

Role of Insurance in Corporate Health and Productive Management: Productivity Loss Analysis after Cancer Treatment Based on Corporate Medical Insurance Claims Data

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Abstract

Corporate health and productivity management draw social attention and are expected to facilitate employees' health, performance, and work-life balance. In response to this societal expectation, some health insurers have started providing health support services to prevent illnesses among insured employees by utilizing health-related data. We focus on cancer as the major lifestyle disease that undermines productivity after or during treatment and evaluate how poor health checkup results and lifestyle habits affect employees' absenteeism and presenteeism due to cancer. Relying on RIDGE logistic regression, we developed estimation models that were applied to the claims and health checkup result data of public corporate health insurance in Japan. The results revealed that insufficient exercise time, smoking habits, and alcohol consumption visibly affected productivity loss after hospitalization. High systolic blood pressure tends to be associated with a poor prognosis in some types of cancer.

Keywords: Health and productivity management, cancer, absenteeism, presenteeism, RIDGE logistic regression

1. Introduction

Corporate health and productivity management (H&PM), which promotes employees' physical and mental conditions, has gained social recognition. It is expected to enhance corporate performance and profit-earning capacity by improving employee vitality and productivity. Additionally, capital market attaches importance to H&PM's positive long-term effects. Moreover, H&PM extends healthy life expectancy by reducing the risk of undermining working capacity, especially lifestyle diseases associated with aging societies, and by promoting social inclusion. For example, the U.S.-Japan Business Conference of 2018 focused on maintaining a healthy and productive workforce, reducing the economic burden of disease, extending healthy life expectancy to enhance productivity, and maintaining

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innovation advantages.¹⁾ The conference statement also stressed the creation of incentives to promote wellness through preventive care measures, including H&PM initiatives by public and private organizations, through systematic process management and behavioral modifications. The conference has since repeatedly committed to supporting and encouraging voluntary business initiatives to promote H&PM in both countries.²⁾ A new international initiative was launched whereby businesses and associations from several G20 countries joined a global health and human resource knowledge partnership. The partnership is based on the premise that a robust future economy starts by investing today in the health of populations over their entire life course, and calls on G20 leaders to support measures that will improve population health, security, and productivity.³⁾ The H&PM literature also recognizes the cost burden of employee absenteeism as well as presenteeism attributable to sickness and has tried to evaluate and identify their causes, as discussed in the next section.⁴⁾

The private insurance sector responds to societal demands and the needs of the business community for H&PM support services. Insurance companies have accumulated knowledge and expertise to evaluate the risks associated with illness through the process of underwriting commercial life and medical insurance contracts based on health-related data, including age, sex, health checkup results, occupation category, working environment, and work hours. By leveraging their collective expertise, insurers have begun to provide risk-control services to policy-holding corporations and their employees with health support services such as health consultations, preventive counseling, and lifestyle modification support to reduce adult disease risk. Additionally, insurance companies can collect a wider range of detailed information on employee health conditions through the increased accessibility of information and communication technologies. Some insurers use telematics to monitor members' daily number of steps, sleep duration, and exercise time. Other insurers periodically collect data from the results of health checkups to derive a health age index⁵⁾ and then provide a reward, such as a premium discount or a bonus return, to policyholders who meet the designated levels of health indicators to encourage them to improve their employees' health.

Nippon Life Insurance Company is the leading insurer of H&PM services in the Japanese market. In 2018, Nippon Life offered a comprehensive health support program called Wellness-Star to private

1) U.S.-Japan Business Council (2018), pp. 4–5.

2) U.S.-Japan Business Council (2018), p. 17.

3) U.S. Chamber of Commerce (2018), p. 1.

4) Ishimaru et al. (2020, p. 95) defined sickness presenteeism as productivity loss due to an impaired work function or reduced performance at work besides illness in the management context.

5) Health Age® was created by JMDC Inc. based on a statistical analysis of a claims database collected by the CHIS of Japan. It is also utilized by Dai-ichi Life Insurance Company for JUST, its health promotion medical insurance program.

corporations and corporate health insurance organizations.⁶⁾ In this program, Nippon Life provides employees and society members with exercise instructions through a walking/exercise application. Additionally, the insurer offers a diabetes prevention service to employees by using a blood glucose measurement application. The Mitsui Sumitomo Insurance and Aioi Nissay Dowa Insurance Companies have jointly underwritten H&PM Support Insurance since 2021 in collaboration with the Tokyo University Center of Innovation.⁷⁾ In addition to income protection against illness and injury for insured employees, the insurers provide health management applications that allow users to rate their exercise, sleep, and dietary habits. They also offer health promotion consultations and discounts on the premiums for the next period to policy-holding corporations to improve employees' health behaviors. In 2022, Daido Life Insurance Company launched a new medical insurance program named KENCO Plus, aimed at small- to mid-sized businesses.⁸⁾ Insurance provides coverage for income protection due to the deterioration in the health of an employee, combined with a health consulting service. It also monitors employees' daily step counts and grants a premium discount for the following year if their average step count is 8,000 or more. In these different types of insurance arrangements by Japanese insurance companies, the management and employees of policy-holding corporations are incentivized to improve their lifestyle habits; if employees' health indicators improve, policyholders' medical insurance costs decrease, employee absenteeism and presenteeism decrease, and productivity increases.

