Exposure-response relationship of self-reported sleep disturbance derived from Japanese socio-acoustic surveys

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ABSTRACT

Socio-Acoustic Survey Data Archive (SASDA), established in 2011 under the Institute of Noise Control Engineering, Japan, is a data archive that accumulates social survey data on community responses to environmental noise throughout Japan. This paper reports exposure-response relationships based on self-reported sleep disturbances due to road traffic, railway, and Shinkansen railway noises derived from 29 Japanese datasets included in SASDA by adding the data obtained from recent surveys in Japan. Although the question wording and the number of scale points on the evaluation differed among the surveys, the cut-off point as the definition of highly sleep disturbed (HSD) was standardized at 72% for all datasets. Comparing among the noise sources, it was found that the response to road traffic is significantly higher in the range of L_{night} above 55 dB. Compared to the WHO guideline values, the response to road traffic is slightly higher, while that to conventional railway is significantly lower. The reason for the different results between road traffic and conventional railway will be discussed in the future.

INTRODUCTION

In the "ENVIRONMENTAL NOISE GUIDELINES for the European Region" [1], published in 2018, the recommendation of L_{den} and L_{night} values for each noise source were shown. We have previously reported the results of a secondary analysis of the exposure-response relationship for L_{dn} and highly annoyed using data derived from social surveys conducted in Japan [2, 3]. However, such analysis for the relationship between L_{night} and sleep disturbance was difficult because the question wording and evaluation scale were not standardized. For this reason, no representative exposure-response relationship for sleep disturbance in Japan has been reported so far. In this paper, using the data set stored in the Social Acoustic Survey Data Archive (SASDA) [4] by adding the data obtained from recent surveys in Japan, we tried to

analyse the relationship between L_{night} (A-weighted equivalent continuous sound level from 22:00 to 7:00) and percentage of the population highly sleep disturbed (%HSD) according to the same definition of cut-off point as in the guideline, and report the results of the comparison with the guideline.

METHOD

Data set

Table 1 shows an overview of the data sets used in the analysis (detached houses only). In this paper, road traffic (RT), conventional railway (CR), and shinkansen railway (SR) noises are considered as the noise source for the exposure-response relationships. In most of the datasets, sleep disturbance about specific sound sources (SPE) was asked, but some of them asked about general sleep disturbance (GEN) without specifying the sound sources. On the other hand, for the evaluation of sleep disturbance, either separate items for the difficulty in falling asleep and arousal (DFA+AWK) or both items (SLD) were used. The number of scales used for each evaluation is shown in bracket.

For some data sets, the exposure data of L_{night} was not available. In such cases, L_{night} was estimated in units of 0.1 dB based on the data such as information on railway operations and measurement data by road traffic noise monitoring posts.

Table 1: Outline of socio-acoustic survey datasets for only detached houses. The value in the bracket of "Evaluation" indicates the number of scale points.

No.	Survey ID	Mode	Survey year	Sample size	Question	Evaluation
1	JPN002CR	CR	1994–1995	1828	SPE	DFA+AWK (5)
2	JPN003RT	RT	1994–1995	387	SPE	DFA+AWK (4)
3	JPN004HR	SR	1995–1996	870	SPE	DFA+AWK (5)
4	JPN005RT	RT	1996	813	SPE	DFA+AWK (4)
5	JPN006CR	CR	1997	310	SPE	DFA+AWK (2)
6	JPN007RT	RT	1997–1998	779	SPE	DFA+AWK (4)
7	JPN009RT	RT	1998	353	SPE	DFA+AWK (2)
8	JPN010RT	RT	1999-2000	657	GEN	SLD (2)
9	JPN011RT	RT	2000–2006	1599	SPE	SLD (2)
10	JPN012CR	CR	2001	1422	SPE	DFA+AWK (4-5)
11	JPN013HR	SR	2001–2003	1101	GEN	SLD (2)
12	JPN014CR	CR	2002	1408	SPE	DFA+AWK (5)
13	JPN015HR	SR	2003	706	SPE	DFA+AWK (5)
14	JPN016RT	RT	2003–2004	272	SPE	DFA+AWK (5)
15	JPN017CR	CR	2003–2006	1544	SPE	DFA+AWK (2)
16	JPN018HR	SR	2003–2006	1277	SPE	SLD (2)
17	JPN021MS	RT	2004–2006	1335	SPE	DFA+AWK (5)
18	JPN021MS	CR	2004–2006	1342	SPE	DFA+AWK (5)
19	JPN022HR	SR	2005	175	SPE	SLD (2)

