

# Lifestyle Intervention to Promote Elderly Workers' Mental Health and Productivity:

An Analysis of Data from Corporate Health Insurance Claims  
and Wearable Devices

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# 0. Summary

## **[Background]**

Corporate health and productivity management (H&PM) has become to put a great effort into maintaining employees' mental health to enhance productivity.

## **[Purpose]**

The study explores what intervention to modify employees' lifestyles an employer and its insurer should make to improve employees' mental health and performance, following the literature finding that lifestyle habits have a significant impact on mental state.

# 0. Summary

## **[Data and Methodology]**

We construct an analytical model based on logistic regression targeting onset and aggravation of mental illnesses, and apply it to claims data of public corporate health insurance of Japan,

combined with lifestyle data i.e. exercise volume and sleep pattern collected via wearable devices of insured employees.

# 0. Summary

## **[Main Findings]**

Having sleep duration exceeding 7 hours per day is positively related to both onset and aggravate of depressive symptom.

Sufficient significance level was not observed for other aspects, but a possibility was found that:

Short sleep duration (<6 hours),  
long social jetlag\* (>2 hours),  
insufficient daily exercise time (<22 minutes), and  
excessive daily walking (>8,000 steps)  
may develop and/or aggravate mental illness.

\* Fluctuation of midsleep point between working days and non-working days.

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# **1. Introduction**

## **1.1. Background**

**Recent H&PM programs put more importance on maintaining good mental state of corporate employees.**

**The literature also discuss that maintaining mental condition is indispensable to improve workers' performance.**

**Medical and psychological studies found evidences that lifestyle habits, such as physical activities and sleep patterns, affect mental condition of individuals.**

# 1. Introduction

## 1.1. Background

**International capital markets and the public sector recognized the relation between mental health and lifestyle habits, and started calling for the execution of research and development aimed at improving mental health and well-being of workers.**

e.g. U.S.-Japan Business Conference,  
U.S. Healthy People 2030,  
G20 Knowledge Partnership.

# 1. Introduction

## 1.1. Background

**The private insurance sector responds to the demands of business community for H&PM support services, such as mental and physical health consultations, preventive counseling, and lifestyle modification support for policy-holding organizations and their employees.**

**Some insurers utilize telematics to monitor daily number of steps, exercise time and sleep duration of insured employees, and then provide a reward e.g. premium discount to policyholders who accomplished a target to encourage them to invest into their employees' health.**



# **1. Introduction**

## **1.2. Purpose**

**The study attempts to provide suggestions for organizational managements and their health insurers on how to design their H&PM programs and services, by analyzing how lifestyles including exercise volume and sleep patterns affect the onset of mental illness and the severity of mental illness.**

## **2. Academic Discussions**

### **2. 1 Psychological State, Workplace Well-being and Productivity Management**

**Recent research efforts** from the 1990s to 2000s **elucidated the importance of workplace well-being affecting workers' mental and psychological state to facilitate working productivity in addition to preventing medically recognizable physical illness** including Daniels and Guppy (1997) and Daniels and Harris (2000) .

**Studies** in the 2000s **attempted to quantitatively measure the change in productivity affected by employees' mental health conditions and found the cost cannot be ignored** such as O'Donnell (2000), Michaels and Greene (2013) and Loepke et al. (2009).

## **2. Academic Discussions**

### **2. 2 Relation between Physical Activities and Mental Health**

**Medical researches investigate the relation between physical activities and mental condition.**

Master et al. (2022) analyzed the step count captured from participants wearables and **identified the number steps necessary to prevent mental disease at 8,200 per day.**

Currier et al. (2020) and Correia et al. (2023) **determined an optimal level of physical activities to maintain mental health at least 150 minutes per week.**

## 2. Academic Discussions

### 2.3 Relation between Sleep Habits and Mental Health

Lee and Sibley (2019) identified the prevalence of short and long sleep duration; **too short or too long sleep duration (<7 hours or >9 hours) on a regular basis was associated with depression, impaired working performance.**

Islam et al. (2020) pointed that **social jetlag longer than 2 hours is associated with an increased likelihood of having depressive symptoms.**

# 3. Methodology

## 3. 1. Data

We access to **the information bank of JMDC which includes social health insurance claims data** sourced from the corporate health insurance societies of Japan (CHIS) **covering employees of large businesses and their dependents** insured by social health insurance (approximately 17 million cumulative population as of December 2023) from which the name of the disease, the details of treatment and medication can be identified.

