Original Article

The Influence of the Japanese Nationwide Cardiovascular Prevention System Health Guidance on Smoking Cessation Among Smokers:

A Propensity Score Matching Analysis

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Aim: We investigated whether 2 types of personalized health guidance (repeated and single counseling) in the Japanese nationwide cardiovascular prevention system promoted smoking cessation among smokers.
Methods: The study included 47,745 Japanese smokers aged 40 to 74 years classified into 2 personalized health guidance schemes. After a 1-year follow-up, we compared the rates of smoking cessation between individuals who had received counseling ("supported") and those who had not received counseling ("unsupported"). Using propensity score matching analysis, we estimated the average treatment effect (ATE) of each approach on smoking cessation after balancing out the characteristics between the supported and unsupported groups. The propensity score regression model included age, medical insurance type, weight gain since the age of 20 years, exercise, eating habits, alcohol intake, quality of sleep, readiness to modify lifestyle, willingness to receive support, and body mass index.
Results: In the repeated counseling scheme, the age-adjusted rates of smoking cessation in the supported and unsupported groups were 8.8% and 6.3% for males, and 9.8% and 9.1% for females respectively. In the single counseling scheme, the corresponding rates were 8.4% and 7.3% for supported and unsupported males, and 11.0% and 11.7% for supported and unsupported females respectively. The ATE of repeated counseling was +2.64% (95% confidence interval: +1.51% to +3.77%) for males and +3.11% (−1.85% to +8.07%) for females. The ATE of single counseling was +0.61% (−1.17% to +2.38%) for males and −1.06% (−5.96% to +3.85%) for females.
Conclusions: In the Japanese cardiovascular prevention system, repeated counseling may promote smoking cessation among male smokers.

Key words: Health guidance, Smoking cessation, Obesity, Propensity score matching analysis, Average treatment effect

Introduction

Cardiovascular diseases, including coronary heart disease and stroke, cause considerable burden in terms of premature death and disability worldwide[1-3]. For Japanese people, who are relatively lean[4], cardiovascu-

lar diseases have been attributed primarily to elevated blood pressure in both sexes and/or tobacco smoking in men[5, 6]. Salt consumption, which accounts to a large extent for elevated blood pressure in the Japanese population, is decreasing[7, 8]. Similarly, smoking is losing popularity among Japanese men[9]. However, the prevalence of obesity in the Japanese population is rising mainly due to consumption of a Western diet. The Western diet is known for its high fat content[4]. Consequently, there is growing concern over the increasing prevalence of obesity and the associated metabolic disorders in Japan[10, 11]. In 2008, the Japanese government launched a nationwide system comprised of the Specific Health Checkups and Specific Health Guidance, which focused mainly on obesity and the associated metabolic disorders[12, 13]. The objective of this system was to reduce the burden of premature death and disability due to cardiovascular disease. The system was designed to identify obese individuals with metabolic disorders and provide advice on modifying lifestyles linked to obesity. Lifestyle modifications can reduce body weight and improve blood pressure and lipid and glucose metabolism, thereby preventing cardiovascular disease[13, 14].

Smoking is a risk factor for cardiovascular disease, cancer and respiratory illnesses[6, 15-17]. Despite a recent reduction in smoking prevalence among Japanese males[9], the prevalence of smoking remains higher among Japanese males than among males in highly developed Western countries[18]. Health guidance by the cardiovascular prevention system may play a role in implementing tobacco control in Japan, although the system prioritizes the metabolic syndrome. However, whether health guidance promotes smoking cessation among smokers remains unclear.

Aim

The present study investigated the potential benefit of health guidance on smoking cessation using propensity score matching analysis, a statistical method for estimating treatment effects in the real world if a randomized controlled trial is not feasible[19, 20].

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Participants and Methods

The Specific Health Checkups and Specific Health Guidance

All Japanese residents are required to enroll in 1 of 3 medical insurance groups to receive medical services, with eligibility determined by an individual's age and occupation (i.e., "health-insurance-for-all")[21]. Individuals younger than 75 years are required to enroll in either the Employee's Health Insurance scheme (for employees and their dependents) or the National Health Insurance scheme (for self-employed individuals, retirees and their dependents). Each local organization of these 2 insurance schemes provides Specific Health Checkups and Specific Health Guidance annually for eligible beneficiaries between 40 and 74 years of age[12, 13]. Briefly, the Specific Health Checkups assessed medical history, lifestyle, anthropometric indices, blood pressure, and biomarkers, including blood glucose and serum lipids, and categorizes individuals into 1 of 3 health guidance schemes (**Supplementary Table 1**). This categorization is partially in accordance with the Japanese criteria for metabolic syndrome[12, 13, 22]. In general, individuals who are obese with at least 1 associated metabolic disorder are categorized into 1 of 2 schemes offering personalized health guidance. The Specific Health Guidance provides appropriate health guidance for individuals within each scheme. Individuals on medication for at least 1 metabolic disorder or those who need to seek medication for at least 1 moderate-to-severe metabolic disorder are excluded from the Specific Health Guidance.

