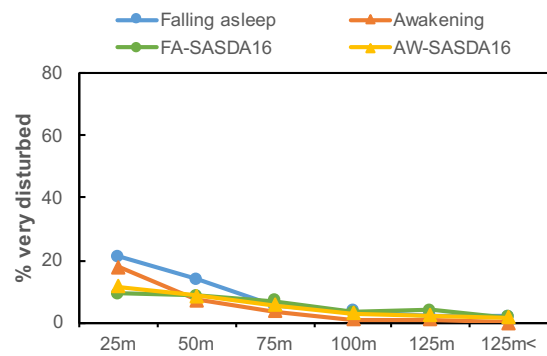
**Figure 9:** Results of relationships between noise annoyance and the distance (left: the top category of 5-point scale, right: the top two categories of 5-point scale)



**Figure 10:** Results of relationships between vibration annoyance and the distance (left: the top category of 5-point scale, right: the top two categories of 5-point scale)



**Figure 11:** Activity disturbances



**Figure 12:** Sleeping disturbances

## CONCLUSIONS

This study showed the results of a social survey of residents living near the Hokuriku Shinkansen railway. The response rate was greater than 50%, and as the target of the survey was largely residents of detached houses, the respondents were primarily the elderly.

It was confirmed that the window type changed after approximately 20 years from when the houses were built. House and residential environment satisfaction were the same as in the previous study [5] and quietness corresponded to the distance from the Shinkansen line. The respondents closer to the Shinkansen track showed higher noise and vibration annoyance, and activity disturbances. Noise and vibration disturbance was found to be greater in Toyama than in Ishikawa.

In the next step, it will be necessary to estimate noise and vibration exposure levels at each house immediately and to investigate the exposure–response relationship.

### **Acknowledgements**

We are grateful to respondents in Ishikawa and Toyama for our research. The present study was supported by Grant-in-Aid for Scientists Research (C) of Japan Society for the Promotion of Science (No.15K06341).

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