We also utilize the **lifestyle habit database collected by JMDC via wearables worn by the insured employees who participate in Fitbit platform** linked to PepUp, a healthcare platform offered by JMDC Inc. to the CHIS members.

# 3. Methodology

## 3. 2. Variables

**The analysis is conducted in two steps:** how lifestyle habits are related to (1) the onset of mental illness, and (2) the development of severe condition of illness.

**In the 1<sup>st</sup> step, the explained variable is the onset of mental illness, which is replaced in the 2<sup>nd</sup> step with the appearance of severe condition of illness. Severity of mental condition is determined by Medical Score Chart Classification Code and ICD10 sub-categories as indicated in Table 1.**

	Identification Criteria	Identification Code
Onset of Mental Illness	Psychiatric Visit	Medical Score Chart Classification Code: "I002" or "I002-2"
	Diagnosis of Mental-related Illness on Receipt	ICD10 Sub-categories: "F30-F39" or "F40-F48"
Severe Condition of Mental Illness	Prescription for Antidepressants within 4 Months after Diagnosis of a Mental Disorder	ATC Classification: "N06A"

# 3. Methodology

## 3. 2. Variables

We select two exercise-related variables, and three sleeping habits as explanatory variables, relying on the literature, as listed in Table 2.

Table 2. Definitions of Explanatory Variables

Variable		Value	Definition (6 months average)
Physical Activities	<b>Daily Walking Steps</b>	0	<b>8,000 or more per day</b>
		1	Less than above
	<b>Daily Exercise Time</b>	0	<b>22 minutes or more per day</b>
		1	Less than above
Sleeping Habits	<b>Long Time in Bed</b>	0	Shorter than below
		1	<b>423 min. <math>\cong</math> 7 hrs. or longer per day</b>
	<b>Short Time in Bed</b>	0	<b>356 min. <math>\cong</math> 6 hrs. or longer per day</b>
		1	Shorter than above
	<b>Social Jetlag</b>	0	Shorter than below
		1	<b>120 minutes or longer</b>

# **3. Methodology**

## **3. 2. Variables**

**Variables relating to exercise habits are the number of daily footsteps and daily exercise time as the average for the last 6 months.**

- For the walking count, the threshold is determined at 8,000 per day relying on the findings of Master et al. (2022).**
- For the exercise time, the threshold value is set at 22 minutes per day, according to Currier et al. (2020) and Correia et al. (2023) findings that exercise time necessary to prevent depressive disorder is at least 150 minutes per week.**



# 3. Methodology

## 3. 2. Variables

**Sleep-related variables are the average time in bed and social jetlag for the last 6 months.**

**—For the sleep duration, the thresholds are set at 75 percent point (423 minutes) and 25 percent point (356 minutes) to ensure accountability.**

**The lower threshold is consistent with the findings by Blackwelder et al. (2021) and Zhu et al. (2021) that proved sleep duration shorter than 6 hours tended to aggravate mental health.**

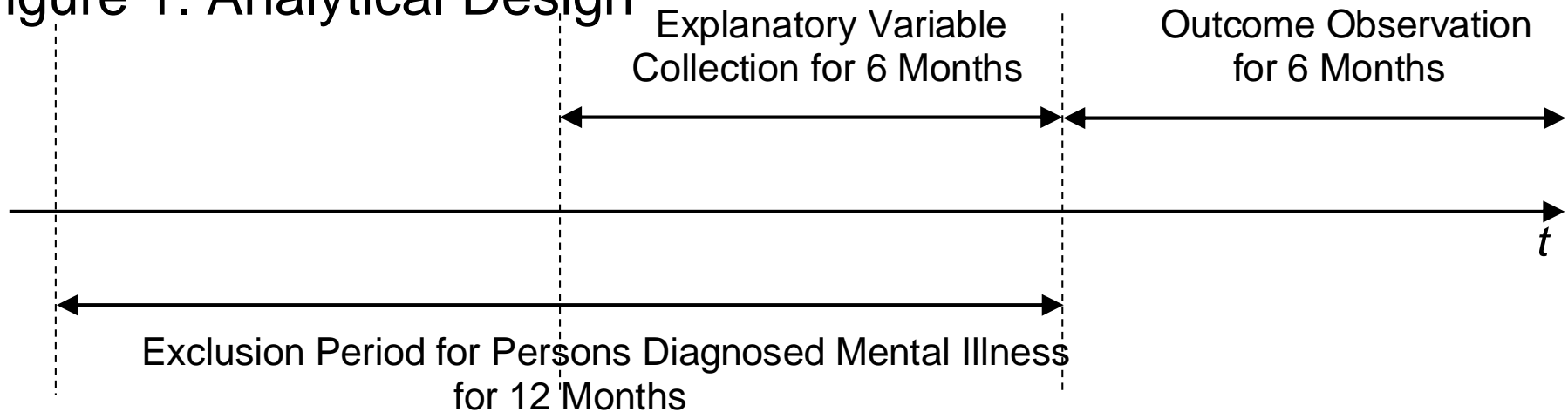
**—We set the threshold of social jetlag at 120 minutes by observing midsleep point of week days and that of days off, based on the finding of Rutters et al. (2014) revealing social jetlag exceeding 2 hours negatively affects the mental condition.**

# 3. Methodology

## 3. 3. Analytical Approach

The analytical model estimates how the lifestyle status for the first 6 months (the explanatory variable collection period) affects the onset of mental illness and its severity during the next 6 months (the outcome observation period) as describe in Figure 1.

Figure 1. Analytical Design



Persons who had already developed a mental illness in the past 12 months including variable collection period were excluded from the dataset.

# 3. Methodology

## 3. 3. Analytical Approach

The estimation model is constructed based on the standard logistic regression model:

$$p = 1 / \left\{ 1 + \exp \left( \beta_0 + \sum_{i=1}^6 \beta_i x_i \right) \right\}$$

where  $p$  is the onset of mental illness in the 1<sup>st</sup> analysis, replaced with the appearance of severe condition of mental illness in the 2<sup>nd</sup> analysis.

Explanatory variables are  $x_i$  :

- : Daily Walking Steps,
- : Daily Exercise Time,
- : Long Time in Bed,
- : Short Time in Bed, and
- : Long Social Jetlag.

## 4. Results

### 4. 1. Outline of explanatory variables

Table 3. Comparison of Quantitative Variables

Variable	Mental Illness Onset	No Mental Illness Onset
Age	42.91	47.54
Daily Walking Steps	9,343.42	9,646.56
Time of Exercise	37.63	46.93
Time in Bed	404.25	386.57
Social Jetlag	40.64	36.85

The average age of those who developed mental illness is lower than that of those without mental disorder.

## 4. Results

### 4. 1. Outline of explanatory variables

Table 3. Comparison of Quantitative Variables

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Both the number of steps and exercise time per day indicate higher values for those without mental illness, which is consistent with the scientific results.

The time in bed is about 18 minutes longer for the group with mental illness than those without it.

Social jetlag is longer for the group with mental illness than healthy group, but the difference is small.

