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Mortality from major causes and lifestyles by proportions of public assistance recipients among 47 prefectures in Japan: Ecological panel data analysis from 1999 to 2016

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A R T I C L E I N F O

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A B S T R A C T

Objective: Comprehensive investigations of correlations between subnational socioeconomic factors and trends in mortality and lifestyle are important for addressing public health problems.
Methods: Forty-seven prefectures in Japan were divided into quartiles based on the proportion of public assistance recipients (PPAR). Age-standardized mortality from all causes, cancer, heart disease, and stroke in each prefecture were averaged for these quartiles in 2000, 2005, 2010, and 2015. Data from the National Health and Nutrition Survey were obtained for the following periods: 1999–2001, 2003–2005, 2007–2009, 2012, and 2016. Body mass index (BMI), intake of total energy, vegetable and salt, step count, and prevalence of current smoking and drinking for individuals aged 40–69 years age range were standardized for each prefecture and averaged by quartile. A two-way analysis of variance was used to assess differences in mortality and lifestyle across different years or periods, and quartiles.
Results: Mortality rates decreased, with the first (lowest) quartile showing the lowest rates, across all causes, cancer and heart diseases in both sexes. BMI exhibited an increase in men, whereas, BMI in women and other lifestyle factors in both sexes, excluding smoking and drinking in women, exhibited a decrease. BMI, vegetable and salt intake, total energy intake in men, and smoking in women varied across quartiles. Lower quartiles exhibited lower BMI and smoking prevalence but higher energy, vegetables, and salt intake.
Conclusions: PPAR exhibited favorable trends and significant differences in mortality related to all causes, cancer and heart disease across both sexes, along with BMI among women.

1. Introduction

Population aging and declining birth rates have been major demographic trends for decades in Japan (Statistics Bureau of Japan, 2022). These trends are accompanied by several demographic and social changes, such as population decline, urban centralization, and diminishing household size (Cabinet Office, 2005). Since these changes are interrelated and dynamically complex, they tend to create vicious

Abbreviations: PPAR, Proportion of public assistance recipients; BMI, Body mass index; NHNS, National Health and Nutrition Survey; RII, Relative inequality index.

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cycles. Despite these circumstances, owing to several contributing factors (Tsugane, 2021; Iso, 2021 Dec 31), life expectancy has continued to increase until the COVID-19 outbreak (Huang et al., 2023). The increase in life expectancy leads to further aging of the population and an increase in both medical and long-term care expenditures (Nishi et al., 2020 Dec).

Since demographic and social changes vary across subnational areas (prefectures) in Japan, it is imperative to examine health-related temporal changes at the prefectural level. To investigate the correlation between socioeconomic factors and trends in mortality from major causes and lifestyle factors by prefecture, Nishi et al. (Nishi et al., 2023) conducted an ecological panel data analysis using vital statistics data, data from the National Health and Nutrition Survey (NHNS), and per capita prefectural income. The study revealed favorable trends and significant differences in mortality rates from all causes, cancer, and stroke among men, as well as body mass index (BMI) in women, in relation to per capita prefectural income. Although favorable (decreasing) trends in mortality from 1995 to 2015 were observed for all causes, cancer, heart disease, and stroke in both sexes, significant differences in mortality from all causes, cancer and stroke in relation to per capita prefectural income were observed exclusively in men. Such discrepancies in results between men and women may be due to the choice of socioeconomic indicators. Per capita prefectural income is defined as the sum of per-person employee compensation, property income, and business income within a prefecture (Economic and Social Research Institute of Cabinet Office, 2023), without sex-based differentiation. In Japan, the labor force participation rate was higher in men than in women, although it decreased to 70–80 % in men and remained nearly stable at approximately 50 % in women between 1995 and 2010 (Kawata and Naganuma, 2023). Thus, per capita prefectural income may rely more on the labor force of men rather than women. Alternatively, a sex-specific socioeconomic indicator would be better for elucidating trends in mortality and lifestyle according to sex.

Since the 1980 s, the relative poverty rate in Japan, defined as the percentage of the population below 50 % of the median equivalized household income, has risen steadily from 12.0 % in 1985 to 15.7 % in 2015 in Japan (National Institute of Population and Social Security Research, 2019). Public assistance is one of the initiatives of the social security system implemented by the Ministry of Health, Labor, and Welfare, Japan. Over the period from 1985 to 2015, the proportion of recipient households increased from 21.0 to 32.4 per 1,000 households (National Institute of Population and Social Security Research. Official Statistics on the Public Assistance System. [cited, 2023). The public assistance program comprises eight assistance categories, including livelihood, education, housing, medical, long-term care, maternity, occupational, and funeral assistance (National Institute of Population and Social Security Research, 2019). The distribution of recipients by household type was as follows: 49.5 % for older adults, 15.6 % for sickness, 11.7 % for disability, 6.4 % for single mothers, and 16.8 % for other categories (National Institute of Population and Social Security Research, 2023). The categories of recipient households exhibited variations based on age, health status, and sex, with the proportions of public assistance recipients (PPAR) influenced by the social and economic situation of local governments. Therefore, it can be inferred that the PPAR could serve as a comprehensive socioeconomic indicator on a prefectural level.

