Chapter 12
Who Are Free from Hypertension, Dyslipidemia, and Diabetes Mellitus in the Middle-Aged and Elderly Population of Japan?

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Abstract In the present study, we explored who are more (less) likely to be diagnosed with mild lifestyle-related diseases (MLDs) defined as hypertension, dyslipidemia, and diabetes mellitus as a whole among middle-aged and elderly persons. Data from 11 years of the Longitudinal Survey of Middle-Aged and Elderly Persons by the Japanese Ministry of Health, Labour and Welfare were used for the analyses. A complementary log–log model was chosen for the analyses. For men, those who drink alcohol were more likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Men who perform light exercise four days or more per week or those who perform vigorous exercise one to three days per week were less likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Men who take care of eating amounts were more likely to be diagnosed with MLDs. Men who brush teeth after meals were less likely to be diagnosed with MLDs. For women, those who drink alcohol were less likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Women who perform moderate exercise four days or more per week were more likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Women who take care of their eating amount or take vitamin/mineral supplements were more likely to be diagnosed with MLDs. Women who eat a variety of foods or maintain appropriate body weight levels were less likely to be diagnosed with MLDs. Some of these results are inconsistent with previous studies, are contrary to current understanding, or are not well known. Hence, further studies with a greater focus on causal relationships are required.

The present study is a part of the results of the project "Development of New Indicators for Industry Analysis and EBPM Analysis: Focusing on the Service Industry" at the Research Institute of Economy, Trade and Industry (RIETI). The analysis in the present study was based on questionnaire information from the Ministry of Health, Labour and Welfare's Longitudinal Survey of Middle-aged and Elderly Persons.

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1 Introduction

In Japan, several chronic diseases are called “lifestyle-related diseases” (LRDs) (seikatsu shukan byou). In addition to serious diseases such as cancer, stroke, and myocardial infarction, risk factors of them such as hypertension, dyslipidemia, and diabetes mellitus are also regarded as LRDs. For the present study, we define hypertension, dyslipidemia, and diabetes mellitus as mild lifestyle-related diseases (MLDs). According to the Patient Survey (kanja chousa) carried out by the Ministry of Health, Labour and Welfare (MHLW) in 2017, the total number of patients with MLDs was 9,937,000 for hypertension, 3,289,000 for diabetes mellitus, and 2,205,000 for dyslipidemia. These numbers are limited to people who continuously receive medical care, suggesting that more people have MLDs without being diagnosed. One estimation shows that there are 43 million people in Japan with hypertension (Miura et al. 2013).

According to the Overview of National Medical Expenses in 2017 by MHLW, medical expenses for MLDs are 1.79 trillion yen for hypertension and 1.22 trillion yen for diabetes mellitus (dyslipidemia not shown). Prevention of MLDs is expected to reduce the number of visits to medical institutions, make it easier for people to feel healthy, and decrease medical expenses. Medical institutions may experience a downside that their revenue decreases. However, there is a positive side that valuable medical resources can be shifted to responding to serious diseases. Prevention of MLDs can also reduce the financial burden on national and local governments and corporate health insurance society.

From the perspective of reducing visits to healthcare providers, it would be desirable to be able to prevent all three MLDs—hypertension, dyslipidemia, and diabetes mellitus—simultaneously, because any one of the diagnosed MLDs would result in a recommendation to seek medical consultation. However, previous studies have shown that it is not easy to prevent all three MLDs simultaneously.

For example, alcohol intake has been found to raise blood pressure levels (Roerecke et al. 2017) while reducing LDL-C (so-called bad cholesterol), thus leading to the prevention of dyslipidemia (Vu et al. 2016). With regard to diabetes mellitus, studies have shown that people who drink moderately have a lower risk of developing diabetes mellitus than non-drinkers (Li et al. 2016). Since abstention from drinking may prevent hypertension but may instead increase dyslipidemia and diabetes mellitus, it is unclear whether abstaining from alcohol consumption reduces MLDs as a whole.

Another example to suggest the difficulty of preventing all three MLDs simultaneously is a relationship between socio-economic status and MLDs. Oshio and Kan (2019a) showed that people with higher level of education were less likely to have hypertension (for women only) and diabetes mellitus, but more likely to have dyslipidemia. Thus, it is unclear whether attaining a high level of education reduces MLDs as a whole.

With these issues in mind, the present study attempts to determine who is more likely to be diagnosed with any one of the three MLDs focusing on socio-economic status and lifestyle. For our analyses, we used the raw data from the Longitudinal Survey of Middle-aged and Elderly Persons (LSM), an annual longitudinal questionnaire survey conducted by the Japanese Ministry of Health, Labour and Welfare (MHLW).

2 Method

2.1 Dataset

The present study used individual data from the LSM conducted by MHLW every year since 2005. As of the end of October 2005, the LSM targeted people aged 50–59 in 2515 districts randomly selected from survey areas of the Comprehensive Survey of Living Conditions in 2004. The LSM was conducted for a week beginning on the first Wednesday of November. Up to the fifth survey, it was conducted through home visits by surveyors. Since the sixth survey, it has been carried out by mail. The number of survey respondents in the first survey was 40,877, and 34,240 people responded (response rate was 83.8%). Since the second year, only those who participated in the survey of one or two preceding years remained contacted. In the present study, the answers from the first survey to the 11th survey were used. In the 11th survey, the number of people who were sent the questionnaire was 23,485, and the number of collected responses was 22,595 (response rate was 96.2%).

2.2 Measures

2.2.1 Primary and Secondary Outcomes

In the LSM, respondents were asked whether they were presently diagnosed with any of the relevant conditions or diseases by a doctor. Those diseases include each one of the three MLDs: hypertension, dyslipidemia, and diabetes mellitus. Using the answers to this diagnosis-related question, people who were diagnosed with at least one of the three MLDs were defined as people who were presently diagnosed with MLDs and were defined as primary outcomes. Each diagnosis of hypertension, dyslipidemia, and diabetes mellitus was used as secondary outcomes.

2.2.2 Explanatory Variables

Socio-Economic Status

Explanatory variables related to socio-economic status include final educational background (0: junior high school, 1: senior high school, 2: junior college/vocational school/other, 3: four-year college/graduate school), marital status (0: married, 1: divorced or bereaved, 2: never married), and the employment status (0: currently in the workforce to be paid, 1: not currently in the workforce to be paid). The LSM has questions about income and savings. However, due to the low response rate, these variables were not used in the present study.

Variables Related to Lifestyle

Smoking We created a categorical variable consisting of three categories: those who smoke, those who quit smoking, and those who have never smoked.