Among lifestyle diseases, the increasing number of cancer patients increases the cost burden on the business community. In recent years, a growing number of corporate employees have wanted to work during and after cancer treatment. This trend is partly attributable to shorter hospital stays and increased survival rates resulting from medical advances. In response, some corporations have begun providing support to employees who have battled cancer to continue working. For example, employers have introduced various measures, including paid medical leave, flexible work arrangements, and relevant procedural manuals.⁹⁾ The insurance industry provides employee support services by utilizing technical knowledge to control disease risk.

With the aim of providing suggestions for insurers on how to design their corporate medical

6) Nomura Research Institute (2017) "Development of a Service Package of Health Promotion Furnished for Nippon Life Insurance," news release May 17, 2017, https://www.nri.com/-/media/Corporate/jp/Files/PDF/news/newsrelease/cc/2017/170517_1.pdf (written in Japanese; accessed on Dec. 1, 2022).

7) Mitsui Sumitomo Insurance Co. and Aioi Nissay Dowa Insurance Co. (2020) "New Sales of H&PM Support Insurance," news release Dec. 10, 2020, https://www.ms-ins.com/news/fy2020/pdf/1210_2.pdf (written in Japanese; accessed on Dec. 1, 2022).

8) Daido Life Insurance (2021) "New Health Promotion Medical Insurance Integrating Prevention and Preparation," news release Dec. 20, 2021 (https://www.daido-life.co.jp/company/news/2021/211220_news.pdf (written in Japanese; accessed on Dec. 1, 2022).

9) Noda (2017), pp.41–43.

insurance and health support services, this study evaluates whether health checkup results and lifestyle habits affect prognosis, productivity loss after hospitalization due to four major types of cancers that significantly undermine the working productivity of patients, even after discharge from the hospital. The analyses were performed based on estimation models that applied a database constructed from the claims and health checkup data of public corporate health insurance societies in Japan.

2. Literature review

2.1 Early development of productivity management

H&PM originated in the early 20th century in exploratory studies based on business management and organizational behavior theories. Mayo (1924) conducted experiments in a spinning factory and concluded that H&PM was effective in alleviating worker fatigue due to monotonous labor and an oppressive working environment. In the 1950s, Herzberg et al. (1959) identified two factors that affect workplace satisfaction and productivity levels: a motivation factor that is positively related to job satisfaction, such as achievement, recognition, and advancement; and a hygiene factor that must be present in the workplace to prevent dissatisfaction, including pay grades, workplace policy, and relationships with peers. Their idea became known as motivation–hygiene theory and has been widely adopted in business practice. The 1970s and 1980s saw a rapid increase in healthcare costs, especially in the U.S., and corporate management came under pressure to reduce insurance program costs. Employers have started investing in fitness programs to promote the health of their employees, reduce the frequency of healthcare utilization, and save on insurance premiums. Falkenberg (1987) critiqued applied and experimental research related to the impact of employee fitness programs on work-related variables, such as productivity, absenteeism, commitment, and employee turnover. Maintaining good physical and mental health has become widely recognized as indispensable for cost reduction and improved performance.

2.2 Workplace well-being and productivity management

Academic and practical efforts from the 1990s to the 2000s elucidated the importance of workplace well-being in facilitating worker productivity, in addition to medically discernable physical and mental health. Daniels and Guppy (1997) conducted a follow-up study on accountants and revealed that internal locus of control, social support, and job autonomy jointly buffer the effects of stressors on well-being. Daniels and Harris (2000) provided evidence from an empirical study that work performance, as a result of the behavior required to perform the duties necessary for the job, is a causal consequence of psychological well-being and work stressors.

Some productivity management studies in the 2000s attempted to measure quantitatively the change in productivity affected by employees' health conditions. O'Donnell (2000) developed a model to evaluate the loss in productivity caused by employee presenteeism and revealed that the cost of decreased performance surpassed the direct costs of healthcare based on a questionnaire investigation and insurance claims analysis. Recognizing the direct and indirect costs of employee absenteeism and presenteeism, Michaels and Greene (2013) provided key concepts and strategic tips for worksite wellness programs in American corporations. They found that decreasing absenteeism and presenteeism improved quality of life and morale. Goetzel et al. (2001) analyzed the relationship between health and productivity using data on absenteeism, employee turnover, and the use of medical, disability, and worker compensation programs by corporate employees. They estimated the cost of productivity loss at US\$9,992 per employee, of which health insurance costs accounted for 47%.¹⁰⁾ Loepke et al. (2009) measured the cost of health-related productivity loss among employers using a questionnaire on health and work performance as well as medical and pharmacy claims. Their regression analysis showed that the costs were 2.3 times that of the medical and pharmacy costs.¹¹⁾ Additionally, they found that chronic conditions, such as depression, obesity, arthritis, and back/neck pain are especially important causes of productivity loss.