The Specific Health Guidance Schemes

The Specific Health Guidance consists of 3 health guidance schemes: (1) active support, (2) motivational support, and (3) provision of information (**Supplementary Table 1**)[12]. Active support offers more intensive personalized health guidance comprised of face-to-face counseling for lifestyle modification, followed by repeated counseling for at least 3 months. Repeated counseling is conducted face-to-face or via a communication device such as the telephone, facsimile, or e-mail. Motivational support offers less intensive personalized health guidance comprised of only a single face-to-face counseling session for lifestyle modification. The active support and motivational support schemes target obese individuals with the priority of encouraging them to modify lifestyle choices linked to obesity and may render additional advice on other lifestyle modifications if necessary. However, these 2 schemes provide personalized health guidance only for eligible individuals who are
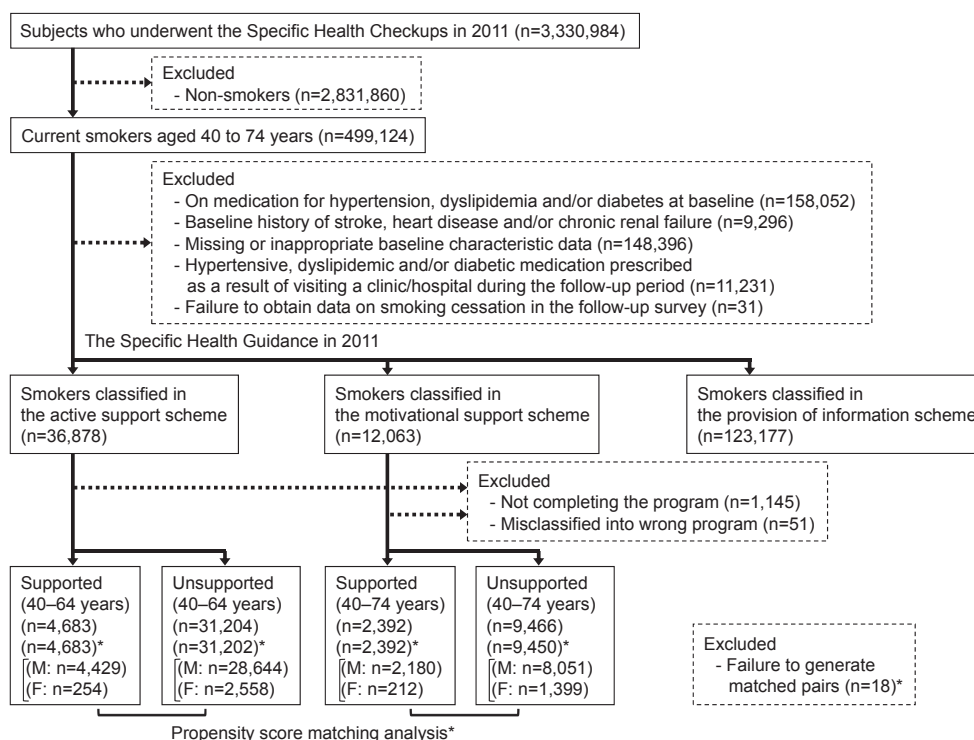
Fig. 1. Study flow chart for the subjects participating in the 2011 Specific Health Checkups in Japan

F, females; M, males. *Subjects involved in propensity score matching analysis after excluding 18 subjects who failed to generate matched pairs.

willing to receive it. The provision of information scheme merely offers general healthcare information by distributing leaflets to all individuals participating in each scheme.

