

# Development of Subjective Evaluation Tool of Work Environment for Office Workers' Work Performance and Health Promotion

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## ABSTRACT

In recent years, not only the residence but also the effort of health promotion by improving the social environment including the working and the regional environment has attracted attention. Because of the significant amount of time that office workers spend in the workplace, ideal modification of their working environment and work habits could potentially improve both their intellectual productivity and their physical health. However, optimal environmental improvements have not yet been identified. Therefore, in the present study, we developed a revised version of CASBEE-OHC. This version incorporates items evaluated in CASBEE-Wellness Office (CASBEE-WO), which is an objective workplace evaluation tool developed by the committee. This tool is constructed so that the question item does not have deflection by considering in various areas such as basic performance of buildings, operation management, and programs. The basic performance of buildings is focused on various fields such as design, installation, and structure. In particular, in the field of installation, we also set up questions about the room temperature and air quality by air conditioning and ventilation equipment, which are suggested to have a great impact on the workers' intellectual productivity and health. In order to verify the effectiveness of the revised CASBEE-OHC, we conducted a survey on workers' health and psychological status, in addition to their general environment (working environment, residence, community). At first, the relationship the degree of dysfunction in labor and the environments (working environment, residence and community) in which the office workers stay, was analyzed. Next, the analyses considering the influence of confounding factors were carried out, by conducting multiple regression analysis on subjective work efficiency and logistic regression analysis on the degree of dysfunction in labor and Sleep efficiency. As a result, it was confirmed that if the office environment and residence, community of the office worker are good, it will have a good influence on health condition and workers' intellectual productivity. Also, the correlation analysis for evaluation item indicated that the correlation between office air conditioning, air quality and dysfunction in labor was high. Furthermore, among air conditioning and air quality field, it was confirmed that the influence of the item regarding air quality was the largest. And, based on multiple regression analysis, it was confirmed that the working environment and age of the officer, influenced the work efficiency. And, from the logistic regression analysis, it was suggested that the risk of having a high degree of labor impairment and sleeping disorder increases when the surrounding environment including office space was bad.

## KEYWORDS

Health promotion, Intellectual productivity, Wellness office, Questionnaire, Dysfunction in labor

## 1 INTRODUCTION

In recent years, not only the residence but also the effort of health promotion by improving the social environment including the working and the regional environment has attracted

attention. Because of the significant amount of time that office workers spend in the workplace, ideal modification of their working environment and work habits could potentially improve both their intellectual productivity and their physical health<sup>1)</sup>. Previous studies<sup>2)</sup> have shown that the workplace conditions of office workers influence both physical health and job performance. Thus, increased attention has been paid to identification of relevant health promotion strategies in these environments. However, optimal environmental improvements have not yet been identified. The Japan Sustainable Building Consortium (JSBC) launched the Smart Wellness Office Research Committee in 2012, and has worked to develop the CASBEE-Office Health Checklist (CASBEE-OHC), an evaluation tool aimed at not only improving intellectual productivity in office buildings, but also enhancing resilience and saving energy<sup>3)</sup>. In a previous study, we conducted a survey on health and psychological status in addition to workers' everyday environment (workplace, residence, community), and identified relationships via regression analysis<sup>4)</sup>. However, due to the non-normality of the score distribution of the beta version of CASBEE-OHC, revision and subsequent verification of the tool is needed. Therefore, in the present study, we developed a revised version of CASBEE-OHC. This version incorporates items evaluated in CASBEE-Wellness Office (CASBEE-WO), which is an objective workplace evaluation tool developed by the committee. In this paper, we outline the checklist, describe the outline of an online questionnaire survey using this checklist and discuss the results of our analysis. In this survey, the CASBEE is used to evaluate not only the working environment, but also the broader everyday environment to which workers are exposed.

## 2 OVERVIEW OF RELATED TOOLS IN CASBEE-WELLNESS OFFICE <sup>5)6)</sup>

### 2.1 Overview of CASBEE-WO

CASBEE-WO is an *objective* evaluation tool that architectural experts use to assess environmental optimization for promoting health and productivity. Unlike the conventional CASBEE and related instruments, the scope of CASBEE-WO is the interior layout and furniture present in the specific department in which the employee works, and the efforts of the tenants. The items evaluated by CASBEE-WO are shown in Table 1. Items are distributed across three categories, and all evaluation items are scored according to a 5-level scale (level 1 to level 5), as is done in CASBEE-New Construction.