2.3 Work-life environment and productivity

Some studies that have attempted to establish a managerial approach that would enhance productivity performance have been conducted concurrently with efforts to evaluate the cost of productivity loss. Judge et al. (2001) reviewed the relationship between job satisfaction and job performance and derived a positive correlation between these two indices from a quantitative meta-analysis; however, no conclusive results were obtained from the qualitative review because of a lack of assimilation and integration in the literature.¹²⁾ Harter et al. (2003) showed that, based on the results of a meta-analysis, business units with positive workplace perceptions demonstrated higher customer loyalty, profitability, productivity, and lower staff turnover, which implies that favorable cognitive and emotional antecedents in the workplace tend to generate positive effects on the efficient application of work, employee retention, creativity, and ultimately business outcomes. Grawitch et al. (2006) synthesized previous research to link healthy workplace practices in organizations with employee well-

10) The data used by Goetzel et al. (2001) consisted of approximately one million employees in 43 American corporations.

11) Loepke et al. (2009) utilized data from 10 employers with a total of 51,648 employee responses using the health and work performance questionnaires along with 1,134,281 medical and pharmacy claims.

12) Judge et al. (2001) derived a positive correlation between overall job satisfaction and job performance from a quantitative meta-analysis of 312 samples with a combined number of 54,417.

being and organizational improvement. They identified five general categories of healthy workplace practices: work-life balance, employee growth and development, health and safety, recognition, and employee involvement. They also suggested that the link between these practices and employee and organizational outcomes is contingent on effective communication within an organization.

In an experimental study on the effect of operating practices and employee autonomy on productivity, DeJoy et al. (2010) challenged retail store employees to formulate and implement a business improvement plan of their own initiative.¹³⁾ The two-year observation showed that the intervened stores performed better than comparable non-intervened stores on general indices of business outcomes, such as employee turnover and sales per labor hour. Von Thiele Schwarz and Hasson (2011) examined the effect of physical exercise and reduced work hours on performance in a Swedish large dentistry practice and observed that health-related measures differed between the types of interventions; decreased glucose levels and upper-extremity disorders were observed in the exercise group, and increased high-density lipoprotein levels were found among those working reduced hours.¹⁴⁾ Additionally, they found that the number of treated patients and quality of work increased, while illness-related absenteeism decreased across all conditions during the intervention period.

2.4 Insurance functions of health promotion

Controlling the incentive effect has been an important research issue in insurance literature, with many studies attempting to find ways to ameliorate moral hazards (Acharya et al., 2012; Einav and Finkelstein, 2018). Some studies have expanded the analytical perspective by minimizing moral hazards to promote insured health by designing insurance contracts. De Preux (2011) found that individuals tend to maintain healthy lifestyles to reduce the probability of illness when current preventive behaviors affect future changes in insurance coverage. Heffley and Miceli (1998) analyze medical savings accounts and find that well-constructed experience ratings induce health activities and preventive care without reducing insurers' profit margins. Schmidt et al. (2009) analyzed a German medical insurance program and examined the potential of mandatory future risk evaluations to reduce medical costs and facilitate the long-term financial viability of the insurance system. Kankaanpää (2010) demonstrated that experience ratings can effectively lower the frequency of claims, although the severity of the costs remains unchanged. Bates et al. (2014) noted that adopting electronic health records in a healthcare

13) DeJoy et al. (2010) obtained the cooperation of a major American retail company, selected 11 stores for intervention, and compared their business outcomes with those of other stores.

14) Von Thiele Schwarz and Hasson (2014) randomized six dentistry practices with 177 employees to one of the three conditions: mandatory physical exercise to be performed during work hours, a reduction of full-time weekly work hours from 40 to 37.5 hours, and a reference group without any intervention.

system provides opportunities to reduce medical costs by analyzing a large amount of data on high-cost patients, readmissions, and triage. In contrast, Patel et al. (2016) monitored obese participants' engagement in a wellness program under a premium-adjustment program based on weight loss but found no statistically significant differences in weight change between the incentive and control groups.