Study Design and Participants

A total of 155 local health insurance organizations that were recruited throughout Japan participated in this study. This study aimed to investigate the influence of the Specific Health Guidance on lifestyles and health status. Each organization provided data on the Specific Health Checkups and Specific Health Guidance after anonymizing the data to protect the participants' privacy. Data were obtained for 3,330,984 beneficiaries, including 535,259 individuals from 12 local Employee's Health Insurance organizations and 2,795,725 from 143 local National Health Insurance organizations. The present study enrolled 499,124 beneficiaries aged 40 to 74 years who reported that they smoke regularly at the Specific Health Checkups in 2011 and who were then followed for 1 year (2011 to 2012) to confirm their smoking cessation status (**Fig. 1**). This study was approved by institutional review committees for ethical issues at the Research Institute of Strategy for Pre-

vention and the National Cerebral and Cardiovascular Center.

Of the 499,124 smoking beneficiaries, 328,202 met 1 or more exclusion criteria; 170,922 subjects provided valid data for calculating the rate of smoking cessation (**Fig. 1**). After excluding those in the provision of information scheme (n=123,177) and those who failed to generate matched pairs within a caliper width (n=18), the propensity score matching analysis was performed using data for the supported and unsupported groups within the active support (n= 4,683 and n=31,202, respectively) and motivational support (n=2,392 and n=9,450, respectively) schemes.

Data Collection

Baseline data were obtained from the Specific Health Checkups and Specific Health Guidance in 2011. Using a self-administered standardized questionnaire, data on the following variables were collected: age, sex, medical history, lifestyle factors (exercise, eating habits, alcohol intake, and sleep), readiness to modify lifestyle, and willingness to receive health guidance. Height and body weight were measured using standard methods. Body mass index was calcu-

lated as: weight (kg) / height (m)^2.

Using a similar self-administered questionnaire, a follow-up survey was conducted at the Specific Health Checkups in 2012 to assess smoking cessation status and medical history. Smoking cessation status was determined by the following question: "Are you currently smoking?" Individuals who responded "yes" were classified as non-quitters (i.e., smokers), whereas those who responded "no" were classified as quitters.

Statistical Analysis

Separate analyses were conducted for males and females. First, we calculated the crude and age-adjusted rates of smoking cessation over 1 year for each of the following 5 groups: 1) active support scheme, supported; 2) active support scheme, unsupported; 3) motivational support scheme, supported; 4) motivational support scheme, unsupported; and 5) the provision of information scheme. For each group, the crude annual rate (%) of smoking cessation was calculated as: [quitter (*n*) / smoker (*n*)] × 100. The age-adjusted rate was calculated using the direct method, where the eligible study population (males and females combined) represented the reference population. After excluding the provision of information scheme and balancing out the characteristics between the groups via propensity score matching analysis, we estimated the difference between the respective smoking cessation rates for individuals who received support and those who did not receive support within the active support and motivational support schemes[19, 20]. All analyses were performed using Stata 14 (StataCorp LP, College Station, TX, USA). Probability values were 2-tailed, with the threshold for statistical significance set at $p < 0.05$.

Propensity scores were computed for each subject using a logistic regression model with potential determinants included as independent variables and the status of support designated as the dependent variable. Based in part on a previous study by Okayama and colleagues[23], the model included the following covariates: age (years) as a continuous variable, type of medical insurance (Employee's Health Insurance or National Health Insurance), weight gain ≥ 10 kg since age 20 years (yes/no), exercise for ≥ 30 minutes 2 days or more per week (yes/no), eating supper before bedtime 3 days or more per week (yes/no), no breakfast ≥ 3 per week (yes/no), drinking alcohol everyday (yes/no), sleeping well (yes/no), readiness to modify lifestyle (yes: trying or will try/no: will not try), willingness to receive support (yes/no), and body mass index (kg/m^2) as a continuous variable. The propensity score for each subject denoted the probability of belonging to the supported group (i.e., recipients of active sup-

port and motivational support).

Following the approach developed by Abadie and Imbens[24-27], we estimated the average treatment effect (ATE) among all subjects; the ATE is an estimator of the treatment effect on the outcome of interest under the assumption that the entire population is originally untreated and then treated[20]. In the counterfactual framework of causal inference[20], for each subject, there is both an observed and potential outcome resulting from the presence and absence of treatment. The potential outcome of a subject was imputed from the outcome of a subject in the group receiving the opposite intervention, matched according to a similar propensity score. Matching was performed using a greedy 1:1 matching algorithm with replacement. The algorithm employed a caliper width of 0.2 standard deviations of the logit of the propensity score[28]. If multiple subjects in groups receiving opposite interventions had similar scores, this algorithm used the average outcomes and the average baseline characteristics of all subjects with similar scores to impute the potential outcome. Replacement allowed repetitive use of subjects at later matching. To apply the same caliper across all analyses, we determined the average standard deviation of the logit of the propensity score derived for each stratum of sex and support. The matching procedure described above was repeated for every subject in the group receiving the intervention, as well as every subject in the group not receiving the intervention. Finally, the ATE and 95% confidence interval (CI) were estimated by computing the difference between the observed and potential outcomes resulting from the presence and absence of the intervention for each subject. The ATE represented the number of additional quitters per 100 smokers (supported vs. unsupported).