Table 1 The evaluation items of CASBEE-WO

Major items	Second items	Third items
I. Basic performance of the building	(1) Health and comfort	①Space, interior
		②Sound, noise
		③Lighting
		④Air and air conditioning
		⑤Refresh
		⑥Exercise
	(2) Convenience improvement	①Mobile space and communication
		②Telecommunications
	(3) Ensuring safety	①Disaster
		②Harmful substance
		③Water safety
		④Security
II. Operational management		①Maintenance plan
		②Satisfaction survey
		③Disaster response
III. Program		

### 2.2 Overview of CASBEE-OHC

CASBEE-OHC is a *subjective* evaluation tool that workers themselves use to evaluate their job satisfaction and health. The tool therefore evaluates the behavior and awareness influenced

by physical conditions and the surrounding environment. Each question was examined with reference to the CASBEE-WO evaluation items shown in Table 1, and a tool was developed. The answer format is shown in Table 2, and questions from CASBEE-OHC are shown in Tables 3 through 5. In addition, each question item was designed to correspond to the three categories used in CASBEE-WO, and we did not identify bias in the contents of CASBEE-OHC.

Table 2 Example of answer format

Achievement of optimal factors				Removal of dysfunctional factors			
3 point	2 point	1 point	0 point	3 point	2 point	1 point	0 point
very well	A little	Not true	Not at all true	No	Rare	Sometimes	Common

Table 3 Question item of Q1

Achievement of optimal factors		Removal of dysfunctional factors	
Q1	There is planting that people can feel green	Q10	Feeling that work space and storage place are narrow
Q2	There is desk corresponding to standing work	Q11	Feeling discomfort due to heat or cold
Q3	There is a chair suitable for both work and rest	Q12	Making the air-conditioning air flow uncomfortable
Q4	You can enjoy the outside view from inside the office	Q13	Remembering the dryness and moisture of the air
Q5	You can feel a sense of freedom of space	Q14	Feeling the air stagnation, dustiness, unpleasant smell
Q6	Openable windows open to the outside are well introduced	Q15	Feeling uneven brightness
Q7	It has become a comfortable interior	Q16	Feeling that the work space is dark
Q8	You can freely choose the desk that suits your daily work style	Q17	Feeling that sunshine and lighting equipment are dazzling
Q9	During the daytime, you can feel the light from the outside	Q18	Anxious about external sounds
		Q19	Anxious about other people's conversation and equipment machine noise

Table 4 Question item of Q2

Achievement of optimal factors		Removal of dysfunctional factors	
Q1	There is an easy-to-use refresh space	Q14	Having a bad taste or smell in tap water
Q2	There are easy-to-use meals and cafes	Q15	Waiting in the bathroom
Q3	There is an easy-to-use mini kitchen etc.	Q16	Waiting for the elevator
Q4	You can choose meeting space depending on the situation	Q17	Dissatisfaction with outlet capacity, wiring etc.
Q5	There is a staircase located in a convenient location	Q18	Feeling stress on the communication network
Q6	There is a space to take an easy-to-use nap	Q19	Feeling that meeting space is not enough
Q7	There is an easy-to-use internal information sharing infrastructure		
Q8	There is a space promoting easy-to-use conversations		
Q9	There is an entrance hall where you can easily meet and talk		
Q10	Becoming it goes ahead through the barrier-free in a building		
Q11	Facilities to promote daily exercise are abundant		
Q12	There is a comfortable toilet that is fully equipped		
Q13	There is a safe and comfortable elevator		

Table 5 Question item of Q3

Achievement of optimal factors		Removal of dysfunctional factors	
Q1	Questionnaires are conducted to improve the office or building environment	Q10	Feeling uneasy on crime prevention
Q2	Sufficient efforts are being made to maintain and improve mental health	Q11	Feeling uneasy at the time of disaster or emergency
Q3	Efforts are being made for smoke separation and smoking cessation	Q12	Feeling unsanitary throughout the building
Q4	A well-developed health promotion program is being implemented	Q13	Dissatisfaction with management of building, administration method
Q5	There are many postings to promote the use of stairs		
Q6	There is a comfortable green space around the building		
Q7	The scenery is in harmony with the city and surrounding buildings		
Q8	Evacuation drills are conducted regularly		
Q9	Emergency response manual has been prepared and is well known		