In studies specific to health promotion medical insurance, Suzawa (2021) compared the cost of elaborate risk evaluation through telematics and anticipated claims reduction, and found that the demand for medical insurance decreases unless the improvement in the loss ratio sufficiently surpasses the cost of risk evaluation. Suzawa and Nagai (2022) focused on lifestyle habits, such as step counts, dietary habits, and sleep duration, and found that improvements in these variables could enhance insurance solvency but possibly undermine business value because of the cost burden of providing economic rewards or continuous monitoring.¹⁵⁾ Suzawa et al. (2022) examined the financial impact of underwriting health promotion insurance using health checkup results associated with lifestyle-related diseases, such as body mass index (BMI), blood pressure, hemoglobin A1c (HbA1c), and alanine aminotransferase (ALT), and found that an improvement in any of these indices decreased the costs of claims and enhanced insurance solvency.¹⁶⁾

In the Japanese market, some insurance companies now provide H&PM services to corporations, combined with health promotion insurance coverage, for which they utilize a variety of risk indicators in their insurance programs, such as health checkup results, exercise habits, and lifestyle habits. Relatively few years have passed since insurance companies started such services; therefore, research on how insurers design H&PM insurance services, including the selection of health-related indicators for risk evaluation, remains limited. This study attempted to fill this gap in the literature.

3. Methodology

3.1 Data

We constructed an estimation database from the JMDC information bank. The dataset includes social medical insurance claims data sourced from the corporate health insurance societies of Japan (CHIS), which cover employees of large businesses and their dependents insured by social medical insurance (approximately 12 million individuals as of December 2022). The dataset included the name

15) Among the three lifestyle habits examined by Suzawa and Nagai (2022), the number of walking steps demonstrated the most positive impact on insurers' financial status.

16) Suzawa et al. (2022) calculated an economic solvency ratio (ESR) based on the specifications of the International Association of Insurance Supervisors (2021) and identified an improvement in HbA1c enhanced ESR most effectively followed by blood pressure.

of the disease, medical treatment, health checkup results, and attributed information (e.g., sex and age).¹⁷⁾ From the original JMDC data, we extracted three medical conditions associated with cancer at four major sites: stomach, rectal, colon, and lung, all of which are increasing in number in many developed economies, including Japan¹⁸⁾.

We relied on the National Institute of Health and Nutrition of Japan (NIHN) and selected four health checkup results identified by the NIHN as important indices for assessing the risk of contracting lifestyle diseases, including cancer: systolic blood pressure, triglyceride, low-density lipoprotein (LDL) cholesterol, and BMI, as listed in Table 1.¹⁹⁾ The NIHN also highlights exercise habits, sleep duration, smoking habits, and alcohol consumption as factors that increase cancer risk. The data on these three lifestyle habits are obtained through a questionnaire sent to the insured employees and incorporated into the database as described in Table 1.²⁰⁾

Table 1. Variables Affecting Lifestyle Habit Diseases

Variable		Value	
Health Checkup Results	Systolic Blood Pressure	Actual Measured Value	
	Triglyceride		
	LDL Cholesterol		
	BMI		
Lifestyle Habits	Exercise Habit	0	30 Min. or More per Day, 2 Days or More per Week
		1	Less than above
	Sleeping Time	0	Enough Time to Rest
		1	Less than above
	Smoking Habit	0	No Smoking
		1	Smoking
	Alcoholic Consumption	0	Less than 20g Pure Alcohol per Day
		1	20g Pure Alcohol and over per Day

3.2 Estimation model

The analytical model estimates how the pre-status of health checkup results and lifestyle habits of

17) Nagai et al. (2020) and Nagai et al. (2021) provide an overview of the CHIS and the database.

18) According to the Ministry of Health, Labour and Welfare of Japan (2019), pp. 27–28, rectal, colon, lung, and stomach cancers account for the highest percentage (45.5 for men and 34.5 for women) among cancers at all sites, excluding gender-specific cancers (breast cancer accounts for 22.5% for women and prostate cancer accounts for 16.7% for men). The percentage of bowel cancer cases (rectal and colon) is 15.7 and 15.5, that of lung cancer is 9.8 and 14.9, and that of stomach cancer is 9.0 and 15.1 for women and men, respectively.

19) Health Japan 21 (second term) is a 10-year plan that started in 2013 based on the initiative of the NIHN. It publishes the targeted levels of health-related indices to promote health on its website: <https://www.nibiohn.go.jp/eiken/kenkounippon21/en/kenkounippon21/mokuhyou.html#Table02> (accessed on Jan. 10, 2023).

20) The database is completely anonymized by JMDC.

patients hospitalized due to cancer affect their post-health condition after hospitalization due to cancer (if hospitalized), as shown in Figure 1. We constructed an estimation model based on the following RIDGE logistic regression model for regularization to avoid overfitting attributable to the complexity of the variables and bases:

$$L = \sum_i \left\{ \ln \left(1 + \exp(x_i^T w) \right) - x_i^T w y_i \right\} + \alpha \|w\|^2$$

The first term on the right side of the equation represents the log-likelihood with a change in sign, which is the loss function of the maximum likelihood method. The second term is the regularization term.

The model consists of two technical components, as illustrated in Figure 1.

a) The number of people at each health level at the time of discharge was determined based on their health checkup results and lifestyle habits before hospitalization. The levels of health were as follows: no experience of hospitalization and three classes of conditions after hospitalization, namely, working without anticancer drug administration, working with anticancer drug administration, and death, as described in Figure 1 and Table 2. Anticancer drugs can cause adverse reactions and lower the productivity.

b) Each health condition level is matched with the employee's ability to work after hospitalization and the level of productivity loss after hospitalization, that is, no productivity, slight productivity, moderate productivity, and total productivity losses, as shown in Table 2.

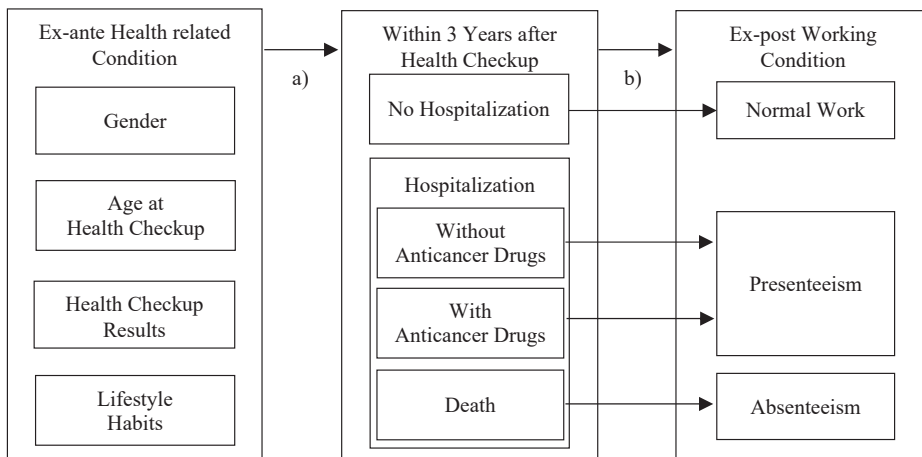


Figure 1. Structure of Estimation Model

Table 2. Levels of Ex-post Health Condition and Productivity Loss

Level	Health Condition		Working Condition	Productivity Loss
1	No Hospitalization		Normal Work	No Productivity Loss
2	Hospitalization	Working without Anticancer Drugs	Presenteeism	Mild to Moderate Productivity Loss
3		Working with Anticancer Drugs		Severe Productivity Loss
4		Death	Absenteeism	Total Productivity Loss

4. Results

4.1. Descriptive statistics

Table 3 shows the relationship between the pre-status of health checkup results and lifestyle habits with ex-post health conditions. Age at health checkups was reasonably higher for hospitalized individuals than for those without a hospitalization experience. According to the health checkup results, systolic blood pressure and triglyceride levels were visibly higher in hospitalized individuals than in those not hospitalized, while no distinct difference was observed with respect to LDL cholesterol and BMI. Among lifestyle habits, the rates of smoking and alcohol consumption over 20 g/day were higher in hospitalized persons than in those without hospitalization. In contrast, the rates of appropriate exercise time and sufficient rest were higher for those without hospitalization, which is presumably attributable to the difference in age distribution.

Table 3. Pre-status of Health Checkup Results and Lifestyle Habits with/without Hospitalization [Stomach Cancer]

Health Condition		No Hospitalization	Hospitalization		
			Working without Anticancer Drugs	Working with Anticancer Drugs	Death
No. of Persons		8,023,508	16,433	1,225	1,726
Gender =Male		67.2%	81.6%	81.5%	82.6%
Age at Health Checkup		45.5 ± 9.7	57.8 ± 8.4	56.6 ± 8.6	56.1 ± 8.5
Health Checkup Results	Systolic Blood Pressure	120.0 ± 15.8	125.7 ± 17.1	125.8 ± 17.8	125.9 ± 19.0
	Triglyceride	110.3 ± 89.3	120.0 ± 89.5	125.6 ± 96.0	119.3 ± 92.5
	LDL Cholesterol	121.1 ± 31.0	119.5 ± 32.0	117.8 ± 32.3	113.5 ± 34.5
	BMI	23.1 ± 3.7	23.2 ± 3.5	23.1 ± 3.8	22.5 ± 3.9
Lifestyle Habits	Exercise Habit =1	78.8%	71.2%	72.4%	79.4%
	Sleeping Time =1	39.9%	32.2%	34.2%	36.8%
	Smoking Habit =1	27.9%	31.2%	37.6%	28.9%
	Alcoholic Consumption =1	18.4%	31.4%	32.3%	25.7%

[Rectal Cancer]

Health Condition		No Hospitalization	Hospitalization		
			Working without Anticancer Drugs	Working with Anticancer Drugs	Death
No. of Persons		8,023,488	16,388	1,753	1,305
Gender =Male		67.2%	72.5%	69.9%	77.3%
Age at Health Checkup		45.5 ± 9.7	55.4 ± 8.4	54.4 ± 8.6	54.9 ± 8.4
Health Checkup Results	Systolic Blood Pressure	120.0 ± 15.8	125.5 ± 17.2	125.1 ± 17.5	127.5 ± 19.5
	Triglyceride	110.3 ± 89.3	123.1 ± 97.9	121.7 ± 96.4	126.5 ± 109.8
	LDL Cholesterol	121.1 ± 31.0	122.1 ± 31.8	123.2 ± 34.3	119.8 ± 36.7
	BMI	23.1 ± 3.7	23.7 ± 3.9	23.9 ± 4.2	22.7 ± 4.6
Lifestyle Habits	Exercise Habit =1	78.8%	75.4%	78.4%	79.2%
	Sleeping Time =1	39.9%	36.6%	36.0%	36.9%
	Smoking Habit =1	27.9%	28.0%	28.5%	25.4%
	Alcoholic Consumption =1	18.4%	29.2%	24.1%	21.6%

[Colon Cancer]

Health Condition		No Hospitalization	Hospitalization		
			Working without Anticancer Drugs	Working with Anticancer Drugs	Death
No. of Persons		8,027,218	10,139	1,187	749
Gender =Male		67.2%	77.0%	78.2%	82.4%
Age at Health Checkup		45.5 ± 9.7	54.0 ± 8.4	53.7 ± 8.3	55.3 ± 8.0
Health Checkup Results	Systolic Blood Pressure	120.0 ± 15.8	125.6 ± 16.9	125.3 ± 18.0	127.8 ± 17.8
	Triglyceride	110.3 ± 89.3	126.1 ± 102.7	127.1 ± 106.8	136.9 ± 137.5
	LDL Cholesterol	121.1 ± 31.0	123.0 ± 32.5	122.5 ± 33.8	119.2 ± 39.6
	BMI	23.1 ± 3.7	23.8 ± 3.8	23.8 ± 3.9	23.4 ± 4.1
Lifestyle Habits	Exercise Habit =1	78.8%	76.8%	77.8%	81.7%
	Sleeping Time =1	39.9%	37.3%	35.4%	34.8%
	Smoking Habit =1	27.9%	27.9%	37.7%	28.7%
	Alcoholic Consumption =1	18.4%	28.1%	28.7%	21.9%

[Lung Cancer]

Health Condition		No Hospitalization	Hospitalization		
			Working without Anticancer Drugs	Working with Anticancer Drugs	Death
No. of Persons		8,025,622	10,718	3,935	2,626
Gender =Male		67.2%	70.6%	79.6%	87.9%
Age at Health Checkup		45.5 ± 9.7	57.1 ± 8.2	56.4 ± 8.2	58.3 ± 8.0
Health Checkup Results	Systolic Blood Pressure	120.0 ± 15.8	124.8 ± 16.9	125.2 ± 16.9	125.4 ± 17.4
	Triglyceride	110.3 ± 89.3	119.5 ± 93.0	123.2 ± 99.6	125.9 ± 90.2
	LDL Cholesterol	121.1 ± 31.0	123.2 ± 31.8	121.3 ± 32.2	117.6 ± 33.1
	BMI	23.1 ± 3.7	23.0 ± 3.6	23.0 ± 3.4	22.8 ± 3.6
Lifestyle Habits	Exercise Habit =1	78.8%	73.7%	77.3%	78.2%
	Sleeping Time =1	39.9%	33.9%	34.3%	33.2%
	Smoking Habit =1	27.9%	26.9%	45.3%	41.6%
	Alcoholic Consumption =1	18.4%	27.8%	32.4%	32.8%

4.2. Estimation results

Relying on the RIDGE logistic regression model, we estimated the levels of ex-post health conditions. Table 4 details the estimated regression model parameters based on the health checkup results and lifestyle habits by incorporating the data in Table 3. As shown in Figure 1 and Table 2, the models estimated the levels of ex-post health conditions from the health checkup results and lifestyle habits before hospitalization. To verify the model accuracy, we estimated the area under the curve (AUC) by 10-fold cross-validation and obtained satisfactory values between 74.1% and 83.7% for all patterns, as described in Table 5.

Table 4. Estimated Model Parameter by Health Checkup Result and Lifestyle Habit

[Stomach Cancer]

Levels of ex-post Health Condition		Levels 2-4 (Hospitalization)	Levels 3-4 (Hospitalization with Anticancer Drugs or Death)	Level 4 (Death)
Constant		-7.719359	-8.218489	-8.627576
Gender =Male		0.114060	0.023324	0.014449
Age		0.024605	0.004059	0.002364
Health Checkup Results	Systolic Blood Pressure	0.003427	0.000792	0.000483
	Triglyceride	0.000127	0.000047	0.000022
	LDL Cholesterol	0.000000	0.000000	0.000000
	BMI	0.000000	0.000000	0.000000
Lifestyle Habits	Exercise Habit =1	0.000000	0.000000	0.000000
	Sleeping Time =1	0.000000	0.000000	0.000000
	Smoking Habit =1	0.026728	0.007848	0.000971
	Alcoholic Consumption = 1	0.129921	0.022594	0.009814

[Rectal Cancer]

Levels of ex-post Health Condition		Levels 2-4 (Hospitalization)	Levels 3-4 (Hospitalization with Anticancer Drugs or Death)	Level 4 (Death)
Constant		-7.573884	-8.192968	-8.879167
Gender =Male		0.033232	0.009095	0.007185
Age		0.019862	0.003527	0.001587
Health Checkup Results	Systolic Blood Pressure	0.003444	0.000855	0.000469
	Triglyceride	0.000214	0.000058	0.000032
	LDL Cholesterol	0.000000	0.000014	0.000000
	BMI	0.006098	0.001632	0.000643
Lifestyle Habits	Exercise Habit =1	0.000000	0.000511	0.000430
	Sleeping Time =1	0.000000	0.000000	0.000000
	Smoking Habit =1	0.000000	0.000000	0.000000
	Alcoholic Consumption =1	0.104466	0.010520	0.003224

[Colon Cancer]

Levels of ex-post Health Condition		Levels 2-4 (Hospitalization)	Levels 3-4 (Hospitalization with Anticancer Drugs or Death)	Level 4 (Death)
Constant		-7.544288	-8.540393	-9.372384
Gender =Male		0.053533	0.013097	0.006300
Age		0.011681	0.002205	0.000963
Health Checkup Results	Systolic Blood Pressure	0.002556	0.000571	0.000283
	Triglyceride	0.000218	0.000059	0.000030
	LDL Cholesterol	0.000080	0.000003	0.000000
	BMI	0.004806	0.000841	0.000173
Lifestyle Habits	Exercise Habit =1	0.000000	0.000850	0.001635
	Sleeping Time =1	0.000000	0.000000	0.000000
	Smoking Habit =1	0.002326	0.006620	0.000040
	Alcoholic Consumption =1	0.070356	0.011612	0.002079

[Lung Cancer]

Levels of ex-post Health Condition		Levels 2-4 (Hospitalization)	Levels 3-4 (Hospitalization with Anticancer Drugs or Death)	Level 4 (Death)
Constant		-7.569480	-7.784978	-8.337665
Gender =Male		0.053001	0.050301	0.029018
Age		0.021643	0.009290	0.004286
Health Checkup Results	Systolic Blood Pressure	0.002737	0.001418	0.000642
	Triglyceride	0.000159	0.000110	0.000057
	LDL Cholesterol	0.000000	0.000000	0.000000
	BMI	0.000000	0.000000	0.000000
Lifestyle Habits	Exercise Habit =1	0.000000	0.000000	0.000026
	Sleeping Time =1	0.000000	0.000000	0.000000
	Smoking Habit =1	0.043499	0.057887	0.021157
	Alcoholic Consumption =1	0.108685	0.065507	0.029220

Table 5. AUC (Area Under the Curve) Estimated by 10-fold Cross Validation

Levels of ex-post Health Condition	Levels 2-4 (Hospitalization)	Levels 3-4 (Hospitalization with Anticancer Drugs or Death)	Level 4 (Death)
[Stomach Cancer]	0.821793	0.790958	0.787066
[Rectal Cancer]	0.766631	0.743766	0.755718
[Colon Cancer]	0.740875	0.744716	0.779908
[Lung Cancer]	0.809209	0.812432	0.837122

The results reveal that lifestyle habits, including smoking and alcohol consumption, generally tend to visibly affect productivity loss after hospitalization, but insufficient exercise and sleeping time demonstrate only an imperceptive relationship with the prognosis of cancer. It was also found that maintaining an acceptable level of health checkup results—including systolic blood pressure,

triglyceride levels, and BMI—affects productivity loss. It is expected to have the same effect as improving lifestyle habits by reducing the systolic blood pressure and triglyceride levels by several tens.

In case of stomach cancer, alcohol consumption, and smoking habits are notably related to prognosis, especially the necessity of anticancer drug treatment or death after hospitalization. The impact on productivity loss is more significant for the former. Shortage of sleep and exercise time had little effect on the prognosis of stomach cancer. Among the health checkup results, only systolic blood pressure and triglyceride levels were slightly related to the ex-post health condition, indicating that the higher the pressure, the more severe the prognosis (anticancer drug treatment or death).

Alcohol consumption and insufficient exercise time also, or even more significantly, affect the grave prognosis of both types of bowel cancer, especially colon cancer. Smoking habits moderately affected poor health after hospitalization in patients with colon cancer; however, this tendency was not observed in patients with rectal cancer. BMI demonstrates a relatively clear relationship with bowel cancer; the higher the BMI, the worse the post-hospitalization health condition. High systolic blood pressure may affect the prognosis to a limited extent.