# 4. Results

## 4. 1. Outline of explanatory variables

Table 4. Distributions of Categorical Variables

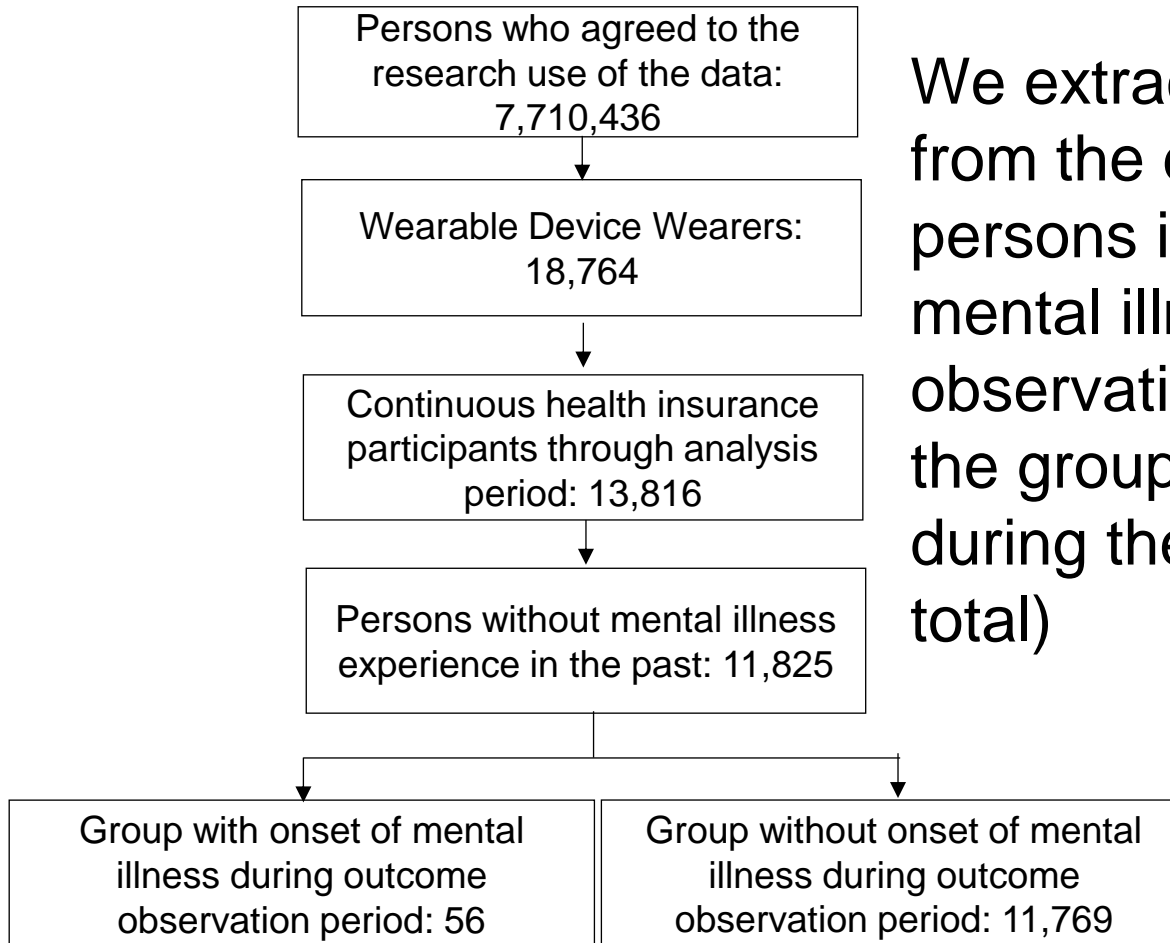
Variable		Group with Mental Illness Onset	Group without Mental Illness Onset
Gender	Male	32	8,686
	Female	24	3,083

Although there is a large difference in the number of samples, the incidence rate of psychiatric disorder is higher for women (0.78%) than for men (0.37%).

# 4. Results 4. 2. Estimation Results—Onset of Mental Illness

The first step of the analysis is how lifestyle habits are related to the onset of mental illness.