We evaluated the balance between matched subjects via graphical inspection of the propensity score distributions and by calculating the standardized differences for the baseline characteristics included in the propensity score regression model. The standardized difference is a useful indicator for assessing the similarity of matched pairs in propensity score matching analysis[29]. An absolute value < 0.1 indicated a negligible difference in a given characteristic between matched subjects[29].

Due to the age-dependent categorization of the health guidance schemes (**Supplementary Table 1**), the active support scheme included subjects aged 40 to 64 years, and the motivational support scheme included subjects aged 40 to 74 years. To account for the different age distributions, a similar propensity score matching analysis was repeated after stratifying subjects in the motivational support scheme by age:
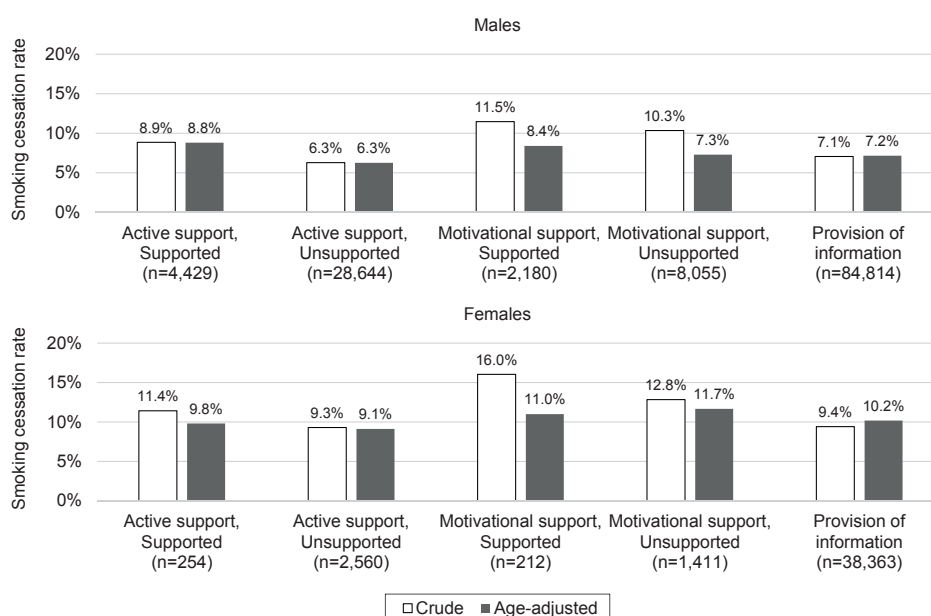
Fig. 2. Annual rates of smoking cessation (2011–2012) among male and female smokers classified by the Specific Health Guidance schemes in Japan

those aged 40 to 64 years versus 65 to 74 years.

Results

Crude and Age-Adjusted Rate of Quitting Smoking

At study entry, the mean ages of males and females were 54.7 and 53.1 years, respectively. Among the smokers, approximately 13.4% of males and 9.0% of females in the active support scheme and 21.3% of males and 13.1% of females in the motivational support scheme received support. **Fig. 2** shows the crude- and age-adjusted rates of smoking cessation in male and female smokers grouped by health guidance scheme. Among the male subjects in the active support scheme, the age-adjusted smoking cessation rate was higher in supported smokers than in unsupported smokers (8.8% vs. 6.3%, respectively). In contrast, smoking cessation rates were similar between the supported and unsupported groups for females in the active support scheme, as well as for both males and females in the motivational support scheme.

ATE of the Specific Health Guidance

Table 1 summarizes the baseline characteristics of supported and unsupported subjects in the active support and motivational support schemes. The supported and unsupported groups exhibited several different characteristics regardless of sex and health guidance scheme. The propensity score logistic regression model yielded a c-statistic of 0.59 and 0.61 for males and females, respectively, in the active support scheme,

and 0.58 and 0.64 for males and females, respectively, in the motivational support scheme. The propensity score distributions for the supported and unsupported groups appeared to overlap predominantly for all strata of the data (**Supplementary Fig. 1**). Therefore the propensity score matching analysis was deemed to be valid.

