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Association between income levels and irregular physician visits after a health checkup, and its consequent effect on glycemic control among employees: A retrospective propensity score-matched cohort study

Takumi Nishi[1]*, Akira Babazono[2], Toshiki Maeda[3]

[1]Department of Research Planning and Information Management, Fukuoka Institute of Health and Environmental Sciences, [2]Department of Health Care Administration and Management, Graduate School of Medical Sciences, Kyushu University, and [3]Department of Public Health and Preventive Medicine, Fukuoka University, Fukuoka, Japan

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***Correspondence**
Takumi Nishi
Tel.: +81-92-921-9941
Fax: +81-92-928-1203
E-mail address:
nishi@fihes.pref.fukuoka.jp

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ABSTRACT

Aims/Introduction: The present study aimed to evaluate the effects of income levels on physician visit patterns and to quantify the consequent impact of irregular physician visits on glycemic control among employees' health insurance beneficiaries in Japan.

Materials and Methods: We obtained specific health checkup data of untreated diabetes patients from the Fukuoka branch of the Japanese Health Insurance Association. We selected 2,981 insurance beneficiaries and classified 650 and 2,331 patients into, respectively, the regular visit and irregular visit group. We implemented propensity score matching to select an adequate control group.

Results: Compared with those with a standard monthly income <$2,000 (US$1 = ¥100), those with a higher monthly income were less likely to have irregular visits; $2,000–2,999: odds ratio 0.74 (95% confidence interval 0.56–0.98), $3,000–3,999: odds ratio 0.63 (95% confidence interval 0.46–0.87) and ≥$5,000: odds ratio 0.58 (95% confidence interval 0.39–0.86). After propensity score matching and adjusting for covariates, the irregular visit group tended to have poor glycemic control; increased glycated hemoglobin ≥0.5: odds ratio 1.90 (95% confidence interval 1.30–2.77), ≥1.0: odds ratio 2.75 (95% confidence interval 1.56–4.82) and ≥20% relatively: odds ratio 3.18 (95% confidence interval 1.46–6.92).

Conclusions: We clarified that there was a significant relationship between income and irregular visits, and this consequently resulted in poor glycemic control. These findings would be useful for more effective disease management.

INTRODUCTION

Diabetes mellitus is one of the most prevalent chronic diseases worldwide. It was estimated that there were 425 million people with diabetes mellitus aged 20–79 years and the global proportion of undiagnosed diabetes mellitus was 49.7% among diabetes patients in 2017[1]. Furthermore, the number of people with diabetes mellitus aged 20–79 years would be predicted to increase to 629 million by 2045[1]. Also in Japan, it was estimated that there were 7.23 million adults with diabetes mellitus, while 46.6% of those (3.36 million adults) were undiagnosed diabetes mellitus[2].

For secondary prevention, early detection of pre-symptomatic people and the implementation of health guidance, as well as the initiation of physician visits, are important. Therefore, the Japanese government implemented a "specific health checkup and health guidance" in the fiscal year (FY) 2008 for the early detection of metabolic syndrome among middle-aged people through specific health checkups, and to reduce the number of people at a high risk for lifestyle-related diseases by risk-stratified health guidance. Furthermore, Japanese insurers have recently implemented "data health plans" for the secondary

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prevention of lifestyle diseases using linked specific health checkup and claims data.

In addition to encouraging the initiation of physician visits, it is important to monitor physician visit patterns and clarify whether patients receive regular/continuous treatment using claims data. Indeed, a recent study in Japan using health examination and claims data of health insurance societies reported that untreated patients had worse glycemic control, and the number of clinic visits was dose-dependently associated with better glycated hemoglobin (HbA1c) levels than those with no diabetes management, in a population of newly screened individuals with diabetes[3]. However, as the proportion of people receiving continuous diabetic treatment in Japan is still low, it is important not only to initiate physician visits, but also to provide continuous treatment.

In contrast, in terms of access to care, it is important to consider the effect of socioeconomic status, such as income and levels of education, on care continuity. A study carried out in Canada reported that having higher levels of education was positively associated with the number of general practitioner visits, and Canadians with higher incomes and education levels were more likely to visit a specialist at least once a year[4]. Brown *et al.*[5] showed that socioeconomic position affects health outcomes through access to healthcare, such as primary care-provider visits, specialty visits and waiting times. Although several previous studies have shown the association between socioeconomic status and untreated diabetes mellitus or discontinued treatment, few studies have focused on the effects on glycemic control as a result of physician visit patterns[6–8].

Therefore, the purpose of the present study was to evaluate the effects of income levels on physician visit patterns, and to quantify the impact of irregular physician visits on glycemic control among health insurance beneficiaries.