Alcohol intake The LSM asked both questions about the frequency of drinking alcohol and the average amount of alcohol intake at each drinking occasion. They were converted into a single variable. In this conversion, we multiply the frequency by the average amount based on the following formula. For the frequency, the frequency was converted to 0.5 for frequency 1–3 days per month, 1.5 for 1–2 days per week, 3.5 for 3–4 days per week, 5.5 for 5–6 days per week, and 7 for every day (Saito et al. 2018). For the average amount, respondents are requested to convert their alcohol intake in unis to gou which is used for Japanese sake and equivalent to 22 g of ethanol. Less than 1 gou was counted as 1, 1–3 gous was counted as 2, 3–5 gous was counted as 3, and 5 or more gous were counted as 4. We multiplied frequency by the average amount based on this formula and classified the multiplied amount into five grades. Grade 0 was “rarely drink” or “never” (unable to drink). Grade 1 was 1–3 days a month with an average of less than 5 gous per day or 1–2 days a week with an average of less than 1 gou per day. Grade 2 was 1–3 days a month with an average of 5 or more gous per day or 1–2 days a week with an average of 1 gou per day or more, or 3–4 days a week with an average amount of less than three gous, or 5–7 days a week with an average amount of less than one gou. Grade 3 was 3–4 days a week with an average amount of three or more gous, or 5–7 days a week with an average amount of between one to three gous. Grade 4 was 5–7 days a week with an average amount of three or more gous.

Physical exercise In the LSM, the questions regarding physical exercise are subdivided into (1) light exercises, which do not cause a shortness of breath (for example, stretching), (2) moderate exercises, which causes a slight shortness of breath (for example, walking and jogging), and (3) vigorous exercises, which causes a severe shortness of breath (for example, aerobics and swimming). For each of these three categories, six choices are shown, which are “no exercise”, “about 1 day a month”, "about 1 day a week", "2–3 days a week", "4–5 days a week", and "almost every day". Since the original questions on exercise are difficult to use as explanatory variables as they are, they were reclassified as follows and a dummy variable with 0 as a reference category was created.

Grade 0: Not exercising or about 1 day a month for any of the three types of exercises

Grade 1: Performed only light exercise 1–3 days a week

Grade 2: Performed only light exercise 4 days a week or more

Grade 3: Performed moderate exercise 1–3 days a week (with no vigorous exercise or about 1 day a month only)

Grade 4: Performed moderate exercise more than 4 days a week (with no vigorous exercise or about 1 day a month only)

Grade 5: Performed vigorous exercise 1–3 days a week

Grade 6: Performed vigorous exercise more than 4 days a week

Moreover, we assumed that the larger the grade indicated, the more intense the exercise. Based on this assumption, we analyzed the exercise variable both as a categorical variable and a continuous variable.

Practices to care for health In the LSM, there is a question item "Do you have something that you keep in mind to maintain good health? Please circle all applicable numbers". These are as follows.

1. I do not drink too much.
2. I do not smoke too much.
3. I do moderate exercise.
4. I have a health check-up at least once a year.
5. I take care of the amount of food I take.
6. I take a variety of foods in consideration of balance.
7. I take vitamin/mineral in tablet, capsule, granule or drink form.
8. I maintain proper weight.
9. I brush my teeth after meals.
10. I take an adequate rest.
11. I do not accumulate stress.
12. Others.
13. Nothing in particular.

Since the LSM has more detailed questions on numbers 1, 2, 3, and 4, we did not use them in the present study. Numbers 12 and 13 were not used in the analysis. As a result, the question items 5, 6, 7, 8, 9, 10, and 11 were used as explanatory variables in the analysis as dummy variables (1 if present, 0 if not).

Social participation activities In the LSM, social participation activities are composed of six items: "hobbies and culture", "sports and health", "community events", "support of child-raising", "support for the elderly", and "other social participation activities". Oshio and Kan (2019b) used the LSM to examine the relationship between social participation in at least one of the six types of social participation activities and each of the three MLDs separately, and found that those who participated in social participation activities were less likely to be diagnosed with diabetes mellitus in both men and women, only women were less likely to be diagnosed with hypertension, whereas both men and women were more likely to be diagnosed with dyslipidemia. However, Oshio and Kan (2019b) did not distinguish participation in sports activities from other social participation activities and incorporated them into one social participation category, which makes it difficult to discriminate between social participation activities and physical exercise, which is by itself associated with MLDs (Colberg et al. 2016; Gordon et al. 2016; Hagberg et al. 2000). Therefore, we did not include sports in social participation activities in the present study. In addition, among the remaining items, we did not treat "hobbies and culture" as a social participation activity and created a separate explanatory variable. We created a categorical variable with 0 for those who did not participate in any of the remaining four categories and 1 for those who participated in any of the four remaining items.

Other explanatory variables Other explanatory variables were (1) age (continuous values), (2) whether or not caring for parents or spouse's parents (1 if present, 0 if absent), and (3) whether or not they had difficulties in activities of daily living (1 if present, 0 if absent). We also created a binary variable for health check-ups, which takes 1 if the patient had a health checkup and 0 if he or she did not have a health check-up. We included prefecture dummies and year dummies in the variables.

2.3 Statistical Analysis

To avoid the reverse causality from the diagnosis of MLDs to the explanatory variables, the estimation samples were limited to the respondents who were not diagnosed with any of the three MLDs in each year (year t). The dependent variable was the binary variable that was 1 if they were diagnosed with any one of the three MLDs in year t + 1 and 0 if they were diagnosed with none of the MLDs in year t + 1. The explanatory variables were the values of year t. However, for the health check-up, both values of year t and year t + 1 were included in the explanatory variables to adjust for the possibility that the latest health check-up would increase the diagnosis of MLDs. Since outcome variables were observed every year, we decided to rely on the discrete-time methods and adopted the complementary log–log model to calculate the hazard ratio (Allison 1982; Singer and Willett 1993, 2003). Once respondents were diagnosed with any one of MLDs, they were excluded from the estimation samples next year and thereafter. Each of hypertension, diabetes mellitus and dyslipidemia was analyzed in the same way as MLDs as a whole.

The analyses were carried out separately for men and women. Statistical analyses were performed using STATA 15, with a significance level of 5% on both sides.

3 Results

3.1 Characteristics of Study Respondents

Table 1 shows the respondents' characteristics for both genders in 2005 and 2016. The number of respondents and the ratios of people with a diagnosis of MLDs are shown graphically in Fig. 1 for men and Fig. 2 for women. The proportion of people with a diagnosis of MLDs tends to increase as the respondents get older, with the proportion of people with any diagnosis of MLDs exceeding 50% in 2012 and 2016 for men and women, respectively. In terms of gender differences, men were more likely than women to be diagnosed with hypertension and diabetes mellitus, and the opposite is true for dyslipidemia.

3.2 Age, Final Education, and Marital Status

With respect to age, as shown in Table 2, new diagnoses of MLDs increased by 4% for each additional year of age in men (hazard ratio 1.04; 95% confidence interval, 1.03–1.05). Regarding each of the three MLDs, there was a significant increase in hypertension and diabetes mellitus, but no significant difference in dyslipidemia. As shown in Table 3, new diagnoses of MLDs increased by 5% for each additional year of age in women (hazard ratio 1.05; 95% confidence interval, 1.03–1.06). Individually, there was a significant increase in all three MLDs.