Figure 2. Data Extracting Process



We extract the target individuals from the dataset. There were 56 persons in the group with onset of mental illness during outcome observation period and 11,769 in the group without mental illness during the same period (11,825 in total).

# 4. Results

## 4. 2. Estimation Results—Onset of Mental Illness

Table 5. Regression Results—Onset of Mental Illness

	Regression Coefficient	95% Confidence Interval		<i>p</i> -value
		Lower Limit	Upper Limit	
Age < 50	0.9255	0.292	1.559	0.004*
Gender = Female	0.5177	-0.071	1.106	0.085
Daily Walking Steps < 8,000	-0.3858	-1.016	0.245	0.230
Daily Exercise Times < 22 min.	0.3178	-0.367	1.003	0.363
Time in Bed ≥ 423 min.	<b>0.7136</b>	<b>0.099</b>	<b>1.328</b>	<b>0.023*</b>
Time in Bed < 356 min.	-0.1926	-1.030	0.645	0.652
Social Jetlag ≥ 120 min.	0.9084	-0.049	1.866	0.063
Sleep Data Missed	-0.0177	-0.938	0.902	0.970



# 4. Results

## 4. 2. Estimation Results—Onset of Mental Illness

The case where time in bed is longer than 423 minutes shows a sufficiently low  $p$ -value (0.023) with a positive regression coefficient (0.7136) indicating that sleeping for longer than 7 hours can trigger mental illness.

The relationship is unclear ( $p$ -value= 0.652), but a weak, negative coefficient was observed for cases where time in bed is shorter than 356 minutes (-0.1926), which implies a possible favorable impact of relatively short sleep duration on mental state.

The coefficient was positive (0.9084) when the midsleep point fluctuates by more than 2 hours between working days and days off, inferring prolonged social jet lag may have a negative impact on mental state, but  $p$ -value is not sufficiently low (0.063).

# **4. Results**

## **4. 2. Estimation Results—Onset of mental illness**

**Regarding exercise-related variables, the regression coefficient for cases where walking steps are less than 8,000 was negative (-0.3858), on the other hand, that for cases where exercise time is shorter than 22 minutes was positive (0.3178);**

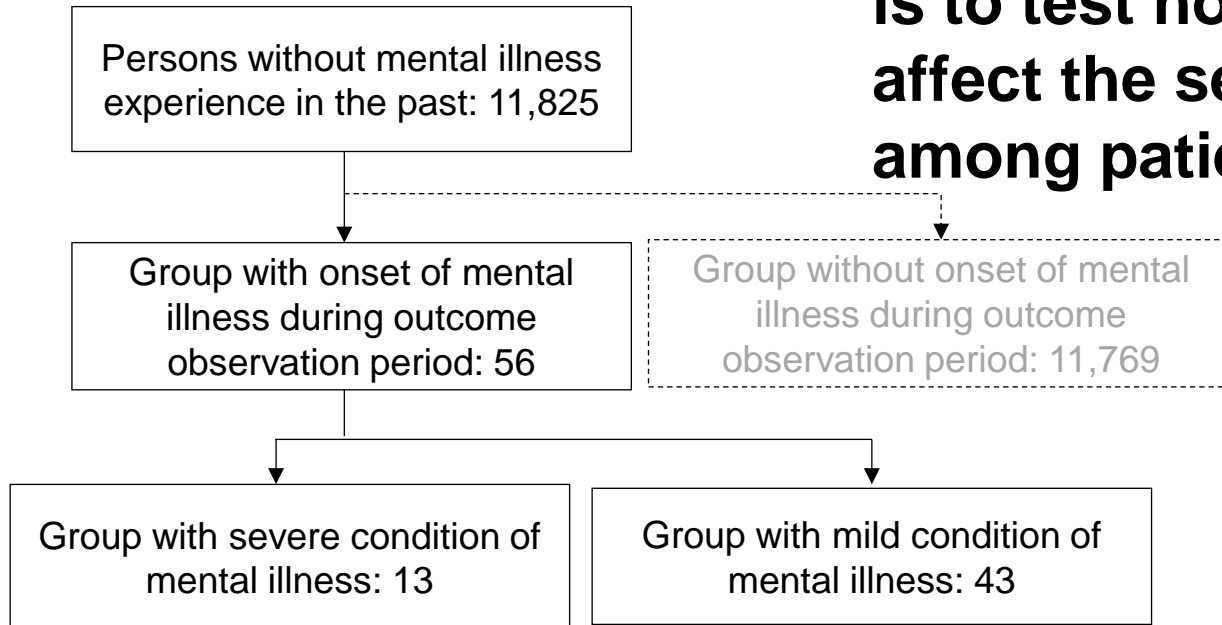
**the result indicates a possibility that short exercise time may induce depression, although no significance was observed. But it also implies excessive walking may associate to the onset of depression.**