METHODS

Data Sources

We obtained data on untreated diabetes patients from specific health checkup data of the Fukuoka branch of the Japanese Health Insurance Association, which insured employees among small and medium enterprises. Figure 1 shows the inclusion

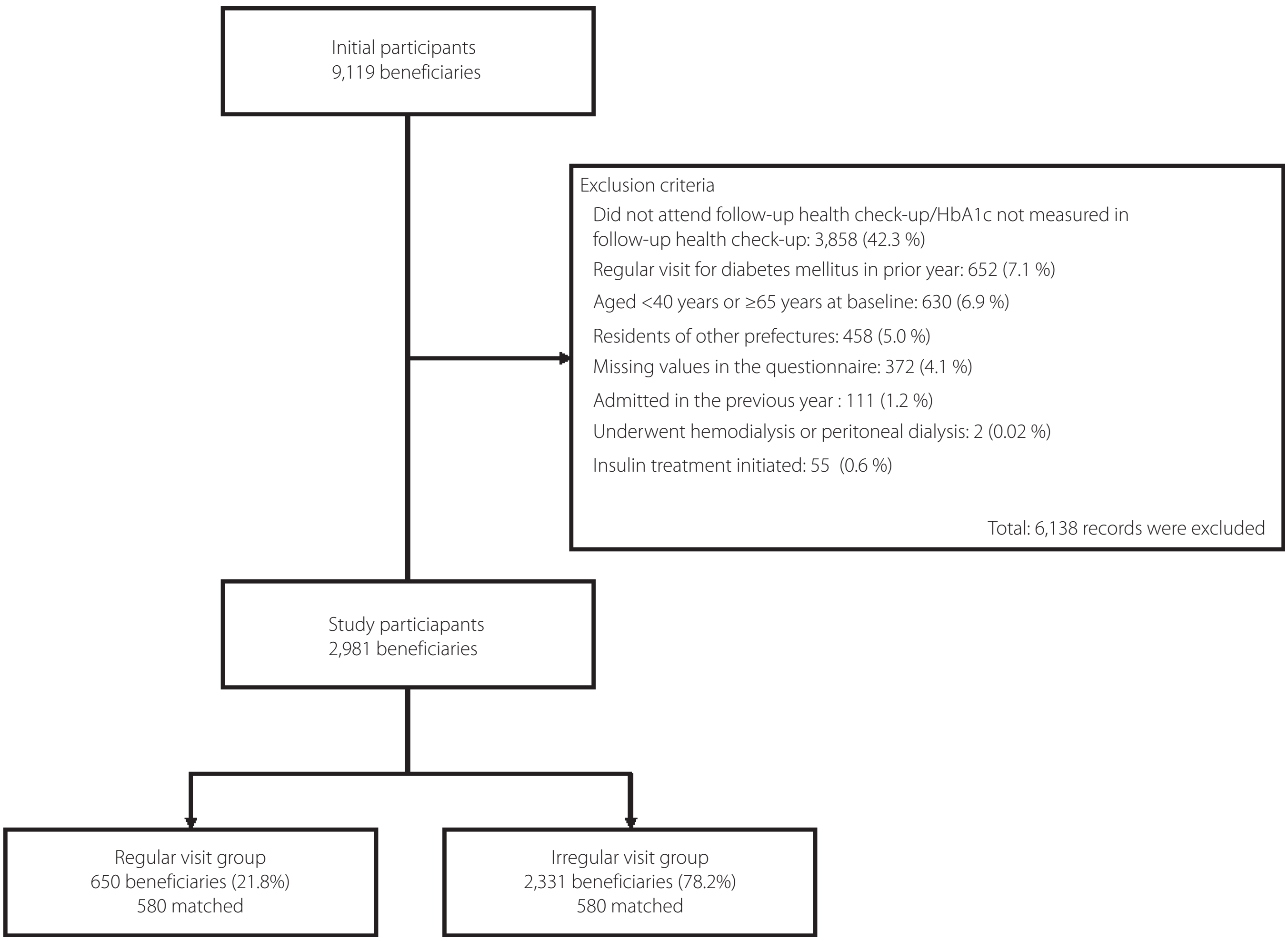

Figure 1 | Flowchart of inclusion and exclusion criteria. HbA1c, glycated hemoglobin

and exclusion criteria, and the participant selection flow chart. Of the 1,899,563 eligible insurance beneficiaries at the end of FY2013, we extracted 441,832 of those who attended health checkups between FY2011 and FY2013. As the Japan Diabetes Society unit for HbA1c was used in specific health checkups until FY2011, we converted the HbA1c (Japan Diabetes Society) value measured in FY2011 to a National Glycohemoglobin Standardization Program unit[9]. Then, we identified 9,119 insurance beneficiaries whose HbA1c (National Glycohemoglobin Standardization Program) values were >6.5% and those without antihyperglycemic treatment. Furthermore, we excluded those in whom the HbA1c level was not measured in the health checkup after 2 years and those already receiving regular treatment for diabetes mellitus, as shown in Figure 2. Those aged <40 years or >64 years, residents of other prefectures and those whose responses to questionnaires were not available at the baseline were also excluded. Finally, we excluded those admitted to the hospital, those who received hemodialysis or peritoneal dialysis before the baseline and those in whom insulin treatment was initiated after the baseline health checkup. Finally, 2,981 insurance beneficiaries were selected as the study participants.