Across the four different final educational levels, no significant difference was found in the new diagnoses of MLDs with respect to men. Regarding each of the three MLDs, four-year college graduates were less likely to be diagnosed with hypertension and diabetes mellitus and more likely to be diagnosed with dyslipidemia than junior high school graduates. This suggests that non-significant difference in MLDs as a whole between junior high school graduates and four-year college graduates is a result of opposite trends between less diagnoses with hypertension and diabetes mellitus and more diagnoses with dyslipidemia for four-year college students in comparison with junior high school graduates. Among females, senior high school graduates were less likely to be diagnosed with MLDs than junior high school graduates (hazard ratio 0.86; 95% confidence interval, 0.78–0.96). Senior high school graduates were less likely to be diagnosed with hypertension and diabetes mellitus than junior high school graduates, but there was no significant difference in dyslipidemia.

Across the three different marital statuses studied here, no significant difference was found in the new diagnoses of MLDs with respect to either men or women. However, women who had experienced divorce or bereavement and never-married women were less likely to be diagnosed with hypertension and more likely to be diagnosed with dyslipidemia than presently married women. This suggests that non-significant difference in MLDs as a whole between women who were presently married and women who were divorced or bereaved is a result of opposite trends

Table 1 Respondents' characteristics in 2005 and 2016

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
	N	%	N	%	N	%	N	%
Total number of respondents	16,409		17,394		10,152		11,757	
Age (mean, standard deviation)	55.2	(2.7)	55.2	(2.7)	66.3	(2.7)	66.3	(2.7)
Final education	92.1%		92.4%		98.8%		98.9%	
Junior high school	2935	19.4%	2964	18.4%	1695	16.9%	1953	16.8%
Senior high school	7033	46.5%	8225	51.2%	4724	47.1%	6068	52.2%
Junior college or vocational school	1315	8.7%	3814	23.7%	892	8.9%	2806	24.1%
Four-year college or graduate school	3837	25.4%	1076	6.7%	2721	27.1%	801	6.9%
Marital status	99.7%		99.6%		98.4%		98.2%	
Presently married	14,228	87.0%	14,672	84.7%	8672	86.8%	9058	78.5%
Divorced or bereaved	903	5.5%	1983	11.5%	771	7.7%	2134	18.5%
Never married	1225	7.5%	669	3.9%	545	5.5%	351	3.0%
Alcohol intake	97.5%		97.1%		98.7%		98.6%	

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
Grade 0	4317	27.0%	11,908	70.5%	3245	32.4%	8432	72.8%
Grade 1	1338	8.4%	1912	11.3%	851	8.5%	1187	10.2%
Grade 2	3696	23.1%	2193	13.0%	2189	21.8%	1415	12.2%
Grade 3	5424	33.9%	776	4.6%	3325	33.2%	514	4.4%
Grade 4	1217	7.6%	108	0.6%	412	4.1%	43	0.4%
Smoking	99.4%		98.3%		99.5%		99.3%	
Currently smoking	7993	49.0%	2253	13.2%	2717	26.9%	765	6.6%
Quitted smoking	5817	35.7%	1476	8.6%	5105	50.5%	1445	12.4%
Never smoked	2503	15.3%	13,369	78.2%	2284	22.6%	9469	81.1%
Physical exercise	93.6%		93.6%		99.0%		98.6%	
Grade 0	8460	55.1%	7313	44.9%	3595	35.8%	3563	30.7%
Grade 1	1407	9.2%	2132	13.1%	1057	10.5%	1797	15.5%
Grade 2	1374	9.0%	1874	11.5%	1082	10.8%	1457	12.6%
Grade 3	2153	14.0%	2167	13.3%	1983	19.7%	2364	20.4%
Grade 4	1201	7.8%	1563	9.6%	1664	16.6%	1477	12.7%
Grade 5	646	4.2%	1087	6.7%	537	5.3%	786	6.8%
Grade 6	110	0.7%	146	0.9%	133	1.3%	151	1.3%
General health check within a year	99.0%		98.7%		98.9%		98.2%	

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
No	3606	22.2%	5362	31.2%	3220	32.1%	4132	35.8%
Yes	12,636	77.8%	11,804	68.8%	6817	67.9%	7419	64.2%
Currently in the workforce to be paid	99.9%		99.8%		99.8%		99.7%	
No	1086	6.6%	5486	31.6%	3504	34.6%	6621	56.5%
Yes	15,301	93.4%	11,875	68.4%	6630	65.4%	5097	43.5%
Difficulty in daily activities	95.5%		94.9%		95.7%		95.3%	
No	14,634	93.4%	14,802	89.7%	8600	88.5%	9316	83.2%
Yes	1038	6.6%	1698	10.3%	1116	11.5%	1883	16.8%
Hobby and cultural activities	91.2%		91.2%		97.1%		95.6%	
No	6674	44.6%	6000	37.8%	3749	38.1%	3572	31.8%
Yes	8286	55.4%	9858	62.2%	6104	62.0%	7665	68.2%
Social participation activities	91.2%		91.2%		97.0%		95.5%	
No	10,187	68.1%	10,569	66.7%	4595	46.7%	5202	46.4%
Yes	4773	31.9%	5289	33.4%	5249	53.3%	6022	53.7%
Practices to care for health								

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
Taking care of eating amounts	100.0%		100.0%		100.0%		100.0%	
No	10,509	64.0%	9413	54.1%	4640	45.7%	4516	38.4%
Yes	5900	36.0%	7981	45.9%	5512	54.3%	7241	61.6%
Taking a variety of foods	100.0%		100.0%		100.0%		100.0%	
No	11,894	72.5%	9116	52.4%	6308	62.1%	5071	43.1%
Yes	4515	27.5%	8278	47.6%	3844	37.9%	6686	56.9%
Taking vitamin/mineral supplements	100.0%		100.0%		100.0%		100.0%	
No	13,667	83.3%	12,993	74.7%	8323	82.0%	9062	77.1%
Yes	2742	16.7%	4401	25.3%	1829	18.0%	2695	22.9%
Maintaining proper body weight	100.0%		100.0%		100.0%		100.0%	
No	11,063	67.4%	10,534	60.6%	5284	52.1%	5825	49.5%
Yes	5346	32.6%	6860	39.4%	4868	48.0%	5932	50.5%
Brushing teeth after a meal	100.0%		100.0%		100.0%		100.0%	
No	12,242	74.6%	10,295	59.2%	6188	61.0%	5319	45.2%
Yes	4167	25.4%	7099	40.8%	3964	39.1%	6438	54.8%

(continued)

Table 1 (continued)