This study aims to investigate trends in mortality rates and lifestyle factors across Japanese prefectures, categorized by PPAR.

2. Materials and Methods

2.1. Mortality

Data on age-standardized mortality rates, which are from the model population of Japan in 1985, from all causes, malignant neoplasms (cancer), heart disease, and cerebrovascular disease (stroke), stratified by prefecture and sex, were obtained from the Specified Report of Vital Statistics for the years 2000, 2005, 2010, and 2015 (Ministry of Health, Labour and Welfare of Japan. Specified Report of Vital Statistics. [cited, 2023). The International Classification of Diseases (10th revision) codes were C00-C97 for cancer, I01-02.0, I05-I09, I20-I25, I27, and I30-I51 for heart disease, and I60-I69 for stroke.

2.2. Lifestyle

Lifestyle data were obtained from the NHNS (formerly the National Nutrition Survey). Details of the survey method have been described previously (Ikeda et al., 2015). In 1995, the initial calculations and reporting of individual dietary intake data were reported (Katanoda and Matsumura, 2002), and subsequent annual data were categorized into distinct periods as follows: 1999–2001 (Period 1), 2003–2005 (Period 2), 2007–2009 (Period 3), 2012 (Period 4), and 2016 (Period 5). A three-year average was computed for Periods 1–3, while data for the stand-alone years 2012 and 2016, during which expanded surveys were conducted, were utilized for Periods 4 and 5, respectively. Data for Kumamoto Prefecture in 2016 were absent due to the cancellation of the survey caused by an earthquake. The number of participants in the survey was 16,077 in Period 1, 12,352 in Period 2, 11,715 in Period 3, 13,909 in Period 4, and 11,611 in Period 5.

The selected parameters included BMI, intake of total energy, vegetables and salt, step count, and prevalence of current smoking and drinking habits. Each parameter was defined as specified in the NHNS (National Health and Nutrition Survey, Health Japan 21 (the second term) Analysis and Assessment Project. National Institute of Health and Nutrition. [cited, 2024). The NHNS consists of three components: the physical examination, the dietary intake survey, and the lifestyle survey. In the physical examination, BMI was calculated by dividing the weight of an individual (kg) divided by the square of their height (m). The dietary intake survey was conducted using a semi-weighed dietary record of a single day, mainly in November, excluding Sundays and public holidays (Matsumoto et al., 2022). It was recorded per household, and the contents were checked by trained fieldworkers. Energy, vegetable, and salt intake were calculated using the regularly revised Standard Tables of Food Composition in Japan: fourth (1999 and 2000 of Period 1), fifth (2001 of Periods 1 and 2), expanded fifth (Period 3), and 2010 edition (Periods 4 and 5) (Matsumoto et al., 2020). The number of steps per day was measured on the same day as the dietary survey using a standardized pedometer. In the lifestyle survey, participants who smoked cigarettes at least once during the past month were defined as current smokers and those who consumed 180 ml or more (equivalent to 22 g or more of pure alcohol) of Japanese sake per day and 3–4 times or more per week were defined as current drinkers. For the comparability of questions on drinking habits, data from Periods 2–5 were used to determine the prevalence of current drinking.

2.3. Proportions of public assistance recipients

The number of public assistance recipients was obtained from the National Survey on Public Assistance Recipients (Ministry of Health, 2023). PPAR was calculated by dividing the number of public assistance recipients by the yearly population estimates in each prefecture obtained from the Statistics Bureau of Japan, Ministry of Internal Affairs and Communications (Statistics Bureau of Japan, 2019). Forty-seven prefectures were divided into quartiles for each year as follows: 12 prefectures each in the first, second, and third quartiles, along with 11 prefectures in the fourth quartile. The PPAR per mil and quartiles for each prefecture categorized by sex are shown for the selected years in Supplementary Table 1. PPAR per mil in Japan has increased since 2000, with values of 4.61 and 5.53 in 2000, 6.02 and 6.80 in 2005, 7.72 and 7.74 in 2010, 8.61 and 8.32 in 2015, for men and women, respectively (Supplementary Table 1).