# 4. Results

## 4. 3. Estimation Results—Severe Condition of Mental Illness

Figure 3. Data Extracting Process

The second step of the analysis is to test how lifestyle habits affect the severe condition among patients of mental illness.



We extract individuals who developed mental illness from the dataset, and analyze the relationship of severity of illness and lifestyle habits.

# 4. Results

## 4. 3. Estimation Results—Severe Condition of Mental Illness

Table 6. Regression Results—Severe Condition of Mental Illness

	Regression Coefficient	95% Confidence Interval		<i>p</i> -value
		Lower Limit	Upper Limit	
Age < 50	2.1659	-0.394	4.726	0.097
Gender = Female	-0.1038	-1.691	1.483	0.898
Daily Walking Steps < 8,000	-1.5589	-4.222	1.104	0.251
Daily Exercise Times < 22 min.	0.4189	-1.617	2.455	0.687
Time in Bed ≥ 423 min.	1.8170	-0.392	4.026	0.107
Time in Bed < 356 min.	1.5914	-0.667	3.860	0.169
Social Jetlag ≥ 120 min.	—	—	—	—
Sleep Data Missed	-0.5420	-3.249	2.165	0.695

\* Social jetlag is excluded due to a lack of sufficient volume of data.

# 4. Results

## 4. 3. Estimation Results—Severe Condition of Mental Illness

Since no significance was recognized for any of the variables, we cannot make a clear judgement, but....

Excessive walking and/or short exercise time are presumed to lead to severe mental disorder from a negative regression coefficient for cases where walking steps are less than 8,000 (coef.= -1.5589).

A positive coefficient for cases where exercise time is shorter than 22 minutes per day (coef.= 0.4189).

# 4. Results

## 4. 3 Estimation Results—Severe Condition of Mental Illness

**Excessively long and/or short sleep duration (longer than 7 hours and shorter than 6 hours) possibly cause severe mental illness;**

from results of cases of time in bed longer than 423 minutes and shorter than 356 minutes that shows positive regression coefficients (1.8170 and 1.5914, respectively).

## **5. Conclusion**

**From the results of the analyses, we can suggest organizational managers and their health insurers to make lifestyle interventions for insured employees;**

**To maintain an appropriate sleep time (6 to 7 hours) per day on a regular basis to avoid onset of mental illness and, even if having got illness, it may prevent becoming severe,**

**To keep the difference of midsleep point between working days and non-working days within 2 hours to prevent the onset of mental illness,**

**To have weekly exercise time more than 150 min.  
But they should advise the employees to keeping 8,000 walking steps per day is enough to maintain good mental condition; more than that is not always better.**

# 5. Conclusion

There are currently several issues that need to be resolved;

a lack of data volume due to the slow dissemination of participation in Fitbit platform among insured workers, and

possible bias regarding the health consciousness of those who are putting on wearable devices; those wearing wearables are considered to be more concerned about their own health.

The study needs to be continued to overcome these issues to provide more robust suggestions for designing H&PM programs and services including interventions and consultations of lifestyle habits to employees.



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Thank you for your attention.