Table 1: Outline of socio-acoustic survey datasets for only detached houses. The value in the bracket of "Evaluation" indicates the number of scale points. (Continue)

No.	Survey ID	Mode	Survey year	Sample size	Question	Evaluation
20	Morihara (2009) [5]	RT	2007	353	SPE	DFA+AWK (5)
21	Matsumoto (2013) [6]	RT	2011	203	SPE	DFA+AWK (5)
22	Matsumoto (2013) [6]	CR	2011	166	SPE	DFA+AWK (5)
23	Tetsuya (2017) [7]	CR	2009–2010	564	SPE	DFA+AWK (5)
24	Tetsuya (2017) [7]	CR	2011–2012	990	SPE	DFA+AWK (5)
25	Tetsuya (2017) [7]	SR	2011–2012	1000	SPE	DFA+AWK (5)
26	Morihara (2014) [8]	SR	2013	287	SPE	DFA+AWK (5)
27	Morihara (2017) [9]	SR	2016	974	SPE	DFA+AWK (5)
28	Morihara (2017) [9]	CR	2016–2017	680	SPE	DFA+AWK (5)
29	Murakami (2018) [10]	SR	2016–2017	685	SPE	DFA+AWK (5)

The method converting to the data equivalent with cut-off 72%

The guidelines set a cut-off point of 72% for determining whether each respondent have experienced a highly sleep disturbance. However, the dataset analysed in this paper contains two-point scale of sleep disturbance and others with four-point to seven-point scales. Therefore, for each number of scales, we converted each respondent's rating into a response corresponding to a cut-off point of 72% by replacing the scores shown in Table 2 with the responses for each category. For example, in the case of the 5-point scale, it was assumed that the scale of the ratings was equally spaced and that a highly sleep disturbance occurred for all respondents in Category 5 (Top 1 category) and for 40% of respondents in Category 4 (Top 2 category). This operation yields a converted value equivalent to a cut-off point of 72%. In the case where the ratings of falling asleep disturbance and arousal were obtained separately, the mean of the converted values of the two items was used as the response to highly sleep disturbance.

Table 2: Scores for %HSD.

	Category						
	1	2	3	4	5	6	7
2-point scale	0	0.56	-	-	-	-	-
4-point scale	0	0	0	1	-	-	-
5-point scale	0	0	0	0.4	1	-	-
6-point scale	0	0	0	0	0.7	1	-
7-point scale	0	0	0	0	0	1	1