In order to minimize the burden on the worker when responding to these questions, all 51 items were classified into three question categories (Q1 to Q3), and were further grouped according to the general categories of “Achievement of optimal factors” and “Removal of dysfunctional factors”. With respect to the classification of “Achievement of optimal factors” and “Removal of dysfunctional factors”, there is a concern that such labels will engender bias in workers’ responses, so such labels are omitted when conducting the actual survey. In addition, Q1 asks “Regarding the environment and equipment of your work space in the office...”, Q2 asks “Regarding the environment and equipment of the entire office or building...”, and Q3 asks “Regarding activities and affiliated organizations in the building...”. In the CASBEE-OHC β version, it is considered that the score distribution has become non-normal because the answer format is 2 options (Yes or No). From this point, the survey adopts a 4-choice format (degree or frequency), with scores ranging from 0 points (worst state) to 3 points (best state).

### 2.3 Utilization scene of CASBEE-OHC

Utilization scene of CASBEE-OHC assumes three scenes of “1. Building owner, Designer, Builder, and Building manager”, “2. Company (General affairs department etc.)”, and “3. Industrial doctor of company”. At the time of utilization, it is assumed that surveys of workers' surrounding environment and health status are conducted and they are related. Image diagram of the evaluation result and the feedback output result are shown in Fig.1. As shown in the fig.2, it is planned to use a radar chart to visually indicate where improvement is needed. This is intended to encourage not only workers but also building managers to create rules for environmental improvement.

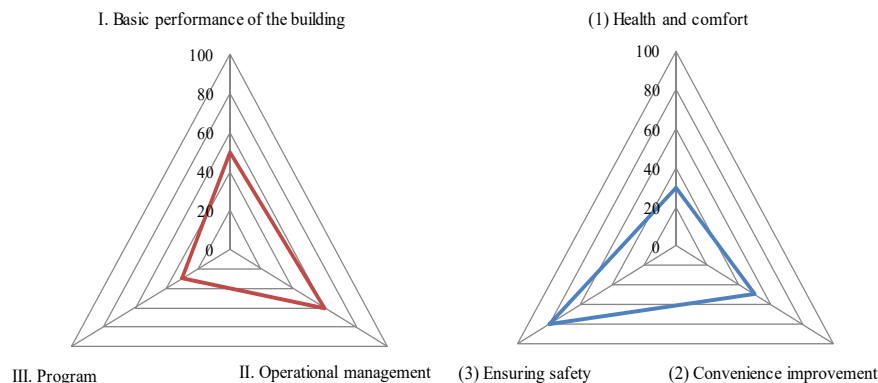


Fig.1 Image diagram of the evaluation result and the feedback output result

### 3 OVERVIEW OF WEB QUESTIONNAIRE

In order to verify the effectiveness of the revised CASBEE-OHC, we conducted a survey on workers' health and psychological status, in addition to their general environment (working environment, residence, community), in the Kanto region of Japan. The survey outline is shown in Table 6.

Table 6 Overview of WEB questionnaire

<b>Implementation period</b>	2018.07.31-08.02
<b>Number of total</b>	5,621
<b>Number of valid responses</b>	3,552
<b>Target</b>	Working in the Kanto district of Working for a company with more than 50 employees doing office work
<b>Implementation method</b>	WEB questionnaire
<b>Outline of question</b>	1) CASBEE-OHC (51questions) 2) CASBEE-Housing (6questions) 3) CASBEE-Community (8questions) 4) WFun (7questions) 5) Health, Lifestyle, Sleep, Work efficiency 6) Occupation, Position, Age, Gender, Annual income etc.

As screening is done in advance, even samples on gender and age were obtained. In these two checklists (CASBEE-Housing and Community), a significant correlation was confirmed between the score and the prevalence rate of residents in the past research<sup>7) 8)</sup>. 4) WFun<sup>9)</sup> is a questionnaire used to measure the degree of dysfunction in labor due to health problems. Although it does not use medical information, strong relations have been identified between WFun's measured degree of dysfunction in labor with workers' medical symptoms and probability of medical leave. 5) Working Efficiency<sup>10)</sup> is a questionnaire that involves self-evaluation of routine work performance.

### 4 RESULT OF ANALYSIS

#### 4.1 Simple Tabulation

The distribution of CASBEE-OHC scores in this questionnaire survey is shown in Fig.2. The CASBEE-OHC  $\beta$  version yielded a non-normal distribution. However, data from the CASBEE-OHC were normally distributed, as shown in Fig.2.

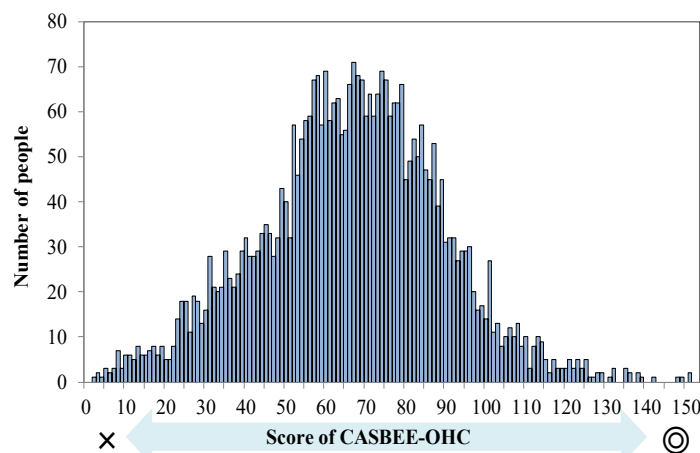


Fig.2 Score distribution of CASBEE-OHC

Next, the interpretations of WFun and Pittsburgh scores are shown in Tables 7 and 8, and the distributions of WFun and Pittsburgh scores in this questionnaire are shown in Fig.3 and 4. As

shown in Tables 7 and 8, higher total WFun and Pittsburgh scores are associated with higher levels of dysfunction in labor and greater probability of sleep disorders. As compared with reference proportions in Table 7, data from questionnaire respondents indicated elevated levels of labor dysfunction. Moreover, as shown in Fig.4, approximately 80% of workers in this sample have a sleep disorder.

Table 7 Interpretations of WFun

Score of WFun	Reference rate (%)	WEBPercentage (%)	Degree of dysfunction in labor
7~13	50~60	37.2	No problem
14~20	20~30	31.5	Slight disorder
21~27	10~15	19.8	Moderate disorder
28~35	2~8	11.5	Severe disorder

Table 8 Interpretations of Pittsburgh

Score of Pittsburgh	WEB Percentage (%)	Degree of sleep disorder
5 points or less	19.1	No problem
6~8 points	52.8	Slight disorder
9 points or more	28.0	Severe disorder