Study Variables

As the American Diabetes Association recommends the measurement of HbA1c levels every 3 months and the expiry time of prescriptions is 3 months in the Japanese health insurance system, we defined cases in which the physician was not visited for diabetes mellitus for >3 months as “irregular visits” during the 1 year after the health checkup, as shown in Figure 2[10]. Thus, we assigned 650 patients to the regular visit group and 2,331 to the irregular visit group.

Ethical Consideration

The need for informed consent was waived according to the Ethical Guidelines for Medical and Health Research Involving Human Subjects in Japan, because the study was a retrospective cohort and the data analyzed were anonymized[11]. This study was approved by the Kyushu University Institutional Review Board for Clinical Research (No. 28-84).

Outcome Measurements

Following the definition of poor glycemic control in a previous study[3], we defined participants whose HbA1c values were >7.0% at the health checkup after 2 years of follow up as having poor glycemic control. An absolute increase in the HbA1c level >0.5% was defined as one outcome variable, because the baseline HbA1c values were >6.5% among all participants. Other outcomes were an absolute increase >1.0% and a relative increase >20% in relation to the baseline HbA1c value.

Definition of Covariates

Ages were categorized into five groups: 40–44 years, 45–49 years, 50–54 years, 55–59 years and 60–64 years. Participants with a body mass index >25.0 kg/m^2 were defined as overweight. HbA1c values at the baseline were categorized into three groups: 6.5–6.9%, 7.0–9.9% and ≥10.0%. According to the cut-off values of liver enzymes for recommendation to detailed examinations in specific health checkups, those with an alanine aminotransferase level >50 U/L, aspartate aminotransferase level >50 U/L or gamma-glutamyltransferase level >100 U/L were defined as having abnormal liver function. According to laboratory values and replies to questions about medications, comorbidities such as hypertension and hypercholesterolemia were categorized into three groups: normal, without medication and

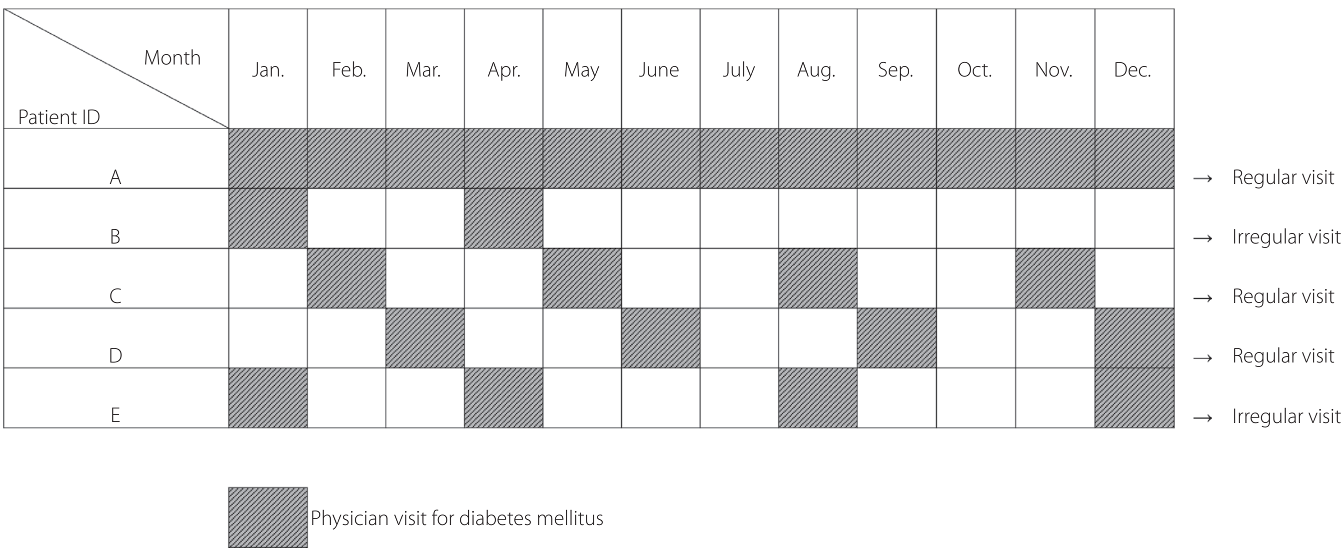

Figure 2 | Example of categorization by physician visit patterns.