Two unsupported female subjects in the active support scheme, and 4 unsupported male and 12 unsupported female subjects in the motivational support scheme failed to generate matched pairs within the predefined caliper width of 0.009. These unmatched subjects were excluded in estimating the ATE. In each cohort categorized by sex and health guidance scheme, the propensity score distributions for matched pairs appeared to overlap precisely (**Supplementary Fig. 1**). The standardized difference was <0.1 for all characteristics and approached zero in most cases (**Table 1**).

A total of 33,073 males (4,429 supported and 28,644 unsupported) and 2,812 females (254 supported and 2,558 unsupported) in the active support scheme and 10,231 males (2,180 supported and 8,051 unsupported) and 1,611 females (212 supported and 1,399 unsupported) in the motivational support scheme provided the data for the counterfactual framework of causal inference. For example, in the active support scheme, 4,429 supported males each had the observed outcome resulting from the intervention actually received (i.e., supported) and the potential outcome resulting from the hypothetically

Table 1. Baseline characteristics of male and female smokers in the supported and unsupported groups stratified by health guidance scheme and standardized difference before and after propensity-score matching

	Males				Females			
	Original (unmatched)			Matched*	Original (unmatched)			Matched*
	Supported	Unsupported	Standardized difference	Standardized difference	Supported	Unsupported	Standardized difference	Standardized difference
Active support								
Subjects, *n*	4,429	28,644			254	2,560		
Age (years)	50.0 ± 7.4	51.0 ± 7.6	−0.14	0.03	53.3 ± 7.1	51.5 ± 7.5	0.24	−0.004
National Health Insurance	33.8%	46.8%	−0.27	0.01	65.0%	53.6%	0.23	−0.03
Weight gain since age 20 years	72.6%	72.0%	0.01	−0.005	77.6%	79.6%	−0.05	0.03
Exercise	21.0%	22.0%	−0.02	−0.005	17.7%	17.0%	0.02	−0.05
Eating supper before bedtime	46.5%	44.8%	0.03	0.01	35.0%	34.9%	0.003	0.02
No breakfast	29.2%	31.7%	−0.05	−0.02	32.3%	32.3%	−0.0005	−0.005
Drinking alcohol everyday	43.1%	45.5%	−0.05	−0.002	21.3%	20.2%	0.03	−0.03
Sleeping well	65.1%	65.8%	−0.01	−0.003	59.8%	57.4%	0.05	0.07
Readiness to modify lifestyle	78.4%	73.3%	0.12	0.009	76.8%	81.0%	−0.10	0.04
Willingness to receive guidance	46.1%	40.5%	0.11	0.02	53.9%	41.7%	0.25	0.04
Body mass index (kg/m²)	26.0 ± 2.8	25.9 ± 2.8	0.02	−0.03	27.6 ± 3.7	28.0 ± 3.5	−0.12	−0.06
Motivational support								
Subjects, *n*	2,180	8,055			212	1,411		
Age (years)	60.7 ± 5.9	66.9 ± 6.3	−0.03	−0.05	62.1 ± 9.1	58.5 ± 10.7	0.36	0.003
National Health Insurance	94.8%	93.0%	0.08	−0.03	86.8%	69.1%	0.44	−0.003
Weight gain since age 20 years	54.3%	54.9%	−0.01	−0.02	64.2%	64.9%	−0.01	−0.01
Exercise	47.4%	46.6%	0.02	−0.03	33.0%	28.6%	0.10	−0.03
Eating supper before bedtime	23.5%	24.3%	−0.02	0.004	21.7%	27.1%	−0.13	0.04
No breakfast	11.5%	12.2%	−0.02	0.03	18.9%	25.0%	−0.15	−0.04
Drinking alcohol everyday	49.7%	51.4%	−0.03	0.04	15.6%	19.3%	−0.10	0.04
Sleeping well	15.6%	15.8%	0.003	−0.02	67.9%	65.5%	0.05	−0.08
Readiness to modify lifestyle	63.2%	59.3%	0.08	−0.01	74.5%	77.1%	−0.06	−0.001
Willingness to receive guidance	52.2%	39.7%	0.25	0.0006	50.9%	40.3%	0.21	0.005
Body mass index (kg/m²)	24.8 ± 2.0	24.8 ± 2.0	0.005	0.006	26.1 ± 1.9	26.3 ± 1.9	−0.09	−0.04