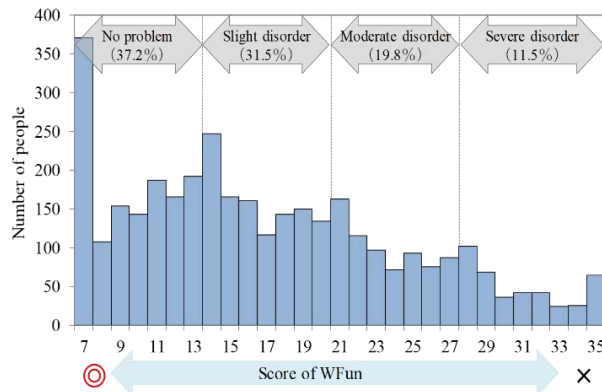


Fig.3 Score distribution of WFun

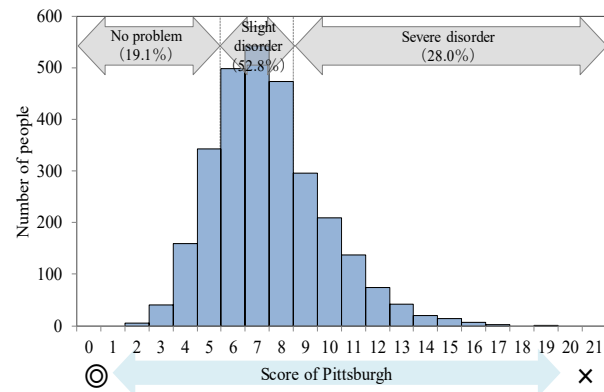


Fig.4 Score distribution of Pittsburgh

The results of correlation analysis between WFun, Pittsburgh, work efficiency, health condition, and each of the general environmental categories are shown in Table 9. Also, Fig.5 shows the relationship between general environments and WFun. Furthermore, the result of the correlation analysis between the score for each the evaluation items of CASBEE-WO and WFun is shown in Table 10.

Table 9 The results of correlation analysis (Each the general environment) \*:p<0.05, \*\*:p<0.01

	WFun	Pittsburgh	Work efficiency	Health Condition									
				Sagging of the body	Headache	Cough and sputum	Mucus	Rash	Stiff shoulder	Backache	Arthralgia	Sensitivity to cold	Catching cold
CASBEE -OHC	-.281**	-.211**	.346**	.244**	.164**	.097**	.102**	.128**	.151**	.188**	.153**	.128**	.060**
CASBEE -Housing	-.304**	-.240**	.160**	.262**	.241**	.162**	.180**	.215**	.169**	.221**	.283**	.281**	.189**
CASBEE Community	-.224**	-.181**	.237**	.201**	.152**	.098**	.088**	.084**	.101**	.117**	.126**	.108**	.059**

Table 10 The results of correlation analysis (Each the evaluation items of CASBEE-WO)

	I. Basic performance of the building												II. Operational management	III. Program		
	(1) Health and comfort						(2) Convenience improvement		(3) Ensuring safety							
	①	②	③	④	⑤	⑥	①	②	①	②	③	④			①	②
WFun	-0.201**	-0.227**	-0.212**	-0.255**	-0.203**	-0.150**	-0.217**	-0.249**	-0.250**	-0.210**	-0.122**	-0.193**	-0.254**	-0.076**	-0.109**	-0.140**

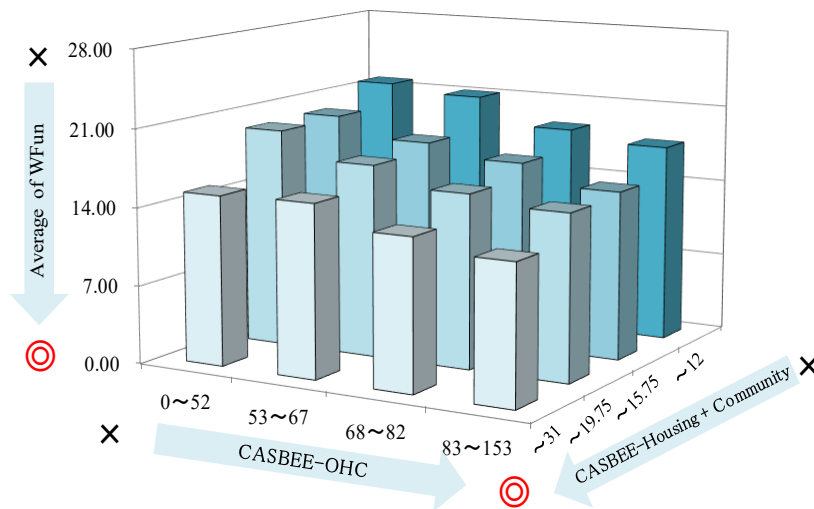


Fig.5 The relationship between the general environments and WFun

From Table 10, results suggest a strong relationship between air quality and dysfunction in labor. Furthermore, in assessing air conditioning and air quality fields, the influence of air quality was greatest. Fig.5 shows that as the score of the environment-related index increases, WFun scores decrease. From this, we speculate that an increase in general environment scores leads to a decreased risk of dysfunction in labor. Moreover, results of the correlation analysis between WFun and Pittsburgh show a negative correlation with each explanatory variable, and indicate a positive correlation with work efficiency and health condition. Compared with the correlation coefficient of WFun, the CASBEE-OHC correlation coefficient is relatively large with respect to subjective work efficiency scores, which suggests a strong influence of the office environment on work efficiency. With respect to health condition, the obtained correlation coefficient with CASBEE-Housing was relatively high across all items. From this, it is reasonable to suggest that workers' dysfunction in labor and work efficiency are influenced by not only their working environment, but also by the broader environment, including their residence and community, and their health condition may be greatly affected by conditions where they reside.