with medication. Participants with systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg were defined as normotensive. Those not using antihypertensive drugs and whose systolic blood pressure values were >140 mmHg or diastolic blood pressure was >90 mmHg were defined as having untreated hypertension; the remaining patients were defined as having hypertension with medication. Similarly, according to the cut-off values for triglycerides (150 mg/dL) and low-density lipoprotein cholesterol (90 mg/dL), participants were categorized into three groups: (i) without hypercholesterolemia; (ii) with untreated hypercholesterolemia; and (iii) hypercholesterolemia with medication. Using claims data after the baseline health checkup, we collected information on oral antidiabetic agent prescriptions. Those who had smoked over the past month and had smoked a total of >100 cigarettes or who had smoked over a period of 6 months were defined as smokers. Those who had habitually exercised for >30 min twice a week for at least 1 year or who habitually walked for >1 h a day were defined as engaging in physical activity. Alcohol consumption was categorized into five groups: (i) rarely or never; (ii) occasionally; (iii) drank <19 g every day; (iv) drank 20–39 g every day; and (v) drank >40 g every day in ethanol converted units. Walking faster, eating before sleeping, eating fast and sleeping well were used as explanatory variables. Based on questions on lifestyle improvement, we categorized participants into four groups: (i) not planning; (ii) starting in the future; (iii) starting soon; and (iv) already trying. Based on standard monthly incomes, which is the calculation basis for insurance premiums, we categorized them into five groups: (i) ≤$1,999; (ii) $2,000–2,999; (iii) $3,000–3,999; (iv) $4,000–4,999; and (v) ≥$5,000 (US$1 = ¥100). Additionally, the number of dependents was used as a proxy variable of family composition and was categorized into 0, one, two or more.

Statistical Analysis

As the study's participants were attendees of specific health checkups, the presence of selection bias could not be ruled out. Furthermore, the estimates would be distorted by regression toward the mean. Therefore, we implemented 1:1 propensity score matching to select an adequate control group, and to show the cause–effect relationship between socioeconomic status and the deterioration of glycemic control through irregular physician visits[12]. In accordance with previous studies of variable selection with propensity score matching[13–15], we calculated propensity scores using a logistic regression model to identify the relationships between irregular physician visits and the covariates defined above. Furthermore, we introduced dummy variables for 13 residential secondary medical tiers in Fukuoka (i.e., 12 variables). We used the Hosmer–Lemeshow test and C-statistic as indicators of how well the logistic regression model fitted the data. Finally, each participant in the regular visit group was matched with a unique control in the irregular visit group within a caliper width of 0.02[16].

Risk Estimation

Multiple logistic regression analyses were used to estimate the effects of irregular visits on outcomes after adjusting for sex, age, overweight, baseline HbA1c level, oral hypoglycemic agent use, other lifestyle diseases and lifestyle habits. Odds ratios (ORs) and their 95% confidence intervals (CIs) were computed to quantify these effects. All statistical analyses used Stata for Windows, version 15.1 (StataCorp, College Station, TX, USA). The level of statistical significance was set at 0.05.

RESULTS

Descriptive Statistics

The descriptive statistics of the participants before propensity score matching are shown on the left in Table 1. The proportion of elderly people was lower in the irregular visit group than the regular visit group, and this difference was statistically significant. The proportion of those with an HbA1c level <7.0 (relatively mild cases) was higher in the irregular visit group. Among those with hypertension or hypercholesterolemia, the proportion of those with medication was higher in the regular visit group, whereas that of those without was higher in the irregular visit group. The number of smokers or participants who skipped breakfast tended to be higher in the irregular visit group. There were significant differences in the proportions of lifestyle improvements between the two groups, whereas the proportion of those who were already trying was higher in the regular visit group.

The associations between patient characteristics and irregular visits are shown on the right in Table 1. After adjustment in the logistic regression model, age, higher HbA1c level, hypertension with medication and lifestyle improvements were significantly associated with a decreased probability of irregular physician visits, whereas smoking and skipping breakfast were positively associated with irregular visits. Among the socioeconomic status variables, although we did not observe a significant relationship between the number of dependents and irregular visits, compared with those with a standard monthly income <$2,000, those with a higher monthly income had a negative association with irregular visits: $2,000–2,999: OR 0.74 (95% CI 0.56–0.98), $3,000–3,999: 0.63 (0.46–0.87) and ≥$5,000: 0.58 (95% CI 0.39–0.86). The C-statistic of this propensity score estimation model was 0.750, and the model did not reject the null hypothesis by the Hosmer–Lemeshow test ($P = 0.515$).

As a result of propensity score matching, 580 participants each were assigned to both groups. As shown in Table 2, no significant difference between the irregular and regular visit groups in terms of patient characteristics was observed after matching.

Comparison of Outcomes

The results of comparison of outcomes are shown on the left in Table 3. In the crude analyses before matching, the numbers and proportions of participants in whom the HbA1c level

Table 1 | Baseline characteristics of participants by physician visit patterns and their effects on irregular physician visits