Variables represent means ± standard deviation or percentages of participants ('yes' response) in each category.
*The mean for each characteristic or the percentage of subjects with each characteristic after the matching are not shown. The standardized difference after matching represents the difference between matched pairs: 33,073 male matched pairs and 2,812 female matched pairs in the active support scheme and 10,231 male matched pairs and 1,611 female matched pairs in the motivational support scheme.
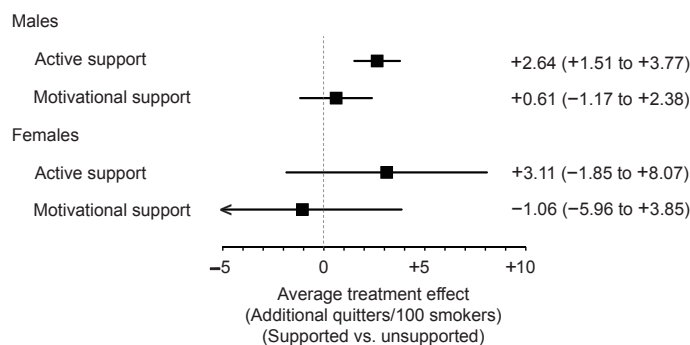
Fig. 3. Average treatment effects of active support and motivational support among male and female smokers

Bars represent the 95% CIs.

opposite intervention (i.e., unsupported), while 28,644 unsupported males each had the observed outcome resulting from the intervention actually received (i.e., unsupported) and the potential outcome resulting from the hypothetically opposite intervention (i.e., supported). **Fig. 3** illustrates the ATEs (95% CI) of active support and motivational support on smoking cessation. The ATE reached significance only for active support in the male smokers (+2.64%; 95% CI: +1.51% to +3.77%).

When the male subjects in the motivational support scheme were stratified by age, 992 males aged 40 to 64 years (337 supported and 655 unsupported) and 9,178 males aged 65 to 74 years (1,790 supported and 7,388 unsupported) were included in the matching analysis after 63 males (53 supported and 10 unsupported) aged 40 to 64 years and 2 unsupported males aged 65 to 74 years failed to generate matched pairs within the same caliper width. The ATEs of motivational support were +2.07% (−1.57% to +5.71%) in males aged 40 to 64 years and +1.22% (−0.74% to +3.18%) in males aged 65 to 74 years. In females, the corresponding analysis was not performed because of the small number of subjects in each age group (40 to 64 years: 90 supported and 746 unsupported females; and 65 to 74 years: 122 supported and 665 unsupported females).

Discussion

The present study examined whether 2 types of personalized health guidance promoted smoking cessation among smokers identified at health checkups in the Japanese nationwide cardiovascular prevention system. Using propensity score matching analysis, we estimated the treatment effect of each personalized health guidance scheme on smoking cessation among the smokers. The results showed that active support had a significant ATE in male smokers, increasing the rate of smoking cessation in this cohort by approximately 2% to 3%, compared with no active support. In contrast, the ATE was not significant for female smokers participating in the active support scheme, nor for male or female smokers receiving motivational support. This study is the first to show the influence of the current Japanese nationwide cardiovascular prevention system on smoking cessation among smokers.

The unsupported smokers in the active support and motivational support schemes, and the smokers in the provision of information scheme represented individuals who did not receive any personalized health guidance. Therefore, it was reasonable that these 3 groups exhibited similar age-adjusted rates of smoking cessation in both sexes. For subjects who did not receive any personalized health guidance, the smoking cessation rate was marginally higher in female smokers than in male smokers. These findings were generally consistent with observations by Honjo and colleagues[30] who observed no remarkable sex-differences in smoking cessation in a Japanese population-based survey of male and female smokers. Moreover, when male and female subjects were considered collectively, the smoking cessation rate in smokers unsupported by personalized health guidance was likely comparable with annual smoking cessation rates recently reported in the general Japanese population (6.9% to 8.3% for men and women combined)[31].

Although active support commonly provided throughout Japan may have promoted smoking cessation in male smokers, the subjects were potentially at various stages of readiness to quit smoking. Because active support involved repeated counseling, this scheme may have allowed sufficient time to assist disinterested smokers in understanding the importance of smoking cessation. Smokers who were then ready to quit may have been encouraged to quit and refrain from smoking. Alternatively, smokers may have been frequently advised to seek specialized counseling and pharmacological therapy for smoking cessation at a clinic/hospital[14]. We assumed that at least 1 of these components of health guidance helped with smoking cessation but could not elucidate what type of advice was useful. Presently, no conclusion can be drawn regarding the potential effect of active support in females. This was largely due to the smaller sample size of female smokers compared with male smokers, which compromised statistical power. In contrast to active support, motivational support in a single counseling session was unlikely to promote smoking cessation among smokers in this study, regardless of age.