	Men in 2005		Women in 2005		Men in 2016		Women in 2016	
Taking moderate rest	<u>100.0%</u>		<u>100.0%</u>		<u>100.0%</u>		<u>100.0%</u>	
No	11,053	67.4%	10,616	61.0%	6233	61.4%	6301	53.6%
Yes	5356	32.6%	6778	39.0%	3919	38.6%	5456	46.4%
Not accumulating stress	<u>100.0%</u>		<u>100.0%</u>		<u>100.0%</u>		<u>100.0%</u>	
No	10,132	61.8%	9427	54.2%	5478	54.0%	5732	48.8%
Yes	6277	38.3%	7967	45.8%	4674	46.0%	6025	51.3%
Caring for a relative	<u>95.3%</u>		<u>95.4%</u>		<u>96.3%</u>		<u>95.7%</u>	
No	14,659	93.7%	14,861	89.6%	8742	89.4%	9749	86.7%
Yes	983	6.3%	1734	10.5%	1037	10.6%	1498	13.3%

Note Underlined percentages is the ratio of those who answered the question divided by the total number of respondents. For items in "paying attention to health activities", respondents are asked to place a checkmark if each item is applied to him/her. We treated not placing a checkmark as No to the item. Hence, the underlined percentages are 100% for them

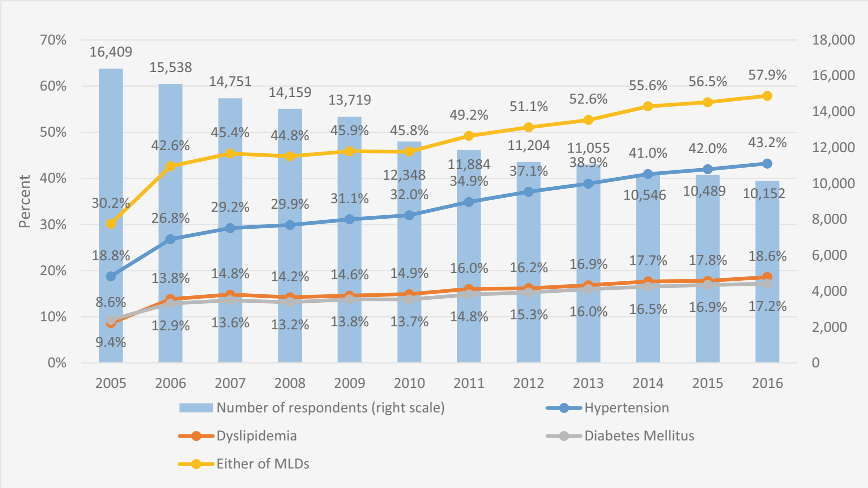

Fig. 1 Ratio of those who are diagnosed with hypertension, dyslipidemia, or diabetes mellitus (men). *Note* The ratio of answering yes to the diagnosis of each disease category on the total responses to the questions is shown in the line graphs (missing data are not included in the denominator). The bar graph shows the total number of responses, including those who did not respond to the question of whether they had a diagnosis. Mild lifestyle-related diseases (MLDs) are defined as hypertension, dyslipidemia, and diabetes mellitus as a whole

between less diagnoses with hypertension and more diagnoses with dyslipidemia for women who were divorced or bereaved in comparison with women who were presently married.

3.3 *Alcohol Intake*

There was a significant increase in MLDs overall in men at alcohol intake levels of grades 3 and 4 in comparison with grade 0 (those who drink little or no alcohol). There was a significant increase in hypertension at grades 2, 3, and 4 in comparison with grade 0, while there was a significant decrease in dyslipidemia at grades 2 and 3 and a significant decrease in diabetes mellitus at grade 3. An increase in hypertension and a decrease in dyslipidemia and diabetes mellitus at grade 3 suggests that there is a opposite trend between hypertension and the other two MLDs.

Women showed a significant decrease in overall MLDs at grade 2 in comparison with grade 0. Otherwise, there was no significant difference. While there was a significant increase in hypertension at grade 3 compared to grade 0, there was a significant decrease in dyslipidemia and diabetes mellitus at grades 2 and 3, suggesting that there is a trade-off between the increasing trend in hypertension and the decreasing trend in dyslipidemia and diabetes mellitus.

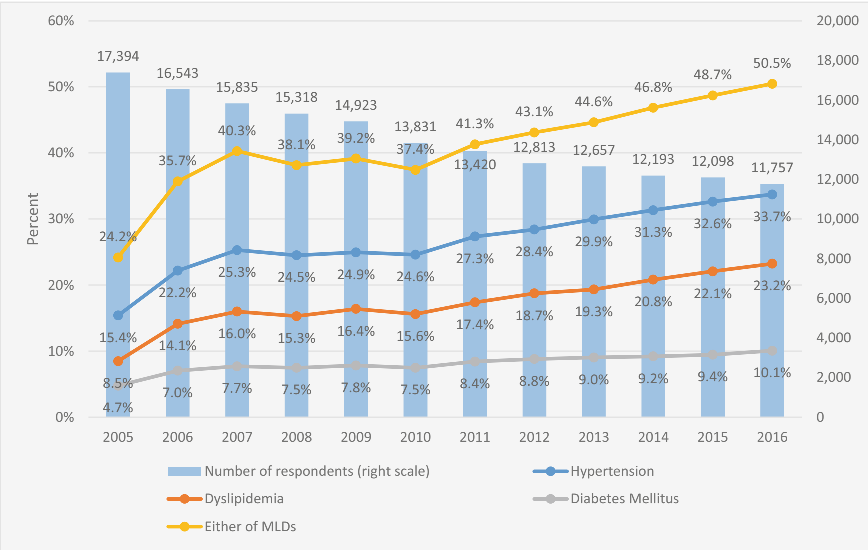

Fig. 2 Ratio of those who are diagnosed with hypertension, dyslipidemia, or diabetes mellitus (women). *Note* The ratio of answering yes to the diagnosis of each disease category on the total responses to the questions is shown in the line graphs (missing data are not included in the denominator). The bar graph shows the total number of responses, including those who did not respond to the question of whether they had a diagnosis. Mild lifestyle-related diseases (MLDs) are defined as hypertension, dyslipidemia, and diabetes mellitus as a whole

3.4 Smoking

For men, those who quit smoking had a 22% increase (hazard ratio 1.22; 95% confidence interval, 1.13–1.32) for overall MLDs diagnoses compared to smokers, with significant increases in hypertension and dyslipidemia and no significant difference in diabetes mellitus. When those who never smoked were compared with smokers, there was no significant difference in MLDs overall, but there was a significant increase in hypertension, with a significant decrease in diabetes mellitus, and no significant difference in dyslipidemia, suggesting a trade-off between hypertension and diabetes mellitus.

For women, those who quit smoking had a 19% increase (hazard ratio 1.19; 95% confidence interval, 1.03–1.39) for MLDs overall compared to smokers, with a significant increase for dyslipidemia and no significant difference for hypertension and diabetes mellitus. When those who never smoked were compared with smokers, there was no significant difference in MLDs overall, with no significant difference in hypertension and dyslipidemia, and a significant decrease in diabetes mellitus.

Table 2 Analysis of new diagnoses of MLDs (men)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Age	**1.04**[1.03,1.05]**	**1.04**[1.03,1.06]**	1.01 [0.99,1.02]	**1.04**[1.02,1.06]**
Final education (reference: junior high school)				
Senior high school	0.97 [0.88,1.07]	0.97 [0.88,1.08]	**1.14*[1.01,1.29]**	0.88 [0.76,1.02]
Junior college or vocational school	0.96 [0.84,1.11]	0.94 [0.81,1.09]	1.05 [0.88,1.24]	0.91 [0.73,1.13]
Four-year college or graduate school	0.94 [0.84,1.05]	**0.87*[0.77,0.98]**	**1.21**[1.05,1.38]**	**0.70**[0.59,0.83]**
Marriage (reference: presently married)				
Divorced or bereaved	1.08 [0.94,1.26]	1.13 [0.97,1.31]	1.07 [0.90,1.26]	1.17 [0.94,1.44]
Never married	1.02 [0.88,1.18]	0.98 [0.83,1.15]	0.96 [0.80,1.14]	1.10 [0.88,1.37]
Alcohol intake (reference: Grade 0 (little or no drinking))				
Grade 1	1.01 [0.88,1.14]	1.02 [0.87,1.18]	0.94 [0.82,1.09]	0.99 [0.81,1.21]
Grade 2	1.01 [0.92,1.11]	**1.28**[1.15,1.42]**	**0.81**[0.72,0.90]**	0.97 [0.84,1.12]
Grade 3	**1.21**[1.12,1.32]**	**1.73**[1.57,1.90]**	**0.78**[0.71,0.87]**	**0.85*[0.75,0.98]**
Grade 4	**1.36**[1.18,1.58]**	**1.97**[1.69,2.30]**	0.89 [0.75,1.06]	1.09 [0.88,1.36]
Smoking (reference: Currently smoking)				
Quitted smoking	**1.22**[1.13,1.32]**	**1.24**[1.14,1.34]**	**1.20**[1.09,1.31]**	0.97 [0.87,1.10]
Never smoked	1.09 [0.98,1.20]	**1.14*[1.02,1.27]**	1.01 [0.90,1.14]	**0.83*[0.71,0.98]**
Frequency and intensity of physical exercise (reference: Grade 0 (none or once a month for any exercise))				
Grade 1	1.07 [0.96,1.20]	1.02 [0.90,1.15]	1.08 [0.95,1.23]	0.98 [0.82,1.17]
Grade 2	**0.87*[0.77,0.98]**	0.89 [0.78,1.01]	0.89 [0.77,1.02]	**0.82*[0.67,0.99]**
Grade 3	1.03 [0.93,1.13]	0.94 [0.84,1.04]	1.05 [0.94,1.17]	0.91 [0.78,1.06]
Grade 4	1.06 [0.94,1.19]	0.99 [0.88,1.12]	0.94 [0.82,1.08]	1.01 [0.84,1.20]
Grade 5	**0.80**[0.68,0.95]**	**0.77**[0.64,0.93]**	0.87 [0.72,1.05]	**0.63**[0.46,0.86]**
Grade 6	0.92 [0.65,1.30]	0.81 [0.54,1.20]	0.74 [0.46,1.20]	1.05 [0.60,1.83]
Taking general health check				
Yes for present year (reference: No)	**2.30**[2.07,2.55]**	**1.83**[1.65,2.04]**	**1.94**[1.71,2.19]**	**1.76**[1.51,2.05]**
Yes for last year (reference: No)	**0.84**[0.77,0.93]**	**0.76**[0.68,0.83]**	1.12 [1.00,1.26]	**0.78**[0.68,0.90]**
Currently in the workforce to be paid	1.01 [0.90,1.14]	1.01 [0.90,1.14]	0.97 [0.85,1.10]	0.97 [0.82,1.13]

(continued)

Table 2 (continued)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Difficulty in daily activities	**1.35**[**]**[1.18,1.54]**	**1.43**[**]**[1.25,1.63]**	**1.21**[*]**[1.04,1.40]**	**1.69**[**]**[1.43,2.01]**
Hobbies or cultural activities	0.99 [0.92,1.06]	0.97 [0.89,1.04]	1.09 [1.00,1.18]	0.96 [0.86,1.08]
Social participation activities	**1.09**[*]**[1.02,1.17]**	1.01 [0.93,1.09]	1.05 [0.97,1.14]	1.03 [0.92,1.15]
Practices to care for health (reference: No)				
Taking care of eating amount	**1.15**[**]**[1.07,1.24]**	1.07 [0.99,1.16]	**1.13**[**]**[1.04,1.24]**	**1.30**[**]**[1.15,1.46]**
Taking a variety of foods	0.96 [0.89,1.04]	**0.92**[*]**[0.84,1.00]**	1.03 [0.95,1.13]	0.99 [0.88,1.12]
Take vitamin/mineral supplements	1.07 [0.99,1.17]	1.06 [0.97,1.16]	**1.13**[*] **[1.03,1.25]**	0.96 [0.84,1.10]
Maintaining proper body weight	0.94 [0.87,1.01]	0.97 [0.89,1.05]	0.92 [0.84,1.00]	**0.88**[*]**[0.78,0.98]**
Brushing teeth after meal	**0.89**[**]**[0.83,0.96]**	**0.81**[**]**[0.75,0.88]**	0.97 [0.89,1.06]	**0.85**[*]**[0.75,0.96]**
Taking moderate rest	0.94 [0.87,1.01]	1.01 [0.94,1.10]	**0.91**[*]**[0.84,0.99]**	**0.87**[*]**[0.77,0.98]**
Not accumulating stress	1.02 [0.95,1.10]	**1.09**[*]**[1.01,1.18]**	1.04 [0.96,1.13]	0.98 [0.87,1.09]
Caring for a relative	1.08 [0.96,1.22]	0.98 [0.86,1.11]	**1.19**[*]**[1.04,1.35]**	**1.28**[**]**[1.08,1.51]**
N	41,200	58,609	70,480	79,508

Note A discrete hazard model was adopted and a complementary log–log model was used to show the hazard ratios and 95% confidence intervals. The dependent variable was a binary variable for people who did not receive a diagnosis of each lifestyle disease in each year (the year t) between 2005 and 2015, with 0 if they did not receive a diagnosis in the year t + 1 and 1 if they did. The explanatory variable was the value for the year t except for the general health check. See text for grades of alcohol consumption and physical excercise. ** 1% significant * 5% significant. MLDs = mild lifestyle-related diseases

3.5 Physical Exercise

For MLDs overall in men, there was a 13% decrease (hazard ratio 0.87; 95% confidence interval, 0.77–0.98) in those who performed only light exercise four or more days per week (grade 2) and a 20% decrease (hazard ratio 0.80; 95% confidence interval, 0.68–0.95) in those who performed vigorous exercise 1–3 days per week (grade 5) compared to those who did not exercise or about 1 day per month (grade

Table 3 Analysis of new diagnoses of MLDs (women)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Age	**1.05**[**]**[1.03,1.06]**	**1.06**[**]**[1.04,1.08]**	**1.03**[**]**[1.01,1.04]**	**1.07**[**]**[1.05,1.10]**
Final education (reference: junior high school)				
Senior high school	**0.86**[**]**[0.78,0.96]**	**0.79**[**]**[0.70,0.89]**	1.06 [0.95,1.19]	**0.67**[**]**[0.56,0.80]**
Junior college or vocational school	0.93 [0.83,1.04]	**0.76**[**]**[0.67,0.88]**	1.13 [1.00,1.29]	**0.70**[**]**[0.57,0.86]**
Four-year college or graduate school	0.86 [0.74,1.01]	**0.65**[**]**[0.53,0.79]**	1.12 [0.94,1.33]	**0.53**[**]**[0.39,0.74]**
Marriage (reference: presently married)				
Divorced or bereaved	0.99 [0.89,1.10]	**0.83**[**]**[0.73,0.94]**	**1.12**[*]**[1.00,1.25]**	0.93 [0.77,1.14]
Never married	0.98 [0.82,1.18]	**0.77**[*]**[0.61,0.98]**	1.02 [0.83,1.25]	0.88 [0.60,1.27]
Alcohol intake (reference: Grade 0 (little or no drinking))				
Grade 1	0.98 [0.88,1.09]	0.97 [0.85,1.11]	1.01 [0.90,1.13]	0.82 [0.66,1.02]
Grade 2	**0.84**[**]**[0.76,0.93]**	1.04 [0.91,1.17]	**0.80**[**]**[0.71,0.90]**	**0.70**[**]**[0.56,0.87]**
Grade 3	0.89 [0.76,1.06]	**1.49**[**]**[1.24,1.79]**	**0.58**[**]**[0.47,0.72]**	**0.43**[**]**[0.28,0.66]**
Grade 4	0.99 [0.62,1.59]	1.61 [0.98,2.65]	0.84 [0.48,1.45]	0.18 [0.03,1.28]
Smoking (reference: Currently smoking)				
Quitted smoking	**1.19**[*]**[1.03,1.39]**	1.19 [0.99,1.44]	**1.22**[*]**[1.03,1.44]**	1.01 [0.77,1.33]
Never smoked	1.00 [0.88,1.13]	1.06 [0.91,1.24]	0.97 [0.84,1.11]	**0.73**[**]**[0.59,0.92]**
Frequency and intensity of physical exercise (reference: Grade 0 (none or once a month for any exercise))				
Grade 1	1.05 [0.94,1.17]	0.90 [0.79,1.03]	1.12 [1.00,1.26]	0.94 [0.77,1.15]
Grade 2	1.09 [0.97,1.22]	1.03 [0.91,1.18]	1.07 [0.95,1.21]	0.88 [0.71,1.10]
Grade 3	1.06 [0.96,1.17]	0.91 [0.80,1.03]	**1.12**[*]**[1.01,1.25]**	0.86 [0.70,1.06]
Grade 4	**1.26**[**]**[1.12,1.41]**	1.14 [1.00,1.30]	**1.21**[**]**[1.07,1.37]**	1.12 [0.90,1.39]
Grade 5	0.87 [0.75,1.00]	**0.80**[*]**[0.67,0.96]**	0.92 [0.78,1.08]	0.99 [0.73,1.33]
Grade 6	0.96 [0.69,1.34]	1.06 [0.73,1.54]	0.76 [0.50,1.15]	1.62 [0.95,2.78]
Taking general health check				
Yes for present year (reference: No)	**2.42**[**]**[2.20,2.66]**	**1.76**[**]**[1.58,1.97]**	**2.47**[**]**[2.22,2.76]**	**1.71**[**]**[1.44,2.03]**
Yes for last year (reference: No)	0.94 [0.86,1.02]	**0.84**[**]**[0.76,0.93]**	**1.17**[**]**[1.06,1.29]**	**0.78**[**]**[0.66,0.91]**
Currently in the workforce to be paid	1.00 [0.93,1.08]	1.02 [0.94,1.12]	0.98 [0.91,1.06]	0.92 [0.80,1.06]

(continued)

Table 3 (continued)

	MLDs	Hypertension	Dyslipidemia	Diabetes
Difficulty in daily activities	**1.29**[**]**[1.16,1.44]**	**1.27**[**]**[1.12,1.44]**	**1.16**[*]**[1.03,1.30]**	**1.74**[**]**[1.47,2.07]**
Hobbies or cultural activities	0.95 [0.88,1.02]	**0.84**[**]**[0.77,0.93]**	1.05 [0.97,1.15]	0.89 [0.77,1.02]
Social participation activities	0.96 [0.90,1.03]	0.93 [0.85,1.01]	0.96 [0.89,1.03]	0.88 [0.77,1.01]
Practices to care for health (reference: No)				
Taking care of eating amount	**1.14**[**]**[1.06,1.23]**	**1.15**[**]**[1.05,1.26]**	**1.19**[**]**[1.09,1.29]**	**1.28**[**]**[1.11,1.48]**
Taking a variety of foods	**0.92**[*]**[0.86,0.99]**	0.94 [0.86,1.03]	0.95 [0.87,1.03]	**0.81**[**]**[0.70,0.94]**
Take vitamin/mineral supplements	**1.10**[*]**[1.02,1.18]**	1.06 [0.97,1.16]	**1.10**[*]**[1.01,1.20]**	1.11 [0.96,1.29]
Maintaining proper body weight	**0.85**[**]**[0.79,0.92]**	**0.77**[**]**[0.70,0.84]**	**0.91**[*]**[0.84,0.99]**	**0.73**[**]**[0.63,0.85]**
Brushing teeth after meal	0.94 [0.88,1.01]	0.92 [0.84,1.00]	0.96 [0.89,1.04]	**0.79**[**]**[0.69,0.91]**
Taking moderate rest	1.03 [0.96,1.11]	1.04 [0.95,1.14]	0.98 [0.90,1.06]	1.01 [0.88,1.17]
Not accumulating stress	1.00 [0.93,1.08]	**1.13**[**]**[1.03,1.23]**	0.96 [0.89,1.04]	0.99 [0.87,1.14]
Caring for a relative	**1.11**[*]**[1.01,1.23]**	0.99 [0.88,1.12]	1.10 [0.99,1.22]	1.12 [0.93,1.34]
N	50,800	69,115	72,416	90,075

Note Same as the note in Table 2

0). Other categories (light exercise 1–3 days per week (grade 1), moderate exercise 1 or more days per week (grade 3 and 4), and vigorous exercise 4 or more days per week (grade 6)) had no difference in overall MLDs compared with those who did not exercise or about 1 day per month. When the exercise was treated as a continuous value, there was no significant trend for MLDs overall (hazard ratio 0.99; 95% confidence interval, 0.97–1.01). Diagnosis of hypertension decreased by 3% for every 1 point increase in exercise level (hazard ratio 0.97; 95% confidence interval, 0.95–1.00). There was no significant trend for dyslipidemia (hazard ratio 0.98; 95% confidence interval, 0.96–1.01) and diabetes mellitus (hazard ratio 0.97; 95% confidence interval, 0.94–1.00) (not shown in the table).

For MLDs overall in women, those who performed moderate exercise 4 or more days per week (Grade 4) were 26% (hazard ratio 1.26; 95% confidence interval, 1.12–1.41) more likely to be diagnosed with MLDs compared to those who did not exercise or about 1 day per month (grade 0). Other categories (light exercise 1 or more days per week (grade 1 and 2), moderate exercise 1–3 days per week (grade 3), and vigorous exercise 1 or more days per week (grade 5 and 6)) showed no significant difference in overall MLDs compared to those who did not exercise or about 1 day per month (grade 0). When the exercise was treated as a continuous value, there was no significant trend for MLDs overall (hazard ratio 1.01; 95% confidence interval, 0.99–1.03), for hypertension (hazard ratio 1.00; 95% confidence interval, 0.97–1.02), for dyslipidemia (hazard ratio 1.01; 95% confidence interval, 0.99–1.03) and for diabetes mellitus (hazard ratio 1.01; 95% confidence interval, 0.97–1.05) (not shown in the table).

3.6 Health Check-Up

For men, new diagnoses of MLDs were 2.3 times greater in the year of a health check-up (hazard ratio 2.30; 95% confidence interval, 2.07–2.55). Overall, there was a 16% decrease in new diagnoses of MLDs for those who experienced a health check-up in the previous year (hazard ratio 0.84; 95% confidence interval, 0.77–0.93).

For women, new diagnoses of MLDs were 2.4 times greater in the year of a health check-up (hazard ratio 2.42; 95% confidence interval, 2.20–2.66). There was no significant difference in MLDs overall depending on the experience of a health check-up in the previous year, with a decrease in hypertension and diabetes mellitus and an increase in dyslipidemia, suggesting a trade-off between the three MLDs.

3.7 Practices to Care for Health

For men, those who take care of eating amounts were 15% more likely to be diagnosed with MLDs (hazard ratio 1.15; 95% confidence interval, 1.07–1.24), with significant increases individually for dyslipidemia and diabetes mellitus, and no significant difference for hypertension. Those who brush teeth after meals were 11% less likely to be diagnosed with MLDs overall (hazard ratio 0.89; 95% confidence interval, 0.83–0.96), with individually significant reductions in hypertension and diabetes mellitus, and no significant difference in dyslipidemia.

For women, those who take care of eating amounts were 14% more likely to be diagnosed with MLDs overall (hazard ratio 1.14; 95% confidence interval, 1.06–1.23), and all of the three MLDs. Those who take a variety of foods were 8% less likely to be diagnosed with MLDs overall (hazard ratio 0.92; 95% confidence interval, 0.86–0.99), and individually there was a significant decrease in diabetes mellitus. Those who take vitamin/mineral supplements were 10% more likely to be diagnosed with MLDs (hazard ratio 1.10; 95% confidence interval, 1.02–1.18) and individually, there was a significant increase in dyslipidemia. Those who maintain proper body weight were 15% less likely to be diagnosed with MLDs overall (hazard ratio 0.85; 95% confidence interval, 0.79–0.92), and individually, all were reduced.

3.8 Others

Having a job had no significant association with MLDs diagnosis for both men and women. Those who had difficulty in daily living were more likely to be diagnosed with overall MLDs and all three MLDs for both men and women.

For men, engagement in hobbies and cultural activities had no significant association with the new diagnoses of MLDs, but those who were engaged in social participation activities were 9% more likely to be diagnosed with overall MLDs (hazard ratio 1.09; 95% confidence interval, 1.02–1.17). For women, engagement in hobbies and cultural activities had no significant associations with overall MLDs diagnosis. Engagement in social participation activities was not associated with MLDs diagnosis as well.

For men, those who cared for a relative had no significant association for diagnosing of MLDs but had a significant increase for dyslipidemia and diabetes mellitus. For women, there was an 11% increase in overall MLDs (hazard ratio 1.11; 95% confidence interval, 1.01–1.23) with no significant difference in each of the three MLDs.

4 Discussion

4.1 General Remarks

In the present study, we defined hypertension, dyslipidemia, and diabetes mellitus as mild lifestyle-related diseases (MLDs) and examined who are more (less) likely to be diagnosed with MLDs among the middle-aged and elderly persons of Japan, focusing on socio-economic status and lifestyle factors. Data from 11 years of the LSM by the MHLW of Japan were used for the analyses. For men, those who drink alcohol were more likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Men who performed light exercise four days or more per week or those who performed vigorous exercise one through three days per week were less likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Men who took care of eating amounts were more likely to be diagnosed with MLDs. Men who brushed their teeth after meals were less likely to be diagnosed with MLDs. For women, those who drink alcohol were less likely to be diagnosed with MLDs. Former smokers were more likely to be diagnosed with MLDs than current smokers. Women who performed moderate exercise four days or more per week were more likely to be diagnosed with MLDs than those who did not exercise or exercised about one day per month. Women who take care of their eating amount or take vitamin/mineral supplements were more likely to be diagnosed with MLDs. Women who eat a variety of foods and maintain appropriate body weight levels were less likely to be diagnosed with MLDs.

4.2 Consideration on Individual Elements

Hereinafter, we will focus on alcohol intake and smoking for which trade-offs between the three MLDs were observed. After that, we will discuss several intriguing findings, that need future explorations.

4.2.1 Alcohol Intake

Similar to previous studies, the present study suggested that alcohol intake has a positive association with hypertension, and moderate alcohol intake has a negative association with dyslipidemia and diabetes mellitus (Li et al. 2016; Roerecke et al. 2017; Vu et al. 2016). As a whole, alcohol intake has a positive association with MLDs for men, whereas moderate alcohol intake has a negative association with MLDs for women. Although the present study looks to suggest that moderate drinking is appropriate for women, careful consideration is required.

Out of the three MLDs, hypertension and dyslipidemia have no symptoms in most cases. Even in diabetes mellitus, many of those who have the disease experience no symptoms at the initial stage. Hence the three MLDs per se are not problematic unless they lead to complications and serious diseases. In reality, they are known to often lead to complication and serious diseases in particular cardiovascular diseases such as stroke and myocardial infarction. Hence, whether or not it is desirable to drink alcohol should not be determined solely based on susceptibility to MLDs, but based on its relation to the incidence of complication and serious diseases. Wood et al. (2018) found that the risk of stroke increased with increasing alcohol consumption, whereas the risk of myocardial infarction decreased. In Wood et al. (2018), in which main analyses were limited to current drinkers in order to avoid reverse causality, the group with the lowest alcohol intake (0–25 g per week) had the lowest incidence of stroke, with the incidence increasing by 14% for every 100 g more per week (hazard ratio 1.14; 95% confidence interval, 1.10–1.17). For myocardial infarction, up to a certain amount, the incidence of myocardial infarction decreased with the larger amount of alcohol intake (hazard ratio 0.94; 95% confidence interval, 0.91–0.97). Another study found that there is no ideal amount of alcohol consumption that is not harmful to health and that it is better not to drink at all (GBD 2016 Alcohol Collaborators 2018). Since strokes are more likely to occur than myocardial infarctions in the Japanese population, it seems that emphasis should be placed on stroke prevention and, even if it worsens cholesterol levels, it may be preferable for health policy to aim at guiding people away from drinking alcohol. In this sense, careful consideration should be taken regarding the results of alcohol intake in the present study.

4.2.2 Smoking

The results of the present study suggest that those who quit smoking are more likely to develop MLDs, in particular, hypertension and dyslipidemia although the length of period since they quit smoking cannot be identified from the LSM. This result may be counterintuitive, but previous studies have shown similar results (Bush et al. 2016; Takayama et al. 2018; Tamura et al. 2010), suggesting that weight gain due to smoking cessation may predispose people to hypertension, dyslipidemia, and diabetes mellitus, for which weight gain is a major risk factor (Brown et al. 2000; Colditz et al. 1995; Huang et al. 1998). Body weights of respondents were not asked in the LSM, so further analysis on this issue was not possible.

Similar to the abovementioned alcohol intake, the results of the present study regarding smoking should be interpreted carefully. Previous studies have shown that quitting smoking reduces the risk of cardiovascular diseases such as stroke and heart disease (Chen et al. 2021; Clair et al. 2013; Kim et al. 2018). Although these preventive effects were attenuated for those who gain weight after smoking cessation, the beneficial effects of quitting smoking remained to exist (Chen et al. 2021; Liu et al. 2020). In a 2019 study, heavy smokers who quit smoking have a significantly lower risk of cardiovascular disease within five years compared to those who continued smoking (Duncan et al. 2019). This indicates that the advantages of quitting smoking outweigh the disadvantages of being more likely to develop hypertension, dyslipidemia, and diabetes mellitus through weight gain.

4.2.3 Intriguing Findings Requiring Further Exploration

Amount of Food

Rather unexpectedly, both men and women who take care of eating amounts were more likely to develop MLDs. One possible explanation of this counterintuitive result is that body weight was a confounding factor; while larger body weight may lead to greater attention to food intake, larger body weight also may lead to higher susceptibility to hypertension, dyslipidemia, and diabetes mellitus. Hence, attention to food intake may be associated with the occurrence of MLDs in spite of the lack of causal relationship between them. Unfortunately, this possible explanation cannot be examined from the LSM that did not have questions on body weight. Another possible explanation is that taking care of eating amount is irrelevant to or increases the occurrence of MLDs contrary to common knowledge. Further examination based on the results of the present study is expected in order to carry out appropriate health policies (Benton and Young 2017). In particular, whether taking care of eating amount leads to an increase or decrease of MLDs should be further explored in a more rigorous manner such as randomized controlled trials.

Brushing Teeth After Meals

The results of the present study show that for men, people who brush their teeth after meals were less likely to be diagnosed with hypertension and diabetes mellitus, and for women, they were less likely to be diagnosed with diabetes mellitus. Teeth brushing had no significant association with dyslipidemia diagnosis for both men and women.

A meta-analysis of observational studies published in 2019 examined the relationship between frequency of tooth brushing and diabetes mellitus and concluded that people who brush their teeth more frequently are less likely to develop diabetes mellitus (Fu et al. 2019). In a cohort study conducted in Japan, less frequency of tooth brushing was significantly associated with diabetes mellitus in men and dyslipidemia in women, while there was no significant association between frequency of tooth brushing and hypertension (Kuwabara et al. 2017).

The results of the present study and previous studies together suggest that tooth brushing may be linked to the prevention of MLDs. However, these studies are all observational ones, and it is not possible to identify a causal relationship. Ideally, the findings of these studies should be further explored by randomized controlled trials that compare reductions in blood pressure, cholesterol, and blood glucose levels in randomized groups of people with and without tooth brushing recommendations.

Taking Vitamin/mineral Supplements

The results of the present study show that women who take vitamin/mineral supplements were more likely to be diagnosed with MLDs, and both men and women who take vitamin/mineral supplements were more likely to be diagnosed with dyslipidemia. The LSM does not ask what kind of specific vitamin/mineral is taken. Hence, specific name of the vitamin/mineral supplements cannot be identified.

Previous studies show that supplementation of zinc (Ranasinghe et al. 2015), vitamin-B3 (niacin) (McKenney 2004), and vitamin-D (Jafari et al. 2016) improve cholesterol levels, suggesting the possibility that those who take these vitamin/mineral supplements are less likely to be diagnosed with dyslipidemia. But there seems to be no adequate evidence to support vitamin C and vitamin E supplementation for dyslipidemia (Hendarto et al. 2019; Tareke and Hadgu 2021). We did not find any studies that demonstrated that vitamin/mineral supplementation increased the incidence of dyslipidemia. One possible explanation of the counter-intuitive result in the present study is that cholesterol level is a confounding factor; while borderline cholesterol level may lead to taking vitamin/mineral supplements to prevent dyslipidemia, this borderline cholesterol level also may lead to higher susceptibility to dyslipidemia. However, we cannot rule out the possibility that some vitamin/mineral supplements lead to more cases of dyslipidemia and further studies are required.

4.3 Limitations of the Present Study

There are several limitations to the present study. The first limitation of the present study is its complete reliance on a particular questionnaire. Because the analysis in the present study relies entirely on the LSM, we do not have data on metrics such as blood pressure and body weight, and we may not be able to get an accurate picture of these diagnoses of MLDs from the responses. We are also concerned that some of the explanatory variables, including alcohol intake and physical exercise, leave room for subjectivity on the part of respondents and that there are problems that cannot be quantified by a questionnaire. It is desirable to construct a panel (longitudinal) dataset that combines the LSM or similar surveys with health examination data, which will elucidate the associations of health markers such as blood pressure and body weight with variables related to socio-economic status and lifestyles more clearly.

The second limitation of the present study is the possibility of bias due to non-response. In the LSM on which the present study's analyses rely, the number of respondents in 2016 was roughly two thirds of that in 2005, indicating a substantial number of dropouts. Even when responses were received, there were still unanswered questions on individual questions, with a particularly large number of unanswered questions on income and assets. For this reason, we did not include these variables in the analyses, but some studies have suggested that these variables affect MLDs (Bird et al. 2015) and including income and assets as explanatory variables may change the results of the analysis.

The third limitation of the present study is that the analysis in the present study is not based on randomized controlled trials, and therefore no causal relationships can be identified. Although interesting results were obtained with regard to eating amount, tooth brushing, etc., they cannot be definitive and would ideally need to be validated by randomized controlled trials.

5 Conclusion

In the present study, we explored who are more (less) likely to be diagnosed with any, some or all of the mild lifestyle-related diseases (MLDs), here defined as hypertension, dyslipidemia, and diabetes mellitus among middle-aged and elderly persons. Our findings showed some intriguing points to be explored in future studies. For example, those who take care of eating amount were more likely to be newly diagnosed with MLDs and those who brush teeth after meals were less likely to be newly diagnosed with MLDs. These relationships are just associations at this stage.

Causal relationships should be examined through randomized controlled trials or other rigorous methods (Figs. 1 and 2).

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