	Physician visit pattern		Absolute standardized difference	*P*-value	Propensity score estimation†		
	Regular (*n* = 650)	Irregular (*n* = 2,331)			OR	95% CI	*P*-value
Sex							
Male	549 (84.5%)	1,947 (83.5%)	0.025	0.568	1.00		
Female	101 (15.5%)	384 (16.5%)			1.07	0.79–1.46	0.652
Age (years)							
Mean (SD)	55.0 (6.4)	52.8 (6.9)	0.327	<0.001			
40–44	65 (10.0%)	390 (16.7%)	0.199		1.00		
45–49	78 (12.0%)	372 (16.0%)	0.114		0.70	0.48–1.03	0.072
50–54	116 (17.8%)	519 (22.3%)	0.111	<0.001	0.76	0.53–1.09	0.129
55–59	176 (27.1%)	538 (23.1%)	0.092		0.53	0.37–0.75	<0.001
60–64	215 (33.1%)	512 (22.0%)	0.251		0.38	0.26–0.55	<0.001
Demographic and physical characteristics							
Mean BMI (kg/m^2)	26.4 (4.3)	26.3 (4.3)	0.020	0.657			
≥25	390 (60.0%)	1,374 (58.9%)	0.021	0.628	1.09	0.88–1.35	0.454
Biochemical characteristics							
Mean HbA1c at baseline (%)	7.8 (1.6)	7.5 (1.4)	0.170	<0.001			
6.5–6.9	274 (42.2%)	1,219 (52.3%)	0.204		1.00		
7.0–9.9	292 (44.9%)	906 (38.9%)	0.123	<0.001	0.53	0.43–0.65	<0.001
≥10.0	84 (12.9%)	206 (8.8%)	0.131		0.26	0.19–0.36	<0.001
Abnormal liver function	227 (34.9%)	796 (34.1%)	0.016	0.713	0.97	0.78–1.20	0.752
Mean AST (U/L)	30.1 (19.8)	29.0 (17.5)	0.059	0.165			
Mean ALT (U/L)	40.2 (33.9)	39.2 (28.6)	0.034	0.419			
Mean GGT (U/L)	73.4 (69.5)	69.6 (66.5)	0.056	0.205			
Comorbidity							
Hypertension without medication	138 (21.2%)	712 (30.5%)	0.214	<0.001	1.03	0.81–1.31	0.779
Hypertension with medication	255 (39.2%)	286 (12.3%)	0.648	<0.001	0.21	0.17–0.28	<0.001
Mean SBP (mmHg)	133.3 (18.2)	133.1 (18.7)	0.008	0.852			
Mean DBP (mmHg)	83.1 (11.6)	82.5 (11.8)	0.046	0.305			
Hypercholesterolemia without medication	523 (80.5%)	2,163 (92.8%)	0.368	<0.001	1.57	0.96–2.59	0.074
Hypercholesterolemia with medication	102 (15.7%)	93 (4.0%)	0.400	<0.001	0.60	0.33–1.08	0.089
Mean TGs (mg/dL)	194.1 (176.3)	196.3 (173.5)	0.013	0.776			
Mean LDL-C (mg/dL)	135.1 (35.2)	140.2 (35.2)	0.145	0.001			
Lifestyle habits							
Alcohol consumption Rarely or never	263 (40.5%)	920 (39.5%)	0.020		1.00		
Occasionally	175 (26.9%)	676 (29.0%)	0.046		1.10	0.86–1.39	0.452
Every day, <20 g/day	57 (8.8%)	193 (8.3%)	0.018	0.764	1.21	0.84–1.75	0.302
Every day, 20–39 g/day	103 (15.8%)	340 (14.6%)	0.035		1.04	0.77–1.40	0.799
Every day, ≥40 g/day	52 (8.0%)	202 (8.7%)	0.024		1.13	0.77–1.64	0.533
Smoking	269 (41.4%)	1,136 (48.7%)	0.148	0.001	1.23	1.00–1.50	0.049
Physical activities	215 (33.1%)	834 (35.8%)	0.057	0.202	1.15	0.93–1.42	0.197
Walking faster	221 (34.0%)	863 (37.0%)	0.063	0.157	1.14	0.92–1.41	0.230
Eating fast	272 (41.8%)	965 (41.4%)	0.009	0.838	1.01	0.83–1.24	0.897
Eating before sleeping	315 (48.5%)	1,112 (47.7%)	0.015	0.733	0.90	0.74–1.10	0.306
Skipping breakfast	148 (22.8%)	721 (30.9%)	0.185	<0.001	1.36	1.09–1.71	0.007
Sleeping well	340 (52.3%)	1,176 (50.5%)	0.037	0.402	1.01	0.83–1.23	0.922
Lifestyle improvement							
Not planning	129 (19.8%)	567 (24.3%)	0.108	0.043	1.00		
Starting in the future (e.g., within 6 months)	292 (44.9%)	1,055 (45.3%)	0.007		0.78	0.60–1.00	0.052
Starting soon (e.g., within a month)	105 (16.2%)	331 (14.2%)	0.054		0.68	0.49–0.94	0.019
Already trying	124 (19.1%)	378 (16.2%)	0.075		0.73	0.53–1.00	0.050
Socioeconomic status							
Mean no. dependents	1.2 (1.2)	1.3 (1.3)	0.103	0.023			

Table 1 (*Continued*)