Table 1-1
Age-standardized mortality in men from all causes, cancer, heart disease, and stroke by quartile of proportions of public assistance recipients (PPAR) of prefectures and relative inequality index (RII) in 2000, 2005, 2010, and 2015 in Japan.

	2000	2005	2010	2015	P^a	
All causes (per 100,000)						
Q1	608.2 (15.3)	570.6 (15.9)	524.9 (19.9)	474.4 (15.8)	Year	<0.001
Q2	636.6 (22.7)	595.7 (26.6)	542.4 (27.6)	487.0 (30.2)	PPAR	<0.001
Q3	649.3 (27.1)	604.8 (24.9)	551.6 (29.6)	492.5 (23.6)	Inter-	0.94
Q4	653.3 (38.9)	623.2 (42.9)	570.4 (33.0)	507.4 (29.1)	action	
RII	1.10 (0.99–1.21)	1.12 (1.05–1.18)	1.11 (1.07–1.16)	1.09 (1.04–1.13)		
Cancer (per 100,000)						
Q1	203.5 (11.8)	185.9 (10.3)	175.2 (11.3)	159.8 (9.6)	Year	<0.001
Q2	209.4 (10.3)	192.6 (7.0)	179.0 (7.5)	161.3 (7.8)	PPAR	<0.001
Q3	219.0 (15.8)	201.6 (14.6)	182.0 (10.4)	166.8 (10.7)	Inter-	0.90
Q4	217.6 (14.7)	205.3 (16.6)	189.8 (14.9)	172.2 (14.1)	action	
RII	1.10 (0.98–1.23)	1.15 (1.08–1.21)	1.11 (1.03–1.18)	1.11 (1.03–1.19)		
Heart disease (per 100,000)						
Q1	81.7 (5.4)	79.2 (6.7)	69.0 (5.3)	62.2 (5.1)	Year	<0.001
Q2	88.5 (7.8)	89.4 (9.0)	76.4 (9.4)	70.5 (8.0)	PPAR	<0.001
Q3	86.4 (7.0)	85.0 (7.5)	77.2 (7.3)	65.3 (9.0)	Inter-	0.93
Q4	86.0 (8.7)	83.7 (10.8)	74.6 (11.0)	63.0 (8.9)	action	
RII	1.05 (0.77–1.33)	1.05 (0.58–1.51)	1.10 (0.72–1.49)	0.99 (0.45–1.52)		
Stroke (per 100,000)						
Q1	73.7 (8.3)	62.3 (5.8)	48.7 (4.9)	39.5 (4.3)	Year	<0.001
Q2	75.2 (8.7)	61.2 (9.0)	49.8 (8.3)	38.2 (7.5)	PPAR	0.77
Q3	74.5 (9.7)	62.6 (9.8)	51.7 (8.9)	38.9 (6.1)	Inter-	1.00
Q4	75.9 (11.5)	64.1 (8.9)	51.0 (7.3)	39.3 (5.9)	action	
RII	1.03 (0.96–1.10)	1.04 (0.91–1.17)	1.07 (0.94–1.20)	1.00 (0.86–1.14)		

Mean (standard deviation) for mortality and mean (95% confidence intervals) for RII.
By PPAR, Q1, 1st quartile (lowest); Q2, 2nd quartile; Q3, 3rd quartile; Q4, 4th quartile (highest).
aTwo-way ANOVA.

2.4. Statistical analysis

Lifestyle data for individuals aged 40–69 years old were employed to exclude prefectures lacking participants within specific age groups. The lifestyle data were standardized using the 2010 Japanese population data based on 10-year age groups. Then, mortality and lifestyle data by prefecture were averaged according to the quartiles. Differences in mortality rates categorized according to year or lifestyle by period, and differences within quartiles were evaluated using a two-way analysis of variance. All analyses were performed using SPSS Statistics, version 25 (IBM, Tokyo, Japan). P-values less than 0.05 were considered to be statistically significant. To describe the magnitude of the inequality in PPAR, the relative inequality index (RII) (Mackenbach and Kunst, 1997) was calculated using Public Health England's Inequalities Calculation Tool (https://www.gov.uk/guidance/phe-data-and-analysis-tools#health-inequalities) (Measuring health inequalities. The Scottish Public Health Observatory, Public Health Scotland. [cited, 2024). For Q1, Q2, Q3, and Q4 data input, 12, 12, 12, and 11, the number of prefectures in each quartile, were entered for population at risk, while 1, 2, 3, and 4 were the deprivation scores, respectively. For input indicator details, "Directly standardized rate" was selected for indicator type, and "High is more deprived" for deprivation measure polarity. "Low is good" was selected for indicator polarity on all the parameters except for vegetable intake and number of steps, for which "High is good" was selected. Then, the RII, with its 95 % confidence intervals, was obtained by entering mean values of each mortality rate and parameter.

2.5. Ethical considerations

This study used vital statistics and publicly accessible data concerning public assistance recipients. Additionally, it utilized anonymized data obtained from the NHNS with the legal approval of the Ministry of Health, Labour, and Welfare. Thus, the study was exempted from institutional review board assessment.

3. Results

Mortality rates from all causes, cancer, heart disease, and stroke exhibited statistically significant variations by year for both men and women and decreased between 2000 and 2015 (Tables 1–1 and 1–2). Among both men and women, mortality rates from all causes, cancer, and heart disease demonstrated statistically significant differences across quartiles, with the lowest mortality observed in the first (lowest) quartile (Table 2-1).

Among men, BMI, total energy intake, vegetable consumption, salt intake, step count, and the prevalence of current smoking and drinking were statistically different across the different periods. Additionally, BMI exhibited an increase, whereas total energy, vegetable, and salt intake, as well as step count and the prevalence of current smoking and drinking exhibited a decrease throughout the study period (Table 2-1). BMI, total energy intake, vegetable consumption, and salt intake exhibited significant differences across quartiles in men. In the lower quartiles, BMI was lower, while the total energy, vegetable, and salt intakes were higher compared to the higher quartiles.

Among women, BMI, intake of total energy, vegetables, and salt, as well as the step count exhibited significant differences among periods; with all the parameters exhibiting a significant reduction throughout the study period (Table 2-2). BMI, vegetable and salt intake, and the prevalence of current smoking exhibited statistically significant differences across quartiles in women. BMI and the prevalence of current smoking were lower, while vegetable and salt intake was higher in the lower quartiles in comparison to the higher quartiles.

4. Discussion

Employing the same panel data from vital statistics and the NHNS as utilized by Nishi et al. (Nishi et al., 2023), the present study incorporated sex-specific PPAR as a socioeconomic indicator. Mortality rates from all causes, cancer, heart disease, and stroke exhibited a significant decrease from 2000 to 2015 in both sexes, and statistically significant differences in PPAR were observed exclusively for all causes, cancer, and heart disease in both sexes. Mortality from stroke did not show

Table 1-2
Age-standardized mortality in women from all causes, cancer, heart disease, and stroke by quartile of proportions of public assistance recipients (PPAR) of prefectures and relative inequality index (RII) in 2000, 2005, 2010, and 2015 in Japan.

	2000	2005	2010	2015	*P*	
All causes (per 100,000)						
Q1	313.5 (17.3)	286.7 (10.7)	267.4 (12.1)	248.9 (9.4)	Year	<0.001
Q2	322.2 (11.9)	302.4 (14.3)	271.1 (10.6)	253.9 (13.5)	PPAR	<0.001
Q3	321.2 (15.3)	296.4 (13.9)	278.5 (11.7)	259.7 (8.9)	Inter-	0.74
Q4	323.9 (15.3)	299.1 (10.0)	277.5 (12.3)	254.5 (13.3)	action	
RII	1.04 (0.96–1.11)	1.04 (0.87–1.22)	1.06 (0.99–1.13)	1.04 (0.91–1.16)		
Cancer (per 100,000)						
Q1	99.1 (5.4)	92.6 (5.0)	88.5 (3.9)	84.1 (4.7)	Year	<0.001
Q2	101.2 (4.5)	95.4 (3.2)	88.6 (4.3)	84.5 (3.5)	PPAR	0.001
Q3	101.1 (7.9)	97.1 (5.6)	91.4 (4.1)	87.6 (5.0)	Inter-	0.85
Q4	102.1 (7.0)	95.9 (5.8)	94.4 (7.0)	88.5 (7.8)	action	
RII	1.04 (0.98–1.09)	1.05 (0.93–1.17)	1.09 (1.00–1.19)	1.08 (1.00–1.15)		
Heart disease (per 100,000)						
Q1	46.7 (5.5)	43.5 (5.2)	37.1 (3.1)	32.2 (2.9)	Year	<0.001
Q2	48.9 (3.7)	48.1 (4.2)	41.7 (4.6)	36.8 (4.3)	PPAR	<0.001
Q3	47.8 (4.1)	45.3 (5.0)	41.8 (3.9)	34.6 (4.3)	Inter-	0.84
Q4	48.1 (4.8)	43.8 (3.7)	38.3 (4.2)	32.9 (4.2)	action	
RII	1.03 (0.86–1.19)	0.99 (0.55–1.42)	1.05 (0.48–1.61)	1.00 (0.43–1.57)		
Stroke (per 100,000)						
Q1	46.1 (5.9)	36.6 (2.6)	27.6 (2.9)	21.5 (2.0)	Year	<0.001
Q2	46.1 (5.9)	37.4 (5.6)	27.1 (5.0)	22.2 (4.7)	PPAR	0.34
Q3	46.1 (5.8)	35.1 (4.6)	27.9 (4.4)	22.8 (3.1)	Inter-	0.97
Q4	44.1 (5.6)	35.9 (5.8)	26.2 (4.1)	20.3 (3.1)	action	
RII	0.95 (0.82–1.08)	0.95 (0.75–1.16)	0.95 (0.74–1.16)	0.95 (0.51–1.40)		

Mean (standard deviation) for mortality and mean (95% confidence intervals) for RII.
By PPAR, Q1, 1st quartile (lowest); Q2, 2nd quartile; Q3, 3rd quartile; Q4, 4th quartile (highest).
aTwo-way ANOVA.

statistically significant differences according to PPAR in either sex. However, point estimates of the RII exhibited distinct patterns between men and women; they were consistently above 1.00 for men, except in 2015, whereas for women they were consistently below 1.00 (0.95). The rationale behind these distinct patterns, particularly in the case of stroke among women, remains unclear. Nonetheless, the lower prevalence of smoking and drinking among women compared to men, with statistically significant differences in the context of PPAR, exclusively, in terms of smoking, may be a potential contributing factor.

In contrast to mortality, the study revealed favorable trends and significant differences solely for BMI in women. Although statistically significant differences by PPAR were evident, with point estimates of the RII mostly exceeding unity, increases were observed in BMI for men, and decreases were noted in vegetable intake for both sexes. These lifestyle factors may not contribute to a reduction in mortality from all causes, cancer, and heart disease. Nevertheless, this observation could be attributed to the relatively narrow age range of 40–69 years considered for lifestyle factors in this study. Prioritizing the life course perspective (Cable, 2014) is more crucial than exclusively focusing on lifestyle factors during middle age.

Total energy intake decreased in both sexes, with statistically significant differences by PPAR observed in men ($P = 0.03$) and marginally significant differences in women ($P = 0.06$), where point estimates of the RII were equal to or lower than unity. The RII for total energy intake was calculated with the perspective that lower values are more favorable in the context of preventing non-communicable diseases. Two issues must be considered regarding total energy intake. First, there was an increase in BMI in men, while women experienced a decrease. It is noteworthy that these trends differed between men and women, despite both sexes showing a reduction in total energy intake and the number of steps taken. Using data from the NHNS, Fallah-Fini et al. (Fallah-Fini et al., 2021) conducted an estimation of the dynamics of the energy imbalance gap from 1975 to 2015. Their findings indicated a decrease in the energy imbalance gap decreased in men since 1987 and in women since 1975. This suggests that the dynamics of the energy imbalance gap follow a similar trend for both men and women. Second, there was a decline in vegetable and salt intake, with statistically significant differences by PPAR observed in both sexes. Point estimates of the RII were above unity for vegetable intake, except for Period 5, and were below unity for salt intake. The RII was calculated with the perspective that higher values are preferable for vegetable intake, while lower values are preferable for salt intake, to prevent non-communicable diseases. Despite the contrasting RII values observed for vegetable and salt intake, it appeared that the reduction in total energy intake contributed to the decrease in both vegetable and salt intake, showing significant differences by PPAR. In this context, the lower the quartile, the higher the intake of these factors. In addition to these considerations, there is a need for discussion regarding the lower RII values below unity for vegetable intake in Period 5. Vegetable intake for those aged 20 years and older in the NHNS in 2016 (276.8 for men and 263.2 for women) was lower than that in 2015 (292.7 for men and 279.3 for women) and in 2017 (289.5 for men and 270.7 for women) (National Health and Nutrition Survey, Ministry of Health, Labour and Welfare. [cited, 2023). Expanded surveys were conducted in 2012 and 2016, but the reason for the lower vegetable intake in 2016 in both sexes, especially in quartile 1, remains uncertain. Further observations of these changes are necessary.

Several epidemiological studies have been conducted on recipients of public assistance in Japan. Okumura et al. (Okumura et al., 2019) examined the geographical variation in psychiatric admissions among public assistance recipients from 2014 to 2016 and found large geographical variations by prefecture in the number and total medical cost of psychiatric admissions. Nishioka et al. (Nishioka et al., 2021) examined the non-financial social determinants of diabetes in a cohort study and found that unemployment and living alone might exacerbate risk of diabetes among young public assistance recipients. No studies have been conducted on public assistance recipients using ecological panel data analysis. PPAR remains relatively low, consistently at less than 3 % from 2000 to 2015 across all 47 prefectures. Nonetheless, it has the potential to serve as a comprehensive socioeconomic indicator. Future studies exploring various health indicators based on PPAR, employing ecological panel data analysis are expected.

Table 2-1
Lifestyle factors in men by quartile of proportions of public assistance recipients (PPAR) of prefectures and relative inequality index (RII) from Periods 1 to 5 in Japan.

	Period 1	Period 2	Period 3	Period 4	Period 5	P^a	
BMI (kg/m^2)							
Q1	23.4 (0.4)	23.6 (0.5)	23.8 (0.2)	23.9 (0.4)	24.0 (0.6)	Period	<0.001
Q2	23.5 (0.4)	23.7 (0.5)	23.9 (0.4)	23.9 (0.4)	24.2 (0.6)	PPAR	0.03
Q3	23.7 (0.6)	24.0 (0.5)	23.8 (0.7)	23.9 (0.5)	24.2 (0.5)	Inter-	0.93
Q4	23.9 (0.8)	24.0 (0.5)	24.1 (0.8)	23.9 (0.5)	24.2 (0.6)	action	
RII	1.03 (1.03–1.03)	1.03 (1.01–1.04)	1.01 (0.98–1.04)	1.00 (0.99–1.01)	1.01 (1.00–1.03)		
Total energy intake (kcal/day)							
Q1	2274 (133)	2254 (90)	2195 (94)	2186 (47)	2162 (76)	Period	<0.001
Q2	2201 (140)	2248 (102)	2243 (69)	2197 (60)	2151 (66)	PPAR	0.03
Q3	2269 (98)	2202 (90)	2226 (102)	2179 (44)	2158 (58)	Inter-	0.35
Q4	2247 (58)	2179 (93)	2140 (127)	2133 (84)	2138 (83)	action	
RII	1.00 (0.86–1.14)	0.95 (0.91–0.99)	0.97 (0.81–1.13)	0.97 (0.90–1.04)	0.99 (0.96–1.02)		
Vegetable intake (g/day)							
Q1	335.6 (32.0)	324.3 (35.7)	337.0 (33.1)	300.9 (35.4)	286.4 (30.3)	Period	<0.001
Q2	323.1 (49.1)	318.0 (39.1)	320.8 (41.8)	300.6 (23.0)	282.6 (17.3)	PPAR	0.005
Q3	311.0 (38.0)	295.8 (27.7)	306.2 (34.1)	299.9 (35.0)	284.6 (24.6)	Inter-	0.58
Q4	307.0 (74.2)	293.2 (18.5)	289.8 (33.3)	290.8 (26.8)	293.7 (22.8)	action	
RII	1.13 (1.05–1.23)	1.16 (1.01–1.37)	1.22 (1.20–1.24)	1.04 (0.96–1.14)	0.97 (0.86–1.10)		
Salt intake (g/day)							
Q1	13.7 (1.1)	13.0 (0.7)	12.4 (0.8)	11.7 (0.5)	11.1 (0.8)	Period	<0.001
Q2	13.5 (2.0)	13.5 (1.3)	12.7 (0.8)	11.6 (1.0)	10.9 (0.4)	PPAR	0.03
Q3	13.0 (1.0)	12.7 (0.9)	12.1 (0.7)	11.5 (0.8)	10.8 (0.6)	Inter-	0.80
Q4	13.6 (2.4)	12.3 (0.8)	11.7 (1.3)	11.2 (0.9)	10.8 (0.9)	action	
RII	0.97 (0.76–1.18)	0.92 (0.68–1.15)	0.92 (0.73–1.12)	0.95 (0.87–1.03)	0.97 (0.91–1.02)		
Number of steps (step/day)							
Q1	7778 (633)	7896 (519)	7455 (497)	7527 (750)	7163 (584)	Period	<0.001
Q2	7830 (907)	7278 (707)	7262 (721)	7182 (591)	7060 (466)	PPAR	0.05
Q3	7956 (873)	7595 (795)	7623 (777)	7262 (508)	7118 (383)	Inter-	0.74
Q4	7612 (700)	7261 (857)	6940 (624)	7317 (763)	7166 (733)	action	
RII	1.02 (0.87–1.22)	1.09 (0.84–1.54)	1.06 (0.80–1.59)	1.03 (0.88–1.24)	1.00 (0.94–1.07)		
Prevalence of current smoking (%)							
Q1	49.7 (6.4)	45.6 (6.7)	39.9 (4.7)	38.1 (6.0)	36.1 (5.0)	Period	<0.001
Q2	50.8 (7.8)	44.4 (4.2)	41.9 (5.0)	39.0 (4.6)	36.5 (5.5)	PPAR	0.82
Q3	47.5 (7.3)	45.5 (5.8)	40.8 (5.8)	38.5 (4.6)	37.3 (6.2)	Inter-	0.68
Q4	46.6 (6.1)	41.7 (8.4)	42.9 (7.7)	40.7 (5.8)	35.4 (5.3)	action	
RII	0.90 (0.70–1.10)	0.91 (0.67–1.16)	1.08 (0.88–1.28)	1.08 (0.91–1.25)	0.99 (0.78–1.19)		
Prevalence of current drinking (%)							
Q1		69.0 (6.5)	67.8 (6.4)	63.9 (4.8)	58.4 (6.0)	Period	<0.001
Q2		68.2 (5.6)	64.3 (5.2)	63.9 (3.8)	62.4 (5.9)	PPAR	0.65
Q3		70.2 (6.0)	68.2 (7.8)	63.6 (6.1)	62.4 (6.5)	Inter-	0.63
Q4		67.3 (5.9)	68.0 (9.0)	62.7 (3.6)	61.8 (5.7)	action	
RII		0.98 (0.83–1.14)	1.03 (0.77–1.28)	0.98 (0.93–1.02)	1.07 (0.84–1.30)		

Mean (standard deviation) for mortality and mean (95% confidence intervals) for RII. BMI, body mass index.
Period 1, 1999–2001; Period 2, 2003–2005; Period 3, 2007–2009; Period 4, 2012; Period 5, 2016.
By PPAR, Q1, 1st quartile (lowest); Q2, 2nd quartile; Q3, 3rd quartile; Q4, 4th quartile (highest).

5. Limitations

This study has some limitations. First, data on the number of public assistance recipients were available only for the year 2000 or later. Consequently, data for 1995–1997 reported by Nishi et al. (Nishi et al., 2023) was not included in the present study. Second, the mortality data for 2020 were excluded due to concerns about potential misinterpretation of the impact of the COVID-19 pandemic. In addition, an expanded survey was scheduled for the NHNS in 2020, similar to those conducted in 2012 and 2016. However, it had to be cancelled due to the COVID-19 emergency. Third, to ensure the exclusion of prefectures without data by age group, only lifestyle data for the 40–69-year age range were incorporated. Consequently, due to the limited number of participants, certain estimates, like the current prevalence of smoking in women, may appear unreliable.

6. Conclusion

In an analysis of mortality and lifestyle based on PPAR utilizing panel data, favorable trends and significant variations were observed in mortality rates related to all causes, cancer, and heart disease in both sexes. Additionally, significant findings were evident in the case of women's BMI. In conclusion, monitoring mortality and lifestyle trends using PPAR is a valuable approach for identifying implications relevant to public health policies.

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CRediT authorship contribution statement

Nobuo Nishi: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Kaori Kitaoka:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Phap Tran Ngoc Hoang:** . **Yukiko Okami:** Writing – review & editing, Validation, Software, Formal analysis, Data curation. **Keiko Kondo:** Writing – review & editing, Validation, Software, Formal analysis, Data curation. **Mizuki Sata:** Writing – review & editing, Writing – original

Table 2-2
Lifestyle factors in women by quartile of proportions of public assistance recipients (PPAR) of prefectures and relative inequality index (RII) from Periods 1 to 6 in Japan.