A few randomized controlled trials have investigated relatively healthy Japanese smokers who were at various stages of readiness to quit smoking[32, 33]. In one trial, the smoking cessation rate rose by 9.8% following 5 months of personalized counseling tailored to smoking cessation compared with the control (i.e., no intervention) (12.9% vs. 3.1%)[32]. In another trial, subjects who underwent a 6-month program of stage-matched personalized counseling (i.e., an initial 40-minute counseling session followed by 4 20- to 30-minute sessions at 1, 2, 4, and 6 months) exhibited an 11.1% increase in the rate of smoking cessation compared with subjects who had no intervention (13.6% vs. 2.5%)[33]. In summary, effective counseling aimed at smoking cessation may yield an ATE of approximately 10%. Caution is warranted, however, when comparing the ATE between prior trials and our study. This is due to several factors. First, unlike previ-

ous trials assessing smoking cessation status at the end of counseling, the present study assessed smoking cessation status at least a few months after the end of counseling. In general, some quitters start smoking again after successfully completing health guidance[34]. Second, unlike the interventions provided in prior trials, the Specific Health Guidance does not focus exclusively on smoking cessation. Nevertheless, we found that the most intensive scheme of the Specific Health Guidance would produce a modest ATE on smoking cessation.

Smokers participating in the active support and motivational support schemes in the Japanese cardiovascular prevention system were obese[12, 13]. Counseling obese smokers on smoking cessation may be potentially more difficult than advising non-obese smokers and thus may require additional considerations. In this prevention system, obese smokers are advised to abstain from both overeating and smoking, which may be perceived to be pleasurable habits by these individuals. Therefore, obese smokers may generally feel stressed by such challenging lifestyle modifications. Further, because this prevention system prioritizes reducing obesity[12, 13], obese smokers may feel anxious about weight gain after quitting smoking[34, 35]. Lycett and colleagues[36] suggested the need for extending greater care to obese smokers in their attempts to quit smoking, as obese smokers gain weight more frequently after quitting smoking compared with non-obese smokers. In particular, fear of weight gain has been cited as a potential impediment to smoking cessation among female smokers[37] (although our group of smokers were obese at baseline). Therefore, formulating more effective smoking cessation advice for smokers than offered by the current prevention system should also account for critical issues such as these.

The present study surveyed a large sample of individuals from multiple medical insurance organizations nationwide using a consistent method across all organizations. The strength of this approach was that it enabled analysis of the data stratified by sex as well as participation in health guidance support. We assessed smoking cessation status at health checkups in the consecutive year to compare the outcome between the supported and unsupported groups. Assessing smoking cessation status after a lengthy follow-up period, as in the present study, may provide further valuable insight.

We acknowledge several study limitations. First, the subjects determined assignment to either the supported or unsupported group largely by their own accord. Sakai[38] found that health check-up examinees who were more willing to receive health guidance committed to smoking cessation more frequently than those who were less willing to receive health guidance. To address this potential bias, we accounted for the willingness to receive health guidance and readiness to improve lifestyle in calculating the propensity score (although these 2 characteristics were not specific to smoking cessation). Second, the propensity score matching analysis ensured balance between the supported and unsupported groups on the basis of most, but not all, variables included in the propensity score regression model. Other characteristics not accounted for in the model may have had a residual confounding effect. Even variables included in the model may have potentially been inaccurate among smokers as a result of self-reporting. Therefore, the true treatment effect may be weaker than that estimated in the present study. Third, smoking cessation status was self-reported and assessed at a single time point, and the length of time that an individual had refrained from smoking was not considered. Fourth, the intervention involved health guidance targeting obese individuals, thus prioritizing weight reduction rather than smoking cessation. Therefore, the results of the present study should not be extrapolated to general smokers or non-obese smokers. Finally, our study subjects belonged to particular health insurance organizations that voluntarily provided data for the present study, despite the large multicenter study that may have reduced the potential for spurious findings. In addition, caution should be exercised when generalizing these results obtained from obese smokers.

Conclusion

Despite prioritizing the management of obesity and metabolic disorders, health guidance by the Japanese cardiovascular prevention system may assist in promoting smoking cessation among smokers. More intensive personalized health guidance in this prevention system may be beneficial in facilitating smoking cessation at least among male smokers. Further studies are warranted to improve the effectiveness of this prevention system in implementing tobacco control in Japan.

