Social and Geographic Inequalities in Premature Adult Mortality in Japan: Observational Study from 1970 to 2005

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Social and Geographic Inequalities in Premature Adult Mortality in Japan: Observational Study from 1970 to 2005

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Abstract

Objectives: To examine trends in social and geographic inequalities in all-cause premature adult mortality in Japan from 1970 through 2005.

Design: Data were derived from the Vital Statistics and the Census. The participants were entire population aged 25 or older and less than 65 in 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. The total number of decedents was 984,022 and 532,223 in men and women, respectively. For each sex, odds ratios (ORs) and 95% confidence intervals (CIs) for mortality were estimated by using multilevel logistic regression models with "cells" (cross-tabulated by age and occupation) at level 1, eight years at level 2, and 47 prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality.

Results: Adjusting for age and time-trends, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (2.19 to 2.24) among service workers in men. By contrast, in women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (11.40 to 13.10) among security workers. The degree of occupational inequality increased in both sexes. Higher occupational groups did not experience reductions in mortality throughout the period and was overtaken by lower occupational groups in the early 1990s, among men. Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small in both sexes; the ORs ranged from 0.87 (Okinawa) to 1.13 (Aomori) for men and from 0.84 (Kanagawa) to 1.11 (Kagoshima) for women, even though there is a suggestion of increasing inequalities across prefectures since 1995 in both sexes.

Conclusion: The present findings demonstrate that both social and geographic inequalities in all-cause mortality have increased in Japan during the last three decades.

Article summary

Article focus:

While Japan enjoys the highest average life expectancy in the world, less has been documented on the trends and patterns of health inequalities within the nation.

We examined trends in social and geographic inequalities in all-cause premature adult mortality from 1970 through 2005.

Key messages:

This is the first study that simultaneously examines time trends in premature mortality by occupational class as well as geographic locality, and the results of our study indicate that health disparities have widened during the decades following the collapse of the asset bubble in the early 1990s.

Given the multiple challenges that threaten to further dampen economic activity of the nation, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

Strengths and limitations of this study:

The data are census based and cover the whole of Japan from 1970 through 2005.

This study uses multilevel methods to properly adjust for micro- and macro-level bias simultaneously.

We lacked information on whether the individuals were in standard jobs or precarious jobs.

INTRODUCTION

The postwar Constitution (1946) of Japan made equality a primary objective of the health system, and by 1961, the country achieved universal and compulsory health insurance coverage.[1] Although Japanese longevity was well below that of most European countries in 1960, subsequent health gains enabled the country to overtake other nations to the point where Japan reached the top of the national life expectancy rankings by 1985.[1 2] During the period of rapid economic growth (mid-1960s to 1989), Japan's social and economic policies helped to create a broad middle class with secure (often life-long) employment and comparatively egalitarian growth in living standards across the income spectrum.[1 3] Following the collapse of the asset bubble in the early 1990s, however, Japan's economy has been characterized by persistently low growth accompanied by a marked increase in the number of precarious workers (i.e., non-standard jobs such as part-time and contingent workers), from 1 in 5 employees in the 1990s to 1 in 3 employees by 2005.[4] The period since the collapse of the asset bubble – now referred to as the "Lost Two Decades" – has been characterized by a widening of income disparities and the emergence of a new class of "working poor" hitherto unrecognized in Japanese society.[5] In retrospect, the post-War period of comparatively egalitarian economic growth appears to have lasted about forty years,

and today, Japan ranks closer to countries such as the United States and the UK in terms of indicators of relative poverty, such as poverty rate and poverty gap.[6]

While there are considerable studies documenting social and geographic inequalities in mortality in other industrialized countries,[7-12] we are not aware of a similar comprehensive assessment of the trends in health inequalities in Japan that may have accompanied the major macroeconomic changes.[13] In this study, by using occupations as an indicator of socioeconomic position,[14] we examine the trends in occupational and geographic inequalities of all-cause premature adult mortality from 1970 through 2005. Since premature adult mortality focuses on death occurring at younger ages, they constitute a useful measure in public health as well as preventive medicine.[15]

METHODS

Data

Data on deaths were obtained from the "Report of Vital Statistics: Occupational and Industrial Aspects",[16] which has been conducted by the Ministry of Health, Labour and Welfare every five years since 1970, coinciding with the years of the Population Census. The latest year for which data are available is 2005. In the notification of deaths, the respondents are asked to fill in the occupation of decedent at the time of death,[17] and one of the following persons is obliged to submit the notification: (1) relatives who live together with decedents, (2) other housemates, (3) landlord, estate owner, land/house agent, or (4) relatives who do not live together with decedents. The occupation at the time of death is recorded for each decedent following the Japan Standard Occupational Classification.[18] During the follow-up period, the occupational classification scheme underwent four revisions (Supplementary Table 1).[18] In this study, we used the fourth revision of the Occupational Classification, which includes the following 11 groups[18]: (1) specialist and technical workers, (2) administrative and managerial workers, (3) clerical workers, (4) sales workers, (5) service workers, (6) security workers, (7) agriculture, forestry and fishery workers, (8) transport and communication workers, (9) production process and related workers, (10) workers not classifiable by occupation, and (11) non-employed. Note that the group "production process and related workers" includes mining workers. Note also that the group "non-employed" includes the unemployed as well as non-labor force (e.g., home-makers, students, and the retired). Although the Census distinguishes the unemployed from home-makers, the vital records combine these categories as "non-employed".[18] We restricted the analysis to those who are aged 25 or older and less than 65 to exclude students as well as the retired. The total number of decedents was 984,022 and 532,223 in men and women, respectively (Supplementary Figure 1 and Supplementary Table 2).

Denominator data for the calculation of mortality rates were obtained from the Population Census which has been conducted by Ministry of Internal Affairs and Communications every five years since 1920.[19] In the questionnaire for the Census, the occupation was assessed by asking a following question: "Description of work – Describe in detail the duties you are assigned to perform".[19] The questionnaires are delivered to each household, and someone in each household answers the question. We used "production process and related workers" as the referent category since they were the largest occupational category in a majority of the time periods (Supplementary Table 3).

Analysis

The data had a three-level multilevel structure of 32,590 cells for men and 32,542 cells for women at level 1, nested within eight years at level 2, nested within 47 prefectures at level 3. The eight years comprised of 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Each year had a maximum 88 cells (eight age groups times 11 occupational groups) (Supplementary Table 4). Note that the numbers of deaths for each cell are recorded during one fiscal year. For the descriptive purpose, we first calculated age-adjusted mortality rates by occupational class by year and sex (Supplementary Table 5). We used the direct method, using the model population of 1985 as a reference.[20] The model population of 1985 is based on the Japanese population under census of 1985 and it is created on the basis of 1,000 persons as 1 unit, after adjusting radical increase or decrease such as baby boom.[21] We then employed multilevel statistical procedures because of their ability to model complex variance structures at multiple levels.[22] In the present analysis, they allow estimation of the relationship between mortality and occupