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An Analysis of Health Factors Affecting Employees' Absenteeism: Influences of HDL Cholesterol and Blood Sugar Levels

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Abstract

Background: Workers' health condition is an important issue. It affects not only the well-being of workers but also the firms and society as a whole through medical costs and productivity losses due to absenteeism and presenteeism. **Data and Methods:** Data were obtained from 1136 employees at an operational site of a large corporation. The dataset contained both medical checkups and working record information. Health factors affecting long-term absence (over three days in three months) were analyzed. Logistic regression models and the procedure for selecting proper covariates based on likelihood test statistics and the Akaike information criterion were used. **Results:** Among health factors, high-density lipoprotein cholesterol (HDL-C) and blood sugar levels were important in the selected model. For HDL-C, the odds ratio (OR) based on one standard deviation difference was 0.75 with a 95% confidence interval (CI) of 0.59 - 0.95. For blood sugar, the OR was 1.20 with a 95% CI of 1.01 - 1.42. Improving HDL-C and blood sugar levels would reduce long-term absence by 25% and 20%, respectively. **Conclusion:** Controlling HDL-C and blood sugar levels is important to reduce long-term absenteeism. These factors can be improved by modifying eating habits. Since the operational site has its own company cafeterias, which most employees use, nutritional intervention is relatively easy with little or no cost. It may be worthwhile to implement nutritional intervention, especially for patients with low HDL-C or high blood sugar levels. **Limitations:** The results of this study were based on one operational site of a corporation. The employees were mainly operators working inside the building. The results may be different from other types of jobs and working conditions, such as fieldwork. Analyses of different types of jobs and working conditions are necessary.

Keywords

Absenteeism, Reduction of Absence Days, High-Density Lipoprotein

Cholesterol (HDL-C), Blood Sugar

1. Introduction

The health condition of workers is a critical issue. The International Labour Organization (ILO) [1] stated that "Occupational accidents and diseases lead to devastating impacts on workers, enterprises, and entire communities and economies." The ILO [2] estimated that "The losses in terms of compensation, lost work days, interrupted production, training, and reconversion, as well as healthcare expenditure, represent around 3.94 percent of the world's annual GDP." The World Health Organization (WHO) [3] mentioned that "Work-related health problems result in an economic loss of 4% - 6% of GDP in most countries… Research has demonstrated that workplace health initiatives can help reduce sick leave absenteeism and healthcare costs for companies by 27% and 26%, respectively." The National Center for Chronic Disease Prevention and Health Promotion of the Centers for Disease Control and Prevention (CDC) [4] in the United States described "Preventable chronic conditions as major contributors to the costs of health insurance premiums and employee medical claims. These costs are at an all-time high and continue to increase in the United States." In Japan, it is reported that the number of work-related diseases requiring work absences of four days and more was 7844 in 2017 [5].

Evidently, health is not only essential for individuals' well-being [6] but is also a very important social goal and benefit for individual workers, firms, and society as a whole [7]. In other words, maintaining and promoting workers' health will not only improve their well-being but will also lead to medical expense reduction and increased productivity [8]. Health risks are a serious burden to employers owing to the loss of productivity, and various studies have been conducted on this topic [9]-[22].

The monetary costs have been also estimated. Nagata *et al.* [23] estimated that the cost of absenteeism, presenteeism (reduction of productivity due to health conditions in the workplace), and medical/pharmaceutical expenses were $520, $3055, and $1165 per person per year, respectively, in the fiscal year 2014 in Japan. Ramasamy *et al.* [24] reported that direct costs for class I (body mass index (BMI) 30.0 to 34.9, BMI = weight (kg)/(height(m))^2), class II (BMI 35.0 to 39.9 kg/m^2), and class III (BMI ≥ 40.0 kg/m^2) obesity were $1775, $3468, and $11,481 per-patient-per-year (PPPY), respectively, higher than those of the reference; and absenteeism/disability costs were higher than those of the reference by $617, $541, and $1707 PPPY for classes I, II, and III obesity, respectively. Gennep *et al.* [25] reported that the mean annual costs of absenteeism, presenteeism, and overall work productivity for inflammatory bowel disease patients were €1738, €5478, and €6597, respectively. Ademi *et al.* [26] estimated AUD 5.23 billion in lost GDP, with an average of AUD 101,366 lost per person with heterozygous familial hypercholesterolemia over their working lifetime using 2017 GDP data. Cawley *et al.* [27] estimated that annual productivity loss due to obesity was from $271 to $542 per employee in 2016. Kocakulah *et al.* [28] described that "Some sources, including Statistics Canada, cite that absenteeism approximates 15 - 20 percent of payroll (direct and indirect) costs." They also discussed several possible solutions for the companies. Gianino [29] studied economic losses in terms of employee absenteeism due to influenza and reported that the average work loss due to influenza was €327/person.

Another question is whether investments in improving workers' health conditions are worthwhile. Baicker [30] estimated that medical and absenteeism costs fell by approximately $3.27 and $2.73 for every dollar spent, respectively. However, Verelst *et al.* [31] mentioned that while workplace influenza vaccination is relatively inexpensive and convenient, the return on investment is volatile for employers. From a managerial perspective, it is important to identify the risk factors that affect productivity and invest in improving these factors. Lawrance *et al.* [32] proposed a decision support system to improve health and well-being in the workplace and identify groups of employees at risk of sickness absence aiming to reduce or prevent absences.

Various studies have been conducted on overweight and obese individuals. Howard and Potter [33] evaluated the relationship between obesity, obesity-related chronic health conditions, and worker absenteeism using logistic regression. They found that obesity was related to higher rates of worker illness absence after controlling for demographic, socioeconomic, occupational, health-related, and behavioral variables. Keramat *et al.* [34] studied the relationship between absenteeism and obesity in Australian workers. They concluded that workplace absenteeism was significantly associated with being overweight and obese. Hashiguchi [35] evaluated the effect of BMI on working health risks determined by heart rate reserve (HRR) using a logistic regression model with a 40% HRR criterion. However, BMI was not a significant risk factor.

Presenteeism is a complex problem [36] and difficult to measure properly. Moreover, Marmot *et al.* [37] pointed out that worker absence is a good proxy for workers' health. Therefore, the relationships between health factors and absenteeism are analyzed using health and working record data of 1136 employees in this study.

2. Data and Models

2.1. Data

The dataset contained information on the health and working records of 1136 employees at one operational site of a large corporation. The site is located in a suburb of a major city in the north-eastern region in Japan. Most employees commute by car. Health data were obtained from annual mandatory medical checkups conducted in the fiscal year 2020. Work records include information on the work schedule, actual work hours, and employees' absences from October

2021 to December 2021. Most employees are operators supporting end customers for clients using telephones or the Internet at an indoor operational site. To calculate absence days, we excluded paid, maternity and parental, nursing care, bereavement, auspicious, and special leaves admitted by the corporation's regulations. The number of days of absence was calculated from days of not attending work due to disability (sick or injury) and personal reasons. For most of the employees, the total number of working days during this period was 63.

Figure 1 shows the distribution of the number of absence days. 945 (83.2%) employees had no absence days. The total number of absence days for all employees was 1604 days. The number of employees with over three absence days (more than one day per month) was 94 and their absence days were 1440 days, approximately 90% of the absence days of all employees. Hence, the corporation must reduce long-term absenteeism.

2.2. Models and Covariates

Vernekar *et al.* [38] reported the prevalence of overweight, diabetes, hypertension, dyslipidemia, and hypercholesterolemia among IT professionals. In addition to obesity measured by BMI, health factors related to hypertension [39]-[44], hyperglycemia or diabetes [45]-[50], and hypercholesterolemia [26] [51] [52] [53] [54] obtained from the annual medical check-ups are considered. The following covariates were used in the analysis.

Female (dummy variable) 1 if female and 0 if male,

Age (age of an employee),

Height (height of an employee) m,

Weight (weight of employee) kg,

BMI (body mass index) weight (kg)/(height, m)^2,

SBP (systolic blood pressure) mmHg,

DBP (diastolic blood pressure) mmHg,

RedCell (number of red blood cells) 10,000 per mm^3,

Hemoglobin g/dL,

GOT (glutamic-oxaloacetic transaminase) units per liter (U/L),

GPT (Glutamic-pyruvic transaminase) U/L,

GGP (γ-glutamyl transferase) U/L,

Triglyceride (serum triglyceride level) mg/dL,

HDL (high-density lipoprotein cholesterol) mg/dL,

LDL (low-density lipoprotein cholesterol) mg/dL,

B_Sugar (blood sugar) mg/dL, and

HbA1c (Hemoglobin A1c) %.

The summary of these variables is given in **Table 1**.

As the distribution of the absence days has a heavy right tail, we consider long-term absenteeism if an employee was absent over three days and define it as *L_Absence* = 1 if absence days were over three days and 0 otherwise. Of the employees, 8.3% had *L_Absence* = 1. The following logistic regression model was used:

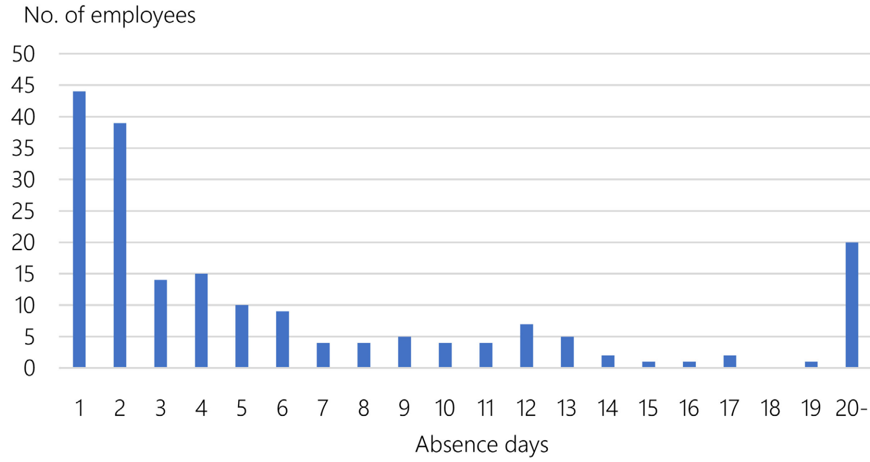

Figure 1. Distribution of absence days.

Table 1. Summary of covariates.

Variable	*Female*	*Age*	*Hight*	*Weight*	*BMI*	*SBP*
Mean	0.70	41.35	162.72	63.41	23.82	125.01
SD	0.46	10.44	8.13	16.11	5.14	20.59
Variable	*DBP*	*RedCell*	*Hemoglobin*	*GOT*	*GPT*	*GGTP*
Mean	74.55	469.27	13.86	24.51	28.38	37.60
SD	13.76	43.97	1.73	15.03	30.21	46.08
Variable	*Triglyceride*	*HDL*	*LDL*	*B_Sugar*	*HbA1c*	
Mean	106.01	60.21	121.74	91.95	5.47	
SD	98.00	15.03	33.15	18.90	0.66	

SD: Standard Deviation.

$$P\left[L\_Absence = 1 \mid x\right] = \Lambda\left(x'\beta\right) \qquad (1)$$

where Λ is the distribution function of the logistic distribution given by $\Lambda(\omega) = \frac{\exp(\omega)}{1+\exp(\omega)}$, x is a vector of a subset covariate and β is a vector of unknown parameters.

2.3. Selection of Covariates

In this study, the problem is that the number of observations is not large, and the percentage of $L\_Absence = 1$ observations is only 8.3%. This implies that the dataset does not contain much information (*i.e.*, eigenvalues of the Fisher Information matrix are not large enough compared to variations of covariates), and all the estimates except Female are not significant at the 5% level if all covariates are included, as shown in **Table 2**.

Another problem is the observation of missing values for some covariates. Some covariates may not be related to the dependent variable (in this case,

Table 2. Estimation result with all covariates.

Variable	Estimate	Standard error	t-value	p-value
Constant	−13.3467	11.2797	−1.1833	0.2367
Female	1.0846	0.4466	2.4283	0.0152
Age	−0.0059	0.0122	−0.4843	0.6281
Hight	0.0628	0.0673	0.9329	0.3508
Weight	−0.0391	0.0816	−0.4786	0.6322
BMI	0.0990	0.2202	0.4496	0.653
SBP	−0.0045	0.0102	−0.4403	0.6598
DBP	0.0052	0.0153	0.3414	0.7328
RedCell	−0.00084	0.0042	−0.2013	0.8404
Hemoglobin	0.0424	0.1072	0.3952	0.6927
GOT	−0.0261	0.0248	−1.0553	0.2913
GPT	0.0061	0.0121	0.5069	0.6122
GGTP	−0.0034	0.0047	−0.7329	0.4636
Triglyceride	0.0015	0.0012	1.2637	0.2064
HDL	−0.0140	0.0098	−1.4303	0.1526
LDL	0.0031	0.0035	0.8771	0.3804
B_Sugar	0.0078	0.0081	0.9690	0.3325
HbA1c	0.0649	0.2575	0.2520	0.801
Log Likelihood		−338.922		
No. of observations		1: 1039, 0:91, total 1130		

L_Absence). If we drop observations with missing values in covariates that are unrelated to the dependent variable, information will be lost. The selection of appropriate covariates is very important. Nawata [55] showed that *SBP* was strongly associated with the occurrence of heart disease when the two variables were directly compared. However, the importance of *SBP* diminished when other covariates were included, suggesting that this relationship may be spurious. It is essential to use an appropriate method to select proper covariates. The same set of covariates should be selected independently without any ambiguity.

In this study, a procedure based on likelihood ratio statistics and the Akaike information criterion (AIC), one of the most widely used criteria in model selection, is used for the selection of covariates. This procedure can be used when missing values exist in the covariates. The cross-validation method, in which the dataset is divided into two groups, estimates the model using observations in one group (training set) and selects a model based on performances in the other group (testing set); the method is widely used in areas such as machine learning. However, this method may not be appropriate because the number of observations with *L_Absence* = 1 is too small.

The covariates are selected by the following stepwise procedure.

1) Let y be a dependent dummy variable that takes the value of 0 or 1. Suppose that there are ℓ (potential) covariates $x_1, x_2, \cdots, x_\ell$, and the numbers of observations excluding missing values are $n_1, n_2, \cdots, n_\ell$ for those variables. If no missing values exist for x_i, $n_i = n$ where n is the total number of observations. First, estimate models containing only constant term; that is $P[y=1] = \Lambda(\beta_0)$ for $i = 1, 2, \cdots, \ell$ and calculate the log likelihood, $\log L_{0i}$. Note that if $n_i = n_j = n$, $\log L_{0i} = \log L_{0j}$.

2) Estimate models containing one covariate, $P[y=1] = \Lambda(\beta_0 + \beta_1 x_i)$, and calculate the log likelihood, $\log L_{1i}$, and $LR_{1i} = \log L_{1i} - \log L_{0i}$ for $i = 1, 2, \cdots, \ell$. It is well known that $2 \cdot LR_{1i}$ is the likelihood test statistic of $H_0 : \beta_1 = 0$ and asymptotically follows $\chi^2(1)$ under H_0 irrelevant of n_i.

3) Choose x_i that maximizes LR_{1i}. Without a loss of generality, we can assume that the first variable x_1 maximizes LR_{1i}. Consider models with two variables given by $P[y=1] = \Lambda(\beta_0 + \beta_1 x_1 + \beta_2 x_i)$ and obtain the second stage log likelihood, $\log L_{2i}$, $i = 2, 3, \cdots, \ell$. For x_i such that the number of observations becomes smaller than n_1, re-estimate $P[y=1] = \Lambda(\beta_0 + \beta_1 x_1)$ and calculate LR_{1i} again using observations without missing values. Calculate $LR_{2i} = \log L_{2i} - \log L_{1i}$.

4) Let x_2 be a variable that minimizes LR_{2i}. Then consider model with three variables $P[y=1] = \Lambda(\beta_0 + \beta_1 x_i + \beta_2 x_2 + \beta_3 x_i)$, $i = 3, 4, \cdots, \ell$, and calculate the log likelihood and select the covariates that maximizes LR_{2i}.

5) Repeat steps $k + 1$ times until $LR_{k+1i} < 1$ for all *i*. This is equivalent to minimizing the AIC. The final model becomes $P[y=1] = \Lambda(\beta_0 + \beta_1 x_i + \beta_2 x_2 + \cdots + \beta_k x_k)$.

A method based on t-tests could be an alternative. However, the t-test can yield misleading results in qualitative choices and related models, particularly when the sample size is small [56] [57].

3. Results of Estimation

Table 3 shows the results of the covariate selection using the procedure described in the previous section. The bold values indicate the largest value of LR_{ji}, satisfying over 1 in step *j*, where *j* covariates are included.

In the first step, *HDL* was selected. *Female*, *B_Sugar*, *Height*, and *GOT* were selected using the following steps. All values of LR_{6i} were less than 1, and the procedure was stopped at this stage. The final model, which contains five covariates, is given by:

$$P[y=1] = \Lambda(\beta_0 + \beta_1 HDL + \beta_2 Female + \beta_3 B\_Sugar + \beta_4 Hight + \beta_5 GOT) \quad (2)$$

Table 4 presents the estimation results of this model. The estimate of *Female* is positive and significant at the 1% level, suggesting that that the female was absent from work more frequently than the male [58]. Concerning health factors, the estimates of *HDL* and *B_Sugar* were negative and positive, respectively, and were significant at the 5% level. This means that a higher level of *HDL* reduces long-term absenteeism but a higher level of *B_Sugar* significantly increases long-term absenteeism and therefore, they are considered important health factors.

Table 3. Values of LR_{ji} and selection of covariates.

Variable	Step (number of covarietes)					
	one	two	tree	four	five	six
Female	1.4171	**2.7855**				
Age	0.0990	0.0505	0.0621	0.1886	0.0855	0.0676
Hight	0.0000002	0.1139	1.2446	**1.2677**		
Weight	0.1918	0.0579	0.1049	0.0000	0.1791	0.0042
BMI	0.3518	0.0002	0.0001	0.1294	0.1356	0.0002
SBP	0.0007	0.1066	0.0002	0.0818	0.1120	0.0186
DBP	0.0038	0.1123	0.0002	0.0777	0.1066	0.0115
RedCell	0.1070	0.6509	0.0078	0.0008	0.0085	0.0093
Hemoglobin	0.6414	1.1127	0.0001	0.0091	0.0075	0.0172
GOT	0.8766	1.5282	0.7496	1.1868	**1.1858**	
GPT	0.3873	1.3112	0.4658	0.7358	0.7352	0.0602
GGTP	0.3229	0.6238	0.1342	0.3565	0.3561	0.0001
Triglyceride	0.2457	0.0047	0.0725	0.0339	0.0565	0.3219
HDL	**1.8093**					
LDL	0.7347	0.3122	0.3567	0.2757	0.3434	0.6125
B_Sugar	1.3755	0.9722	**1.4101**			
HbA1c	1.1608	0.6482	0.6879	0.0253	0.0165	0.0015

The bold values give the largest value of LR_{ji}, satisfying over 1.

Table 4. Estimation results of the selected model.

Variable	Estimate	Standard error	t-value	p-value
Constant	−7.4317	3.3736	−2.2029	0.0276
HDL	−0.0191	0.0081	−2.3626	0.0181
Female	0.9530	0.3689	2.5836	0.0098
B_Sugar	0.0095	0.0045	2.1172	0.0342
Hight	0.0301	0.0190	1.5903	0.1118
GOT	−0.0146	0.0104	−1.3984	0.162
Log Likelihood	−315.786			
No. of observations	1: 1042, 0:94, total 1136			

4. Discussion

The cost of absenteeism among employees is significantly high for corporate employers. Additional replacement employees and their training are necessary to maintain the corporation's services [14] [28] [31] [32] [59]. Moreover, investments for the reduction of absenteeism must be made efficiently from a cost-benefit perspective. The results in the previous section suggest that *HDL* and *B_Sugar* are two important factors directly related to absenteeism.

Figure 2 shows the odds ratios (ORs) and 95% confidence intervals (CIs) for *HDL* (high-density lipoprotein cholesterol) and *B_Sugar* (blood sugar). As these variables are numerical, the OR for variable x_i is calculated by comparing x_i and (x_i + one standard deviation). For HDL, the OR was 0.75 with a 95% CI of 0.59 - 0.95. This indicates that increasing HDL level by 15.0 mg/dL (one standard deviation) reduces long-term absenteeism by 25%. (Because the probability of *L_Absence* = 1 was small, the odds ratio was approximately equal to the probability ratio.) The CDC [60] has labeled *HDL* "good" cholesterol. According to the guidelines of the Japan Atherosclerosis Society, the normal *HDL* level is 40 mg/dL or over [61]. The percentage of long-term absenteeism of 1063 employees with normal *HDL* was 7.8%; however, for 73 employees with *HDL* < 40 mg/dL, the percentage was 15.1%, almost twice as large as that of the normal *HDL* group. The roles and mechanisms of *HDL* have been studied [62] [63] [64]. Ghobadi *et al.* [65] mentioned that nutritional intervention in the workplace seems to be more beneficial in improving *HDL* through a systematic review, and de Liz *et al.* [66] reported a positive impact of regular consumption of some types of juices on *HDL* levels.

For *B_Sugar*, the OR was 1.20 with a 95% CI of 1.01 - 1.42. Decreasing *B_Sugar* level by 18.9 mg/dL (one standard deviation) would reduce long-term absenteeism by 20%. Under the current Japanese criteria, an individual is diagnosed with diabetes if *B_Sugar* ≥ 126 mg, prediabetes if *B_Sugar* is 110 - 125 mg, and normal if *B_Sugar* < 110 mg [67]. For details on the blood sugar distribution in Japan, see Nawata [68]. The percentage of long-term absenteeism is 7.6% for 1059 normal employees; however, it becomes 18.2% for 77 prediabetic and diabetic employees. Blood sugar levels can be controlled through lifestyle improvements such as modifying eating [69] and exercise habits. CDC [70] mentioned that "The goal is to get at least 150 minutes per week of moderate-intensity physical activity."

The correlation between *HDL* and *B_Sugar* is low and negative with a correlation coefficient of −0.144. This means that the corporation could reduce long-term absenteeism by as much as 40% by improving *HDL* and *B_Sugar* levels. This operational site has its own company cafeteria, which is used by most employees, therefore, nutrition intervention and improvement of eating habits could be relatively easy with little or no cost. It may be worthwhile to practice nutritional intervention, especially for those with low *HDL* or high *B_Sugar* levels.

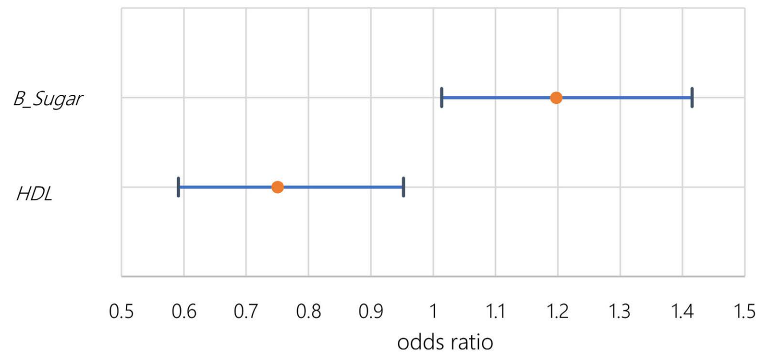

Figure 2. Odds ratios and their 95% confidence intervals for *HDL* and *B_Sugar*.

5. Conclusions

Employees' health is an important issue. It affects not only the well-being of employees but also their productivity through absenteeism and presenteeism. In this study, the health factors affecting absenteeism were analyzed because absenteeism can be directly measured without ambiguity and were good proxy of health conditions. The health and work record information of 1136 workers at an operational site of a large corporation was used in the analysis. The costs of absenteeism are significantly high and this is a serious issue from a managerial viewpoint of the corporation.

The relationship between long-term absences (more than three days in three mouth) and health factors was analyzed using logistic regression models. Because the number of observations is not very large, no health factor is significant at the 5% level when all covariates are included. Therefore, a procedure to determine the optimal selection of covariates was used. It is based on likelihood ratio statistics and the AIC.

In the selected model, the most significant health factors were high-density lipoprotein cholesterol (HDL-C) and blood sugar levels. Corporations can reduce long-term absenteeism significantly by improving these factors. These factors can be improved by modifying eating habits. The operational site has its own company cafeteria, and nutrition intervention is relatively easy. It may be worthwhile to implement nutritional interventions, especially for those with abnormal levels of HDL-C or high blood sugar.

The results of this study are based on one operational site of a corporation. The employees were mainly operators working inside the buildings. The results may be different for other types of jobs and working conditions, such as fieldwork. We may not be able to generalize the results of this study. Analyses of different types of jobs and working conditions are necessary. Evaluation of the exact cost of nutrition intervention and improvement of eating habits is also important. These topics will be investigated in future studies.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] International Labour Organization (ILO) (2023) Safety and Health at Work. https://www.ilo.org/global/topics/safety-and-health-at-work/home/lang--en/index.htm#:~:text=The%20ILO%20aims%20to%20create%20worldwide%20awareness%20of,at%20all%20levels.%20Decent%20work%20is%20safe%20work

[2] International Labour Organization (ILO) (2023) International Labour Standards on Occupational Safety and Health. https://www.ilo.org/global/standards/subjects-covered-by-international-labour-standards/occupational-safety-and-health/lang--en/index.htm

[3] World Health Organization (WHO) (2017) Protecting Workers' Health. https://www.who.int/news-room/fact-sheets/detail/protecting-workers'-health

[4] National Center for Chronic Disease Prevention and Health Promotion and Centers for Disease Control and Prevention (CDC) (2022) Workplace Health Promotion. https://www.cdc.gov/chronicdisease/resources/publications/factsheets/workplace-health.htm

[5] Japan Industrial Safety and Health Association (2021) Statistics of Workers' Health Condition in Japan, 2020. https://www.jisha.or.jp/english/statistics/health_in_detail_2020.html

[6] Global Council for Happiness and Wellbeing (2019) Global Happiness and Well-Being Policy Report 2019. https://www.happinesscouncil.org/report/2019/global-happiness-and-well-being-policy-report

[7] Ose, S.O. (2005) Working Conditions, Compensation and Absenteeism. *Journal of Health Economics*, **24**, 161-188. https://doi.org/10.1016/j.jhealeco.2004.07.001

[8] Kuroda, S. (2018) Health Capital Investment and Productivity. *Japanese Journal of Labour Studies*, **605**, 30-48. (In Japanese with English Abstract)

[9] Thornton, J. (2002) Estimating a Health Production Function for the US: Some New Evidence. *Applied Economics*, **34**, 59-62. https://doi.org/10.1080/00036840010025650

[10] Boles, M., Pelletier, B. and Wendy, L. (2004) The Relationship between Health Risks and Work Productivity. *Journal of Occupational and Environmental Medicine*, **46**, 737-745. https://doi.org/10.1097/01.jom.0000131830.45744.97

[11] Davis, K., Collins, S.R., Doty, M.M., Ho, A. and Holmgren, A.L. (2005) Health and Productivity among U.S. Workers. Commonwealth Fund, Issue Brief. https://www.commonwealthfund.org/sites/default/files/documents/___media_files_publications_issue_brief_2005_aug_health_and_productivity_among_u_s__workers_856_davis_hlt_productivity_usworkers_pdf.pdf

[12] Loeppke, R., Taitel, M., Richling, D., Parry, T., Kessler, R.C., Hymel, P. and Konicki, D. (2007) Health and Productivity as a Business Strategy. *Journal of Occupational and Environmental Medicine*, **49**, 712-721. https://doi.org/10.1097/JOM.0b013e318133a4be

[13] Ron Goetzel, R.Z., Shechter, D., Ozminkowski, R.J., Marmet, P.F., Tabrizi, M.J. and Roemer, E.C. (2007) Promising Practices in Employer Health and Productivity Management Efforts: Findings from a Benchmarking Study. *Journal of Occupational and Environmental Medicine*, **49**, 111-130. https://doi.org/10.1097/JOM.0b013e31802ec6a3

[14] Loeppke, R., Taitel, M., Haufle, V., Parry, T., Kessler, R.C. and Jinnett, K. (2009) Health and Productivity as a Business Strategy: A Multiemployer Study. *Journal of Occupational and Environmental Medicine*, **51**, 411-428. https://doi.org/10.1097/JOM.0b013e3181a39180

[15] Mujan, I., Anđelković, A.S., Munćan, V., Kljajić, M. and Ružić, D. (2019) Influence of Indoor Environmental Quality on Human Health and Productivity—A Review. *Journal of Cleaner Production*, **217**, 646-657. https://doi.org/10.1016/j.jclepro.2019.01.307

[16] Ullah, S., Malik, M.N. and ul Hassan, M. (2019) Impact of Health on Labour Productivity: Empirical Evidence from Pakistan. *European Online Journal of Natural and Social Sciences*, **8**, 139-147.

[17] Satyana, R.P.U., Uli, R.E., Magliano, D., Zomer, E., Liew, D. and Ademi, Z. (2020) Assessing the Impact of Smoking on the Health and Productivity of the Working Age Indonesian Population Using Modelling. *BMJ Open*, **10**, e041832. https://doi.org/10.1136/bmjopen-2020-041832

[18] Siddique, H.M.A., Mohey-ud-din, G. and Kiani, A. (2020) Human Health and Worker Productivity: Evidence from Middle-Income Countries. *International Journal of Innovation, Creativity and Change*, **14**, 523-544.

[19] Adhvaryu, A., Kala, N., Jameel, A.L. and Nyshadham, A. (2022) Management and Shocks to Worker Productivity. *Journal of Political Economy*, **130**, 1-45. https://doi.org/10.1086/717046

[20] Magnavita, N. (2022) Headache in the Workplace: Analysis of Factors Influencing Headaches in Terms of Productivity and Health. *International Journal Environmental Research and Public Health*, **19**, Article 3712. https://doi.org/10.3390/ijerph19063712

[21] Mehmood, A., Siddique, H.M.A. and Ali, A. (2022) Impact of Health on Worker Productivity: Evidence from South Asia. MPRA (Munich Personal RePEc Archive). https://mpra.ub.uni-muenchen.de/113557/

[22] Roczniewska, M., Smoktunowicz, E., Calcagni, C.C., von Thiele Schwarz, U., Hasson, H. and Richter, A. (2022) Beyond the Individual: A Systematic Review of the Effects of Unit-Level Demands and Resources on Employee Productivity, Health, and Well-Being. *Journal of Occupational Health Psychology*, **27**, 240-257. https://doi.org/10.1037/ocp0000311

[23] Nagata, T., Mori, K., Ohtani, M., Nagata, M., Kajiki, S., Fujino, Y., *et al.* (2018) Total Health-Related Costs Due to Absenteeism, Presenteeism, and Medical and Pharmaceutical Expenses in Japanese Employers. *Journal of Occupational and Environmental Medicine*, **60**, e273-e280. https://doi.org/10.1097/JOM.0000000000001291

[24] Ramasamy, A., Laliberté, F., Aktavoukian, S.A., Lejeune, D., DerSarkissian, M., *et al.* (2019) Direct and Indirect Cost of Obesity among the Privately Insured in the United States, A Focus on the Impact by Type of Industry. *Journal of Occupational*

and Environmental Medicine, **61**, 877-886.
https://doi.org/10.1097/JOM.0000000000001693

[25] Gennep, S., Evers, S.W., Rietdijk, S.T., Gielen, M.E., de Boer, N.K.H. and Gecse, K.B. (2021) High Disease Burden Drives Indirect Costs in Employed Inflammatory Bowel Disease Patients: The WORK-IBD Study. *Inflammatory Bowel Diseases*, **27**, 352-363. https://doi.org/10.1093/ibd/izaa082

[26] Ademi, Z., Marquina, C., Zomer, E., Bailey, C., Owen, A., Pang, J., *et al.* (2020) The Economic Impact of Familial Hypercholesterolemia on Productivity. *Journal of Clinical Lipidology*, **14**, 799-806. https://doi.org/10.1016/j.jacl.2020.08.004

[27] Cawley, J., Biener, A., Meyerhoefer, C., Ding, Y., Zvenyach, N.P.B., Smolarz, B.G., *et al.* (2021) Absenteeism Costs of Obesity in the United States, National and State-Level Estimates. *Journal of Occupational and Environmental Medicine*, **63**, 565-573.
https://doi.org/10.1097/JOM.0000000000002198

[28] Kocakulah, M.C., Kelley, A.G., Mitchell, K.M. and Ruggieri, M.P. (2016) Absenteeism Problems and Costs: Causes, Effects and Cures. *International Business & Economics Research Journal*, **15**, 91-96. https://doi.org/10.19030/iber.v15i3.9673

[29] Gianino, M.M., Politano, G., Scarmozzino, A., Stillo, M., Amprino, V., Di Carlo, S., *et al.* (2019) Cost of Sickness Absenteeism during Seasonal Influenza Outbreaks of Medium Intensity among Health Care Workers. *International Journal of Environmental Research and Public Health*, **16**, Article 747.
https://doi.org/10.3390/ijerph16050747

[30] Baicker, K., Cutler, D. and Song, Z. (2010) Workplace Wellness Programs Can Generate Savings. *Health Affairs*, **29**, 304-311. https://doi.org/10.1377/hlthaff.2009.0626

[31] Verelst, F., Beutels, P., Hens, N. and Willem, L. (2021) Workplace Influenza Vaccination to Reduce Employee Absenteeism: An Economic Analysis from the Employers' Perspective. *Vaccine*, **39**, 2005-2015.
https://doi.org/10.1016/j.vaccine.2021.02.020

[32] Lawrance, N., Petrides, G. and Guerry, M.A. (2021) Predicting Employee Absenteeism for Cost Effective Interventions. *Decision Support Systems*, **147**, Article ID: 113539. https://doi.org/10.1016/j.dss.2021.113539

[33] Howard, J.T. and Potter, L.B. (2014) An Assessment of the Relationships between Overweight, Obesity, Related Chronic Health Conditions and Worker Absenteeism. *Obesity Research & Clinical Practice*, **8**, e1-e15.
https://doi.org/10.1016/j.orcp.2012.09.002

[34] Keramat, S.A., Alam, K., Gow, J. and Biddle, S.J.H. (2020) Gender Differences in the Longitudinal Association between Obesity, and Disability with Workplace Absenteeism in the Australian Working Population. *PLOS ONE*, **15**, e0233512.
https://doi.org/10.1371/journal.pone.0233512

[35] Hashikuchi, N. (2021) Research on the Effects of Psychological and Physical Factors on Workers' Productivity. Master's Thesis, Ritsumeikan University, Kyoto. (In Japanese with English Abstract)

[36] Baker-McClearn, D., Greasley, K., Dale, J. and Griffit, F. (2010) Absence Management and Presenteeism: The Pressures on Employees to Attend Work and the Impact of Attendance on Performance. *Human Resource Management Journal*, **20**, 311-328. https://doi.org/10.1111/j.1748-8583.2009.00118.x

[37] Marmot. M.M., Feeney, A. and Shipley, M. (1995) Sickness Absence as a Measure of Health Status and Functioning: From the UK Whitehall II Study. *Journal of Epidemiology Community Health*, **49**, 124-130. https://doi.org/10.1136/jech.49.2.124

[38] Vernekar, P.P., Kalyani, S. and Cacodcar, J.A. (2019) A Cross-Sectional Study of

Health Profile of IT Professionals in Goa. *Epidemiology International*, **2**, 29-33. https://doi.org/10.24321/2455.7048.201909

[39] Hird, T.R., Zomer, E., Owen, A.J., Magliano, D.J., Liew, D. and Ademi, Z. (2019) Productivity Burden of Hypertension in Australia: A Life Table Modeling Study. *Hypertension*, **73**, 777-784. https://doi.org/10.1161/HYPERTENSIONAHA.118.12606

[40] Whelton, S.P., McEvoy, J.W., Shaw, L., Psaty, B.M., Lima, J.A.C., Budoff, M., *et al.* (2020) Association of Normal Systolic Blood Pressure Level with Cardiovascular Disease in the Absence of Risk Factors. *JAMA Cardiology*, **5**, 1011-1018. https://doi.org/10.1001/jamacardio.2020.1731

[41] Asakura, E., Ademi, Z., Liew, E. and Zomer, E. (2021) Productivity Burden of Hypertension in Japan. *Hypertension Research*, **44**, 1524-1533. https://doi.org/10.1038/s41440-021-00731-0

[42] Idham, A. (2022) Impact of Diabetes and Hypertension Control on Work Performance among Malaysian Employees. *ResearchBerg Review of Science and Technology*, **2**, 1-15.

[43] MacLeod, K.E., Ye, Z., Donald, B. and Wang, G. (2022) A Literature Review of Productivity Loss Associated with Hypertension in the United States. *Population Health Management*, **25**, 297-308. https://doi.org/10.1089/pop.2021.0201

[44] Sorato, M.M., Davari, M., Kebriaeezadeh, A., Sarrafzadegan, N. and Shibru, T. (2022) Paid and Unpaid Work Productivity Loss Associated with Treated Hypertension in Southern Ethiopia: A Patient-Level Analysis. *Journal of Pharmaceutical Health Services Research*, **13**, 17-24. https://doi.org/10.1093/jphsr/rmab070

[45] Bansode, B. and Jungari, S. (2019) Economic Burden of Diabetic Patients in India: A Review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, **13**, 2469-2472. https://doi.org/10.1016/j.dsx.2019.06.020

[46] O'Connell, J.M. and Manson, S.M. (2019) Understanding the Economic Costs of Diabetes and Prediabetes and What We May Learn about Reducing the Health and Economic Burden of These Conditions. *Diabetes Care*, **42**, 1609-1611. https://doi.org/10.2337/dci19-0017

[47] Pedron, S., Emmert-Fees, K., Laxy, M. and Schwettmann, L. (2019) The Impact of Diabetes on Labour Market Participation: A Systematic Review of Results and Methods. *BMC Public Health*, **19**, Article No. 25. https://doi.org/10.1186/s12889-018-6324-6

[48] Oyando, R., Njoroge, M., Nguhiu, P., Sigilai, A., Kirui, F., Mbui, J., *et al.* (2020) Patient Costs of Diabetes Mellitus Care in Public Health Care Facilities in Kenya. *International Journal of Health Planning Management*, **35**, 290-308. https://doi.org/10.1002/hpm.2905

[49] Lambert-Obry, V., Lafrance, J., Savoie, M. and Lachaine, J. (2022) The Impact of Hypoglycemia on Productivity Loss and Utility in Patients with Type 2 Diabetes Treated with Insulin in Real-World Canadian Practice: Protocol for a Prospective Study. *JMIR Research Protocol*, **11**, e35461. https://doi.org/10.2196/35461

[50] Butt, M.D., Ong, S.C., Wahab, M.U., Rasool, M.F., Saleem, F., Hashmi, A., *et al.* (2022) Cost of Illness Analysis of Type 2 Diabetes Mellitus: The Findings from a Lower-Middle Income Country. *International Journal of Environmental Research and Public Health*, **19**, Article 12611. https://doi.org/10.3390/ijerph191912611

[51] Ferrara, P., Di Laura, D., Cortesi, P.A. and Mantovani, L.G. (2021) The Economic Impact of Hypercholesterolemia and Mixed Dyslipidemia: A Systematic Review of Cost of Illness Studies. *PLOS ONE*, **16**, e0254631.

https://doi.org/10.1371/journal.pone.0254631

[52] Lázaro, P., de Isla, L.P., Watts, G.F., Alonso, R., Norman, R., Muñiz, O., *et al.* (2017) Cost-Effectiveness of a Cascade Screening Program for the Early Detection of Familial Hypercholesterolemia. *Journal of Clinical Lipidology*, **11**, 260-271. https://doi.org/10.1016/j.jacl.2017.01.002

[53] Bilitou, A., Were, J., Farrer, A., Rabe, A., Ming, S.W.Y., Haq, I., *et al.* (2022) Prevalence and Patient Outcomes of Adult Primary Hypercholesterolemia and Dyslipidemia in the UK: Longitudinal Retrospective Study Using a Primary Care Dataset from 2009 to 2019. *ClinicoEconomics and Outcomes Research*, **14**, 189-203. https://doi.org/10.2147/CEOR.S347085

[54] Barrios, V., Castellanos, M., Campuzano Ruiz, R., Cerezo, J.F.G., Cabello, I.E., Gámez, J.M., *et al.* (2022) Treatment Patterns and Use of Healthcare Resources of Patients with Atherosclerotic Cardiovascular Disease and Hypercholesterolemia and Patients with Familial Hypercholesterolemia in Spain: Protocol of the Reality Study. *Frontiers in Cardiovascular Medicine*, **9**, Article 966049. https://doi.org/10.3389/fcvm.2022.966049

[55] Nawata, K. (2022) Heart Diseases, Hypertension and Effects of Antihypertensive Medications: Is Hypertension a True Risk Factor of Heart Diseases? *Frontiers in Public Health*, **10**, Article 929840. https://doi.org/10.3389/fpubh.2022.929840

[56] Griffiths, W.E., Hill, R.C. and Pope, P.J. (1987) Small Sample Properties of Probit Model Estimators. *Journal of American Statistical Association*, **82**, 929-937. https://doi.org/10.1080/01621459.1987.10478519

[57] Nawata, K. and McAleer, M. (2001) Size Characteristics of Tests for Sample Selection Bias: A Monte Carlo Comparison and Empirical Example. *Econometric Reviews*, **20**, 105-112. https://doi.org/10.1081/ETC-100104082

[58] GapIchino, A. and Moretti, E. (2009) Biological Gender Differences, Absenteeism, and the Earnings. *American Economic Journal*: *Applied Economics*, **1**, 183-218. https://doi.org/10.1257/app.1.1.183

[59] Patel, V., Chesmore, A., Legner, C.M. and Pandey, S. (2022) Trends in Workplace Wearable Technologies and Connected-Worker Solutions for Next-Generation Occupational Safety, Health, and Productivity. *Advanced Intelligent Systems*, **4**, Article ID: 2100099. https://doi.org/10.1002/aisy.202100099

[60] Centers for Disease Control and Prevention (2022) Cholesterol Myths and Facts. https://www.cdc.gov/cholesterol/myths_facts.htm

[61] Japan Atherosclerosis Society (2022) Japan Atherosclerosis Society (JAS) Guidelines for Prevention of Atherosclerotic Cardiovascular Diseases 2022. (In Japanese) https://www.j-athero.org/jp/wp-content/uploads/publications/pdf/GL2022_s/jas_gl2022_3_230210.pdf

[62] Gordon, D.J., Knok, J., Probstfield, J.L., Superko, R. and Tyroler, H.A. (1986) High-Density Lipoprotein Cholesterol and Coronary Heart Disease in Hypercholesterolemic Men: The Lipid Research Clinics Coronary Primary Prevention Trial. *Circulation*, **74**, 1217-1225. https://doi.org/10.1161/01.CIR.74.6.1217

[63] Ouimet, M., Barrett, T.J. and Fisher, E.A. (2019) HDL and Reverse Cholesterol Transport Basic Mechanisms and Their Roles in Vascular Health and Disease. *Circulation Research*, **124**, 1505-1518. https://doi.org/10.1161/CIRCRESAHA.119.312617

[64] Xu, C., Weng, Z., Zhang, L., Xu, J., Dahal, M. and Basnet, T.B. (2021) HDL Cholesterol: A Potential Mediator of the Association between Urinary Cadmium Concentration and Cardiovascular Disease Risk. *Ecotoxicology and Environmental Safety*,

208, Article ID: 111433. https://doi.org/10.1016/j.ecoenv.2020.111433

[65] Ghobadi, K., Eslami, A., Pirzadeh, A., Mazloomi, S.M. and Hosseini, F. (2022) Effects of the Nutritional Interventions in Improving Employee's Cardiometabolic Risk Factors in the Workplace: A Systematic Review. *Clinical Nutrition Open Science*, **42**, 73-83. https://doi.org/10.1016/j.nutos.2022.01.004

[66] de Liz, S., Cardoso, A.L., Copetti, C.L.K., Hinnig, P.F., Vieira, F.G.K., da Silva, E.L., *et al*. (2020) Açaí (Euterpe oleracea Mart.) and Juçara (Euterpe edulis Mart.) Juices Improved HDL-c Levels and Antioxidant Defense of Healthy Adults in a 4-Week Randomized Cross-Over Study. *Clinical Nutrition*, **39**, 3629-3636. https://doi.org/10.1016/j.clnu.2020.04.007

[67] Araki, E., Goto, A., Kondo, T., Noda, M., Noto, H., Origasa, H., *et al*. (2020) Japanese Clinical Practice Guideline for Diabetes 2019. *Diabetology International*, **11**, 165-223. https://doi.org/10.1007/s13340-020-00439-5

[68] Nawata, K. (2021) Estimation of Diabetes Prevalence, and Evaluation of Factors Affecting Blood Glucose Levels and Use of Medications in Japan. *Health*, **13**, 1431-1451. https://doi.org/10.4236/health.2021.1312102

[69] Centers for Disease Control and Prevention (2023) Eat Well. https://www.cdc.gov/diabetes/managing/eat-well.html

[70] Centers for Disease Control and Prevention (2023) Get Active! https://www.cdc.gov/diabetes/managing/active.html