	Period 1	Period 2	Period 3	Period 4	Period 5	P^a	
BMI (kg/m^2)							
Q1	23.0 (0.3)	23.1 (0.7)	22.5 (0.3)	22.4 (0.4)	22.7 (0.4)	Period	<0.001
Q2	23.3 (0.4)	23.3 (0.4)	22.8 (0.6)	22.6 (0.5)	22.7 (0.6)	PPAR	0.046
Q3	23.3 (0.6)	23.3 (0.5)	23.0 (0.7)	22.5 (0.5)	22.7 (0.5)	Inter-	0.78
Q4	23.5 (0.6)	23.3 (0.7)	22.9 (0.8)	22.8 (0.6)	22.5 (0.6)	action	
RII	1.02 (1.00–1.05)	1.01 (0.99–1.04)	1.02 (0.98–1.07)	1.02 (0.97–1.07)	0.99 (0.96–1.02)		
Total energy intake (kcal/day)							
Q1	1806 (63)	1787 (46)	1759 (70)	1750 (46)	1705 (44)	Period	<0.001
Q2	1837 (61)	1794 (48)	1767 (64)	1719 (37)	1725 (47)	PPAR	0.06
Q3	1798 (96)	1793 (73)	1757 (54)	1723 (38)	1697 (45)	Inter-	0.35
Q4	1825 (79)	1759 (60)	1696 (62)	1706 (59)	1711 (57)	action	
RII	1.00 (0.91–1.10)	0.98 (0.92–1.05)	0.96 (0.85–1.07)	0.97 (0.93–1.02)	1.00 (0.93–1.06)		
Vegetable intake (g/day)							
Q1	337.1 (41.1)	311.6 (36.7)	306.8 (36.9)	293.3 (36.8)	270.4 (29.9)	Period	<0.001
Q2	299.8 (35.9)	300.4 (30.1)	318.1 (37.6)	287.0 (22.2)	268.9 (21.7)	PPAR	0.02
Q3	302.6 (37.1)	293.1 (37.8)	302.2 (25.5)	291.5 (23.2)	264.3 (26.2)	Inter-	0.21
Q4	301.5 (56.9)	289.2 (18.3)	280.7 (27.6)	276.8 (23.8)	281.0 (16.5)	action	
RII	1.15 (0.83–1.87)	1.10 (1.04–1.18)	1.13 (0.85–1.69)	1.06 (0.92–1.26)	0.96 (0.80–1.22)		
Salt intake (g/day)							
Q1	12.0 (0.9)	11.5 (0.7)	10.3 (0.6)	10.0 (0.5)	9.2 (0.5)	Period	<0.001
Q2	11.9 (1.2)	11.6 (0.9)	11.0 (0.9)	9.8 (0.7)	9.2 (0.3)	PPAR	0.004
Q3	11.4 (1.1)	11.3 (1.2)	10.3 (0.7)	10.0 (0.7)	9.2 (0.5)	Inter-	0.23
Q4	11.8 (1.6)	10.5 (0.9)	10.1 (0.8)	9.2 (0.6)	9.1 (0.5)	action	
RII	0.96 (0.80–1.12)	0.89 (0.69–1.10)	0.95 (0.65–1.24)	0.92 (0.67–1.17)	0.99 (0.94–1.05)		
Number of step (step/day)							
Q1	7665 (365)	7287 (641)	6950 (421)	6943 (389)	6567 (490)	Period	<0.001
Q2	7675 (348)	6899 (590)	6682 (679)	6931 (489)	6574 (586)	PPAR	0.25
Q3	7733 (589)	7121 (526)	6943 (436)	6702 (443)	6623 (254)	Inter-	0.73
Q4	7672 (448)	7151 (716)	6515 (602)	6765 (480)	6422 (423)	action	
RII	1.00 (0.96–1.03)	1.01 (0.83–1.29)	1.06 (0.86–1.39)	1.05 (0.95–1.16)	1.02 (0.93–1.14)		
Prevalence of current smoking (%)							
Q1	8.0 (2.8)	8.4 (3.4)	7.5 (3.3)	10.2 (2.6)	8.0 (2.6)	Period	0.15
Q2	8.4 (4.1)	10.0 (2.9)	10.0 (3.9)	8.7 (3.5)	10.2 (4.5)	PPAR	0.001
Q3	7.6 (4.7)	8.0 (3.7)	9.1 (3.5)	9.7 (3.6)	8.8 (3.5)	Inter-	0.66
Q4	9.0 (5.4)	13.0 (5.6)	9.4 (5.4)	11.8 (4.1)	12.3 (5.7)	action	
RII	1.11 (0.44–1.78)	1.61 (-0.51–3.72)	1.25 (0.19–2.30)	1.26 (0.15–2.36)	1.60 (0.15–3.05)		
Prevalence of current drinking (%)							
Q1		23.8 (4.6)	22.8 (4.8)	24.9 (4.9)	26.5 (3.5)	Period	0.06
Q2		24.6 (6.5)	24.5 (5.6)	24.2 (4.4)	27.2 (4.7)	PPAR	0.55
Q3		22.2 (6.7)	24.5 (6.3)	25.5 (2.7)	27.3 (5.1)	Inter-	0.86
Q4		26.2 (6.4)	24.9 (6.3)	26.9 (5.2)	26.0 (4.8)	action	
RII		1.07 (0.44–1.71)	1.11 (0.92–1.31)	1.12 (0.86–1.38)	0.98 (0.78–1.18)		

Mean (standard deviation) for mortality and mean (95% confidence intervals) for RII. BMI, body mass index.
Period 1, 1999–2001; Period 2, 2003–2005; Period 3, 2007–2009; Period 4, 2012; Period 5, 2016.
By PPAR, Q1, 1st quartile (lowest); Q2, 2nd quartile; Q3, 3rd quartile; Q4, 4th quartile (highest).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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