Smoking tended to negatively affect the prognosis of patients with lung cancer after hospital treatment. Alcohol consumption and high systolic blood pressure are associated with lung cancer.

5. Conclusion

This study aimed to recommend to insurance companies how they can contribute to H&PM by providing corporate medical insurance and health-promoting support services, especially on risk evaluation indices and incentivizing mechanisms for policy-holding corporations and insured employees to promote health conditions. By focusing on the four major types of cancers that undermine the working productivity of individuals after or during treatment, we attempted to reveal what kinds of lifestyle habits or health checkup results before the pathogeny of cancers affect productivity loss after hospital treatment. We estimated the health conditions and productivity loss of hospitalized cancer patients based on the RIDGE logistic regression model applied to a database constructed from the claims data of corporate health insurance societies, treatment information of medical institutions, and questionnaires completed by the insured in Japan.

From the estimation results, we found different tendencies among cancer types. For stomach cancer, alcohol consumption, smoking habits, and higher systolic blood pressure and triglyceride visibly affect a bad prognosis, that is, continuing dose of anticancer drugs or death after hospital treatment, while we observed no noticeable relationship between any other lifestyle habits and health checkup results with post-hospitalization health conditions. Regarding bowel cancer, both insufficient exercise

time and alcohol consumption tend to negatively affect health after hospitalization. Among health checkups, BMI showed a visible relationship with bowel cancer. There is no room for discussion that smoking habits tend to increase the prognosis of lung cancer. Additionally, alcohol consumption and higher systolic blood pressure and triglyceride levels negatively affected health after discharge from the hospital. In general, lifestyle habits obviously affect productivity loss after hospitalization, with the exception of sleeping time, which demonstrates only an imperceptible relationship with cancer prognosis. Maintaining acceptable levels of health checkup results, such as systolic blood pressure and triglyceride levels, also affect productivity loss.

The estimation results imply that an insurer should prioritize lifestyle factors, such as exercise, alcohol consumption, and smoking, as well as health checkup items, including systolic blood pressure and BMI, when designing corporate medical insurance contracts and H&PM services for policy-holding organizations and their employees. For example, the insurer can utilize exercise time as a risk evaluation factor for corporate medical insurance and set the targeted level at 30 minutes of exercise time per day, twice a week. The insurer then applies a premium discount when the insured employees accomplish the targeted time and frequency of exercise, combined with offering risk-consulting services to support policy-holding corporations in designing fitness welfare programs for their employees. Similarly, when insured employees maintain an acceptable level of systolic blood pressure (e.g., less than 140 mmHg) and BMI (e.g., less than 30 kg/m²), the insurer offers a premium discount. However, a premium surcharge is applied based on the percentage of employees who smoke or consume excessive alcohol (e.g., more than 20 g per day), so that the management of the policy-holding corporation makes efforts to encourage employees to refrain from smoking or drinking. To incentivize individual employees, the insurer can directly intervene by providing a set of exercise-promoting services, such as furnishing hemomanometers, smoking abstention applications, or walking applications built into wearable devices.

Regardless of the discussion, operating such a risk evaluation mechanism and offering consultations may impose no little burden on the insurer. The insurer should thus consider not only the benefit from an improved loss ratio attributable to the health promotion of the insured employees but also the cost of operating the health-promoting program when designing corporate medical insurance and H&PM services.

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健康経営推進に向けた保険事業の役割 —医療保険データに基づくがん治療後の生産性低下に関する分析—

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要旨

近年、健康維持・増進と生産性向上を目指した企業・組織の健康経営が注目されるようになり、勤労者の健康、パフォーマンス、そしてワークライフバランスの促進が社会的にも要請されるようになっている。こうしたなか企業・組織を契約者とした団体医療保険を引き受ける保険会社が、被保険者である従業員に対して、生活習慣病の発症防止のための健康支援サービスを提供する例が見られるようになっている。生活習慣病のなかでもがんについては、医療技術の進歩などにより治療期間中および治療後も働き続けることが、今日では珍しくないことから、本稿では、がんによる勤労者のアブセンティズムとプレゼンティズムが、その発症前の健康診断結果と生活習慣からどのように影響を受けるのかを、RIDGE ロジスティック回帰モデルに基づき分析する。そのために、全国健康保険組合から収集した公的医療保険のレセプト情報、そして健康診断結果と生活習慣の情報から構築したデータベースを用いた。分析の結果、不十分な運動量、喫煙習慣および飲酒習慣ががん治療中・後のパフォーマンス低下に関連することが示された。一方で健康診断結果に関しては、収縮期血圧についてのみ、それが高い値であった場合に一部のがんの予後不良を引き起こす可能性が示唆された。

キーワード：健康経営，がん，アブセンティズム，プレゼンティズム，RIDGE ロジスティック回帰

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