#### 4.2 Multiple regression analysis

The influence of the general environments and personal attributes on work efficiency is verified. From the correlation analysis results, only those variables (general environment, Pittsburgh, Position, Annual income) with a significant correlation coefficient (0.1 or greater) were input as explanatory variables. Table 11 shows that CASBEE-OHC, Community, and Pittsburgh are significant variables. The coefficient of CASBEE-Office was particularly high, from which we may infer that the working environment plays a critical role in influencing work efficiency. Furthermore, we may infer that higher office, community, and Pittsburgh scores are associated with higher subjective work efficiency, and may lead to greater intellectual productivity.

Table 11 Result of multiple regression analysis

	Standard partial regression coefficient	Significance probability	95 % Confidence interval	
			lower limit	upper limit
CASBEE-OHC	0.315	< 0.001	0.021	0.027
CASBEE- Community	0.128	< 0.001	0.042	0.081
Pittsburgh	-0.110	< 0.001	-0.367	-0.176
Annual income	0.057	0.007	0.009	0.059
Position	0.043	0.039	0.003	0.120
Constant		< 0.001	2.921	3.559

### 4.3 Logistic regression analysis (WFun)

The influence of the general environments and personal attributes on WFun was verified. The variables shown in Table 12 were input as explanatory variables. The classification method of the model is shown in Table 13. Based on the interpretation of the WFun score in Table 7, WFun as the objective variable was converted to binary data (as shown in Table 13) and analyzed (Model-1 to Model-3).

Table 12 Input variables in logistic regression analysis

Objective variable	
WFun score	Model-1 0 : No disorder, 1 : have a disorder
	Model-2 0 : No disorder or have a slight disorder 1 : have moderate or severe disorder
	Model-3 0 : No disorder or have a slight or moderate disorder 1 : have severe disorder
Explanatory variable	
CASBEE-OHC	1 : Top 30% of respondents (1,057 samples)      2 : 40% of respondents (1,389 samples) 3 : Lower 30% of respondents (1,106 samples)
CASBEE -Housing	1 : Top 30% of respondents (1,016 samples)      2 : 40% of respondents (1,397 samples) 3 : Lower 30% of respondents (1,139 samples)
CASBEE -Community	1 : Top 30% of respondents (1,086 samples)      2 : 40% of respondents (1,524 samples) 3 : Lower 30% of respondents (942 samples)
Pittsburgh	1 : No problem                      2 : Slight disorder                      3 : Severe disorder
Gender	1 : Man                                      2 : Woman
Age	1 : 20's    2 : 30's                      3 : 40's                      4 : 50's                      5 : 60's
Occupation	1 : Clerical                      2 : Technical                      3 : Sales 4 : Planning                      5 : Reserch                      6 : Others
Position	1 : General employee                      2 : Deputy manager class 3 : Section manager class                      4 : General manager class 5 : Executive                      6 : Manager
Number of employees	1 : Less than 100                      2 : Less than 1000                      3 : Less than 2000 4 : Less than 3000                      5 : Less than 5000                      6 : More than 5000
Annual income	1 : Less than 5 million                      2 : Less than 10 million                      3 : Less than 15 million 4 : Less than 20million                      5 : More than 20 million
Marital status	1 : Married                                      2 : Unmarried

Table 13 WFun data classification method

WFun data classification method		discriminative accuracy rate	Hosmer-Lemeshow test
Model-1	0 : have an disorder, 1 : no disorder	69.1%	0.717
Model-2	0 : no disorder or have an mild disorder	72.8%	0.742
	1 : have moderate or height disorder		
Model-3	0 : no disorder or have an mild or moderate disorder	89.4%	0.095
	1 : have height disorder		

Of the three models, the results of the logistic regression analysis of Model-3 are noteworthy because we found significance with a high discriminative accuracy rate (89.4%) and significance from the Hosmer-Lemeshow test ( $p = 0.095$ ). The analysis results of Model-3 are presented in Table 14.