	Physician visit pattern		Absolute standardized difference	*P*-value	Propensity score estimation†		
	Regular (*n* = 650)	Irregular (*n* = 2,331)			OR	95% CI	*P*-value
0	247 (38.0%)	851 (36.5%)	0.031		1.00		
1	177 (27.2%)	579 (24.8%)	0.055	0.176	1.24	0.96–1.60	0.098
≥2	226 (34.8%)	901 (38.7%)	0.081		1.22	0.95–1.56	0.114
Mean standard monthly income ($)	3,117.5 (1752.4)	3,113.4 (1708.0)	0.002	0.958			
<2,000	145 (22.3%)	537 (23.0%)	0.017		1.00		
2,000–2,999	205 (31.5%)	700 (30.0%)	0.033		0.74	0.56–0.98	0.033
3,000–3,999	163 (25.1%)	595 (25.5%)	0.010	0.394	0.63	0.46–0.87	0.004
4,000–4,999	65 (10.0%)	282 (12.1%)	0.067		0.73	0.50–1.09	0.125
≥5,000	72 (11.1%)	217 (9.3%)	0.058		0.58	0.39–0.86	0.007
Health examination fiscal year							
2011	319 (49.1%)	1,153 (49.5%)	0.008				
2012	163 (25.1%)	657 (28.2%)	0.070	0.107	1.10	0.87–1.39	0.427
2013	168 (25.8%)	521 (22.4%)	0.082		0.79	0.63–1.01	0.057

†Adjusted by all variables in this table and residential secondary tiers of medical care. ALT, alanine transaminase; AST, aspartate transaminase; BMI, body mass index; CI, confidence interval; DBP, diastolic blood pressure, GGT, gamma-glutamyltransferase; HbA1c, glycated hemoglobin; LDL-C, low-density lipoprotein cholesterol; OR, odds ratio; SBP, systolic blood pressure; SD, standard deviation; TG, triglyceride.

increased to >0.5, 1.0 and 20% relatively were: 70 (10.8%), 26 (4.0%) and 13 (2.0%) in the irregular visit group, and 616 (26.4%), 343 (14.7%) and 189 (8.1%) in the regular visit group (all *P*-values <0.001). After adjusting for sex, age, baseline HbA1c level, oral hypoglycemic agent use, other lifestyle diseases and lifestyle habits, irregular visits were significantly associated with poor glycemic control: OR for HbA1c increase ≥0.5: 2.04 (95% CI 1.53–2.74); ≥1.0: 3.00 (95% CI 1.92–4.66); ≥20% relatively: 3.09 (95% CI 1.68–5.68).

After propensity score matching, significant differences in the frequency of poor glycemic control (all *P*-values <0.001) were observed. After adjustment for covariates, those in the irregular visit group were more likely to have poor glycemic control; OR for ≥0.5: 1.90 (95% CI 1.30–2.77); ≥1.0: 2.75 (95% CI 1.56–4.82); ≥20% relatively: 3.18 (95% CI 1.46–6.92).

DISCUSSION

In the present study, we investigated the relationship between income levels and irregular physician visits, and examined the consequent effects on poor glycemic control. It was found that there were significant differences in the physician visit patterns between different income groups, and that irregular visits were associated with poor glycemic control.

In Japan, universal health coverage has been achieved, and beneficiaries as well as dependents have to pay 30% of their healthcare spending as calculated by a nationally uniform fee schedule, except for preschool children, people aged >70 years and those receiving public assistance. Therefore, regardless of their income, Japanese people have equitable accessibility to healthcare for the same treatment. Nevertheless, the present results suggest that those with a lower income had impeded access to regular diabetes treatment. Brown *et al.*[5] stated that there was cumulative evidence on the association between socioeconomic position and access to primary care physicians or specialists, even in countries in which universal health coverage has been achieved, in addition to uninsured people and beneficiaries of managed care plans. In terms of income, a recent study implemented in Norway, by analyzing administrative panel data for general practitioners, reported that patients with a low income receive shorter consultations and fewer medical tests per visit[8]. Furthermore, a previous study in Taiwan – where universal health coverage has been achieved – reported that people exempted from insurance premiums and copayments showed an association not only with the incidence of type 2 diabetes mellitus, but also hospitalization-diagnosed diabetes mellitus, and were less likely to receive the recommended diabetes checkups[6]. Although the present study participants were not exempted from copayments or premiums, as the same copayment would be perceived as expensive among populations with relatively lower incomes, those with lower incomes might be less likely to have regular physician visits.

Furthermore, as we used claims data among employees, employment patterns or environments could affect physician visit patterns. For example, Tsuda *et al.*[17] reported that employees who could comfortably take a day off or time off work, those with a high level of psychological job control and those referred by occupational health professionals were more likely to visit a doctor after worksite screening for diabetes mellitus, whereas those who worked ≥61 h per week were less likely to visit. Therefore, other socioeconomic factors that could influence physician visits – such as work style, employment or labor condition, or leisure time – should be investigated concurrently

Table 2 | Baseline characteristics of participants by physician visit patterns after propensity score matching