RESULTS

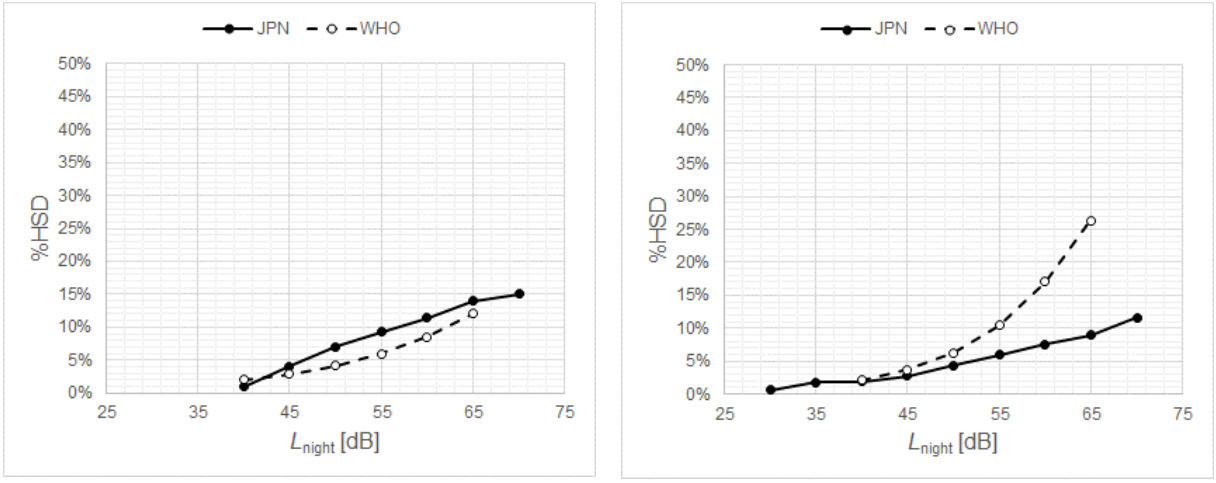
For the calculation of the exposure-response relationship, the L_{night} was divided into 5 dB intervals. For example, the category of L_{night} of 50 dB includes data from 47.5 to 52.4 dB. Table 3 shows the averages of highly sleep disturbance responses for each L_{night} category. Comparing

the exposure-response relationships among the noise sources, it was found that the response to road traffic is the highest in the range that L_{night} is 50 dB and more. In the range that L_{night} is 45 dB and less, Shinkansen noise has the highest response rate.

The comparison of the exposure-response relationships between the present study and the WHO guidelines for road traffic and conventional railway noises are shown in Fig.1. Compared to the WHO guideline values, the response to road traffic in the Japanese data is slightly higher, while that to conventional railway is significantly lower. The reason for the different results between road traffic and conventional railway will be discussed in the future.

Table 3: Highly sleep disturbance for each mode of transportation noises.

L_{night}	RT			CR			SR		
[dB]	%HSD	95% CI	*N*	%HSD	95% CI	*N*	%HSD	95% CI	*N*
30				0.6%	0.0 – 1.7%	533	1.1%	0.0 – 2.6%	344
35				1.8%	0.0 - 3.7%	662	1.9%	0.0 - 3.8%	1353
40	1.0%	0.0- 2.4%	249	1.9%	0.0 - 3.8%	985	4.6%	1.7 - 7.5%	2452
45	4.1%	1.3 - 6.8%	436	2.7%	0.4 - 5.0%	1842	5.5%	2.3 – 8.7%	1420
50	7.0%	3.4 - 10.5%	858	4.3%	1.5 - 7.1%	1940	6.2%	2.8 – 9.6%	472
55	9.3%	5.2 - 13.4%	1134	5.9%	2.6 – 9.2%	1730	3.0%	0.6 – 5.4%	200
60	11.4%	6.9 - 15.8%	1260	7.5%	3.8 – 11.2%	1119			
65	14.0%	9.2 - 18.9%	666	8.9%	4.9 - 12.9%	395			
70	15.0%	10.0 - 20.0%	210	11.6%	7.1 - 16.1%	151			



Road traffic noise Conventional railway noise

Figure 1: The comparison of the exposure-response relationships between the present study and the WHO guidelines

CONCLUDING REMARKS

In this paper, using a dataset derived from a social survey conducted in Japan, the relationships between exposure, L_{night}, and highly sleep disturbance response were established for road traffic, conventional railway, and Shinkansen railway on a trial basis using the same method as the WHO guideline. Future studies are needed to discuss in detail the differences from the results in the guideline and the differences among the noise sources. In addition, the collection of data on aircraft noise and the establishment of exposure-response relationships for sleep disturbance related to aircraft noise are important issues that should be addressed immediately.

To introduce an accurate exposure-response relationship from secondary analysis, we would like to consider the selection criteria for the data set used in the analysis, with a viewpoint different from the guidelines.

Acknowledgements

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