Development (AMED, Practical Research Project for Life-Style related Diseases including Cardiovascular Diseases and Diabetes Mellitus: 15ek0210020h0002).

Conflict of Interest Disclosures

None.

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Supplementary Table 1. Specific Health Checkups and Specific Health Guidance: Screening steps and determination of eligibility for the health guidance schemes (quoted from reference 12)

Screening step 1	Screening step 2		Health guidance scheme (age-dependent)	
Obesity status	Metabolic status: blood pressure, blood glucose, serum lipids	Smoking habit		
Waist circumference ≥ 85 cm for men and ≥ 90 cm for women	≥ 2 metabolic disorders	Any	40–64 years	Active support
			65–74 years	Motivational support
	1 metabolic disorder	Smoking	40–64 years	Active support
			65–74 years	Motivational support
		Non-smoking	Any	Motivational support
	0 metabolic disorder	Any	Any	Provision of information
Body mass index ≥ 25.0 kg/m^2 if waist circumference ＜85 cm for men or ＜90 cm for women	≥ 3 metabolic disorders	Any	40–64 years	Active support
			65–74 years	Motivational support
	2 metabolic disorders	Smoking	40–64 years	Active support
			65–74 years	Motivational support
		Non-smoking	Any	Motivational support
	1 metabolic disorder	Any	Any	Motivational support
	0 metabolic disorder	Any	Any	Provision of information
Neither of the above two conditions	Any	Any	Any	Provision of information

Metabolic disorders were defined as follows: 1) high blood pressure: systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg; 2) high blood glucose: fasting blood glucose ≥ 100 mg/dL and/or hemoglobin A1c (based on the National Glycohemoglobin Standardization Program) ≥ 5.6%; and 3) dyslipidemia: serum triglycerides ≥ 150 mg/dL and/or serum high-density lipoprotein cholesterol ＜40 mg/dL.
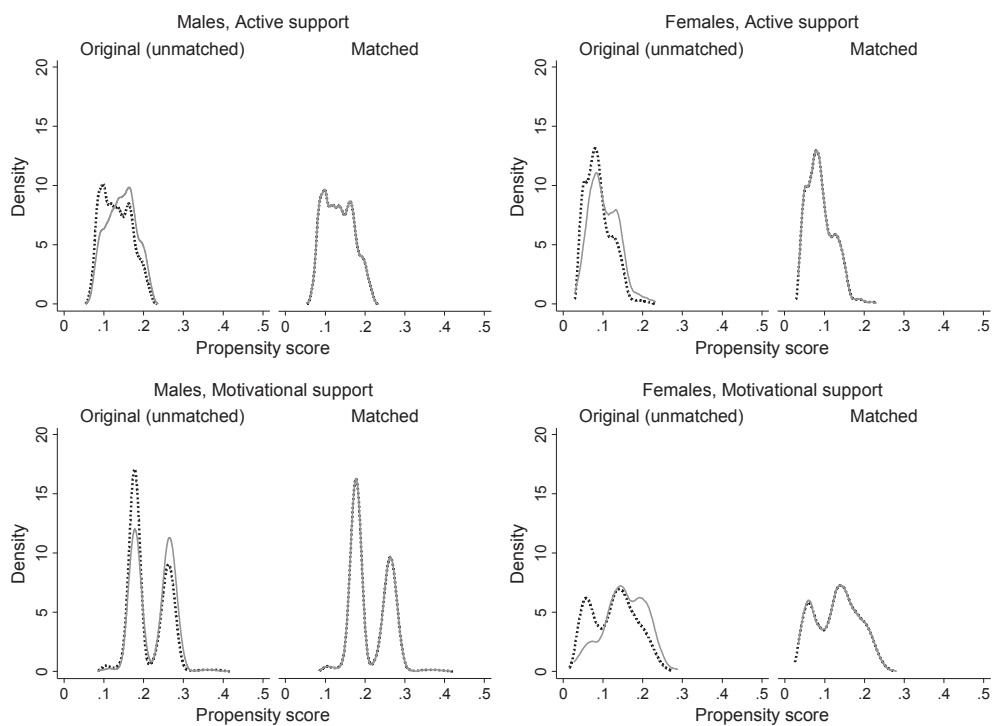
Supplementary Fig. 1. Distribution of propensity scores for receiving health guidance among male and female smokers classified by the active support and motivational support schemes

Data pertain to supported and unsupported smokers stratified by health guidance scheme before and after matching.