Table 14 Result of logistic regression analysis (Model- 3)

		Adjusted odds ratio	Significance probability	95 % Confidence interval	
				lower limit	upper limit
CASBEE -OHC	1 : More than 15 points		< 0.001		
	2 : 12~14 points	1.888	0.003	1.234	2.888
	3 : Less than 12 points	3.274	< 0.001	2.140	5.009
CASBEE -Housing	1 : More than 4.5 points		0.001		
	2 : 3.25~4.5 points	1.070	0.737	0.720	1.592
	3 : Less than 3.25 points	1.845	0.003	1.235	2.758
CASBEE -Community	1 : More than 13 points		0.011		
	2 : 9~12 points	1.088	0.689	0.720	1.645
	3 : Less than 9 points	1.666	0.015	1.106	2.510
Pittsburgh	1 : No problem		< 0.001		
	2 : Slight disorder	1.548	0.099	0.922	2.601
	3 : Severe disorder	4.175	< 0.001	2.495	6.987
Gender		0.652	0.006	0.481	0.882
Age		0.832	0.003	0.737	0.939
Constant		0.055	< 0.001		

The data suggest that lower scores for general environments are associated with elevated risk of high levels of dysfunction in labor. Next, the comparison results for risk of high level of labor dysfunction in each model are shown in Fig.6.

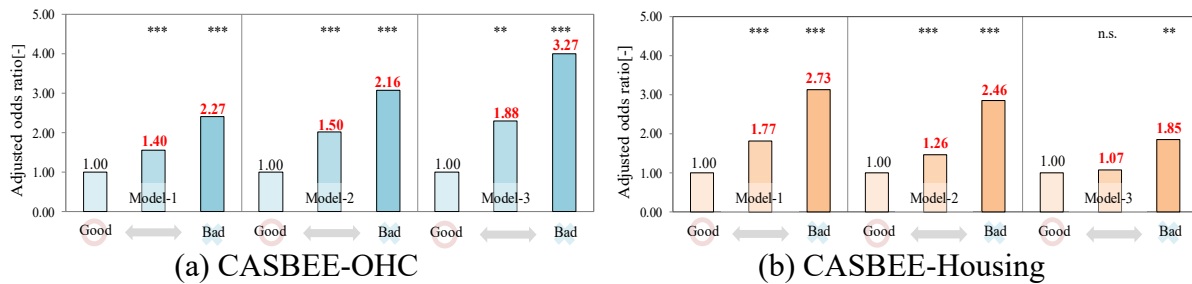


Fig.6 The comparison results in each model (WFun)

The data confirmed the risk of increased disease prevalence due to deficits in the surrounding environment in all models. Furthermore, with regard to the CASBEE-OHC, it was confirmed that the risk of morbidity increases as the degree of labor dysfunction approaches severe levels. Conversely, the opposite was observed for CASBEE-Housing. Such relations suggest that the home environment affects the probability of mild labor dysfunction, while the office environment strongly influences the probability of severe labor dysfunction.

## 5 CONCLUSIONS

In this report, we outlined the checklist and reported the outline of the WEB questionnaire survey using this checklist and the analysis result. The results were as follows;

- 1) It was confirmed that if the office environment and residence, community of the office worker are good, it will have a good influence on health condition and workers' intellectual productivity. Also, the correlation analysis for evaluation item indicated that the correlation between office air conditioning, air quality and dysfunction in labor was high. Furthermore, among air conditioning and air quality field, it was confirmed that the influence of the item regarding air quality was the largest.
- 2) Based on multiple regression analysis, it was confirmed that the working environment and age of the officer, influenced the work efficiency. And, from the logistic regression analysis, it was suggested that the risk of having a high degree of labor impairment increases when the surrounding environment including office space was bad.

## 6 ACKNOWLEDGEMENTS

This survey is part of the results of the activities of the Smart Wellness Research Committee (Chairman, Shuzo Murakami) by the Japan Sustainable Building Consortium, and we are grateful to all the relevant people.

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