	Physician visit pattern		Absolute standardized difference	*P*-value
	Regular (*n* = 580)	Irregular (*n* = 580)		
Sex				
Male	492 (84.8%)	494 (85.2%)	0.010	0.869
Female	88 (15.2%)	86 (14.8%)		
Age (years)				
Mean (SD)	54.7 (6.5)	54.8 (6.7)	0.014	0.807
40–44	63 (10.9%)	56 (9.7%)	0.040	
45–49	76 (13.1%)	83 (14.3%)	0.035	
50–54	105 (18.1%)	99 (17.1%)	0.027	0.917
55–59	159 (27.4%)	161 (27.8%)	0.008	
60–64	177 (30.5%)	181 (31.2%)	0.015	
Demographic and physical characteristics				
Mean BMI (kg/m^2)	26.3 (4.4)	26.3 (4.1)	0.004	0.948
≥25	341 (58.8%)	341 (58.8%)	0.000	1.000
Biochemical characteristics				
Mean HbA1c at baseline (%)	7.8 (1.6)	7.8 (1.7)	0.005	0.935
6.5–6.9	253 (43.6%)	242 (41.7%)	0.038	
7.0–9.9	246 (42.4%)	250 (43.1%)	0.014	0.753
≥10.0	81 (14.0%)	88 (15.2%)	0.034	
Abnormal liver function	201 (34.7%)	199 (34.3%)	0.007	0.902
Mean AST (U/L)	29.7 (17.8)	29.8 (20.5)	0.008	0.898
Mean ALT (U/L)	39.6 (32.8)	38.9 (29.1)	0.025	0.674
Mean GGT (U/L)	73.7 (71.1)	72.2 (64.9)	0.022	0.704
Comorbidity				
Hypertension without medication	137 (23.6%)	129 (22.2%)	0.033	0.577
Hypertension with medication	188 (32.4%)	194 (33.4%)	0.022	0.708
Mean SBP (mmHg)	133.6 (18.6)	135.3 (18.4)	0.092	0.119
Mean DBP (mmHg)	83.2 (11.8)	83.0 (11.2)	0.016	0.779
Hypercholesterolemia without medication	495 (85.3%)	505 (87.1%)	0.050	0.395
Hypercholesterolemia with medication	64 (11.0%)	56 (9.7%)	0.045	0.441
Mean TGs (mg/dL)	195.3 (176.4)	193.8 (173.1)	0.008	0.886
Mean LDL-C (mg/dL)	136.6 (35.2)	136.9 (35.2)	0.009	0.885
Lifestyle habits				
Alcohol consumption	232 (40.0%)	239 (41.2%)	0.025	
Rarely or never				
Occasionally	160 (27.6%)	147 (25.3%)	0.051	
Every day, <20 g/day	51 (8.8%)	48 (8.3%)	0.019	0.884
Every day, 20–39 g/day	92 (15.9%)	101 (17.4%)	0.042	
Every day, ≥40 g/day	45 (7.8%)	45 (7.8%)	0.000	
Smoking	243 (41.9%)	241 (41.6%)	0.007	0.905
Physical activities	204 (35.2%)	198 (34.1%)	0.022	0.711
Walking faster	204 (35.2%)	200 (34.5%)	0.014	0.805
Eating fast	235 (40.5%)	242 (41.7%)	0.025	0.676
Eating before sleeping	271 (46.7%)	267 (46.0%)	0.014	0.814
Skipping breakfast	134 (23.1%)	148 (25.5%)	0.056	0.338
Sleeping well	303 (52.2%)	287 (49.5%)	0.055	0.348
Lifestyle improvement				
Not planning	117 (20.2%)	103 (17.8%)	0.062	0.757
Starting in the future (e.g., within 6 months)	256 (44.1%)	268 (46.2%)	0.042	
Starting soon (e.g., within a month)	94 (16.2%)	94 (16.2%)	0.000	
Already trying	113 (19.5%)	115 (19.8%)	0.009	
Socioeconomic status				
Mean no. dependents	1.2 (1.2)	1.3 (1.3)	0.049	0.408
0	216 (37.2%)	215 (37.1%)	0.004	0.855

Table 2 (*Continued*)

	Physician visit pattern		Absolute standardized difference	*P*-value
	Regular (*n* = 580)	Irregular (*n* = 580)		
1	157 (27.1%)	150 (25.9%)	0.027	
≥2	207 (35.7%)	215 (37.1%)	0.029	
Mean standard monthly income ($)	3124.8 (1756.1)	3,034.1 (1694.0)	0.053	0.371
<2,000	134 (23.1%)	146 (25.2%)	0.048	
2,000–2,999	174 (30.0%)	178 (30.7%)	0.015	
3,000–3,999	148 (25.5%)	145 (25.0%)	0.012	0.770
4,000–4,999	59 (10.2%)	58 (10.0%)	0.006	
≥5,000	65 (11.2%)	53 (9.1%)	0.068	
Health examination fiscal year				
2011	285 (49.1%)	286 (49.3%)	0.003	0.932
2012	146 (25.2%)	150 (25.9%)	0.016	
2013	149 (25.7%)	144 (24.8%)	0.020	

ALT, alanine transaminase; AST, aspartate transaminase; BMI, body mass index; DBP, diastolic blood pressure; GGT, gamma-glutamyltransferase; HbA1c, glycated hemoglobin; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; SD, standard deviation; TG, triglyceride.

Table 3 | Comparison of study outcomes by matched and unmatched participants

	Unmatched physician visit pattern		*P*-value	Matched physician visit pattern		*P*-value
	Regular (reference)	Irregular		Regular (reference)	Irregular	
Unadjusted						
No. participants	650	2,331		580	580	
Increase in HbA1c ≥0.5, *n* (%)	70 (10.8%)	616 (26.4%)	<0.001†	61 (10.5%)	130 (22.4%)	<0.001
Odds ratio (95% CI)	2.98 (2.28–3.93)			2.46 (1.75–3.48)		
Increase in HbA1c ≥1.0, *n* (%)	26 (4.0%)	343 (14.7%)	<0.001†	23 (4.0%)	73 (12.6%)	<0.001
Odds ratio (95% CI)	4.14 (2.74–6.49)			3.49 (2.12–5.93)		
Relative increase ≥20% from baseline, *n* (%)	13 (2.0%)	189 (8.1%)	<0.001†	10 (1.7%)	39 (6.7%)	<0.001
Odds ratio (95% CI)	4.32 (2.45–8.33)			4.11 (1.99–9.31)		
Adjusted‡						
Increase in HbA1c ≥0.5 (%)	14.3 (11.2–17.5)	24.9 (23.2–26.6)	<0.001	12.0 (9.1–15.0)	20.1 (16.8–23.4)	0.001
Odds ratio (95% CI)	2.04 (1.53–2.74)			1.90 (1.30–2.77)		
Increase in HbA1c ≥1.0 (%)	5.3 (3.3–7.4)	13.9 (12.5–15.2)	<0.001	4.6 (2.7–6.5)	11.2 (8.6–13.8)	<0.001
Odds ratio (95% CI)	3.00 (1.92–4.66)			2.75 (1.56–4.82)		
Relative increase of ≥20% from baseline (%)	2.7 (1.2–4.1)	7.6 (6.6–8.7)	<0.001	2.0 (0.7–3.3)	5.9 (4.0–7.9)	0.004
Odds ratio (95% CI)	3.09 (1.68–5.68)			3.18 (1.46–6.92)		

†Comparison made using the χ^2-test. ‡Adjusted by sex, age, baseline glycated hemoglobin (HbA1c), oral hypoglycemic agent use, other lifestyle diseases and lifestyle habits.
CI, confidence interval.

with the recommendation for a physician visit. Further research should focus on showing the relationship between these factors and physician visit patterns.

Beneficiaries with prior lifestyle improvements were less likely to have irregular physician visits. Having an interest in one's own health is key to secondary prevention. As diabetes patients tend to be asymptomatic over a long period spent in a hyperglycemic state, it is important to implement health promotion focusing not only on education, but also health literacy in diabetes mellitus among individuals.

We observed higher ORs for poor glycemic control than those previously reported by Heianza *et al.*[3] In addition to the differences in the characteristics of the study participants, the present results could be generated by our restricted definition of appropriate physician visit, as a previous study simply focused on the initiation and frequency of visits. Therefore, it is useful to monitor not only treatment initiation and frequency, but also treatment patterns including intervals for effective health promotion. As insurers are able to identify beneficiaries with interrupted treatment and those without treatment using the method used in the present study, they might be able to enhance their disease management program by incorporating specific health checkup data into claims data. The objectives of data health plans include the optimization of health expenditure. A previous study analyzing claims data from Japanese health insurance societies reported that individuals who received treatment for <6 months had a higher risk of microvascular complications and a significantly higher cumulative healthcare expenditure than the adherent group during the second to fifth-year period and second to sixth-year period after treatment initiation during 8 years of follow up[18]. Although we investigated only the short-term effects of physician visit patterns on glycemic control, further studies should be implemented to show its long-term effects on diabetes-related complications and healthcare resource utilization.

There were several limitations to the present study. First, we could not analyze some important socioeconomic factors, such as education levels and employment status. Second, as we used the standard monthly income of individual beneficiaries, and not that of the household, as a proxy variable of income levels, the present result could not reflect the effect of household income levels on physician visit patterns. Furthermore, because our study participants were only beneficiaries of the Fukuoka branch of the Japanese Health Insurance Association who attended specific health checkups, it would be difficult to generalize the results to other populations. However, as this was a large-scale insurance-based study including patients who did not visit medical institutions, a strength of the present study was that the propensity score estimation models considered location bias using data on the residential areas of patients.

In conclusion, we clarified that lower-income beneficiaries were more likely to have irregular visits, and this consequently resulted in poor glycemic control. Although it would be difficult to implement direct interventions to reduce income inequalities, interventions to improve patients' visiting behaviors would be implementable to indirectly reduce health inequalities. Therefore, insurers' strategies that motivate such beneficiaries, especially those in lower-income groups, to make regular physician visits would be useful for effective disease management.

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DISCLOSURE

The authors declare no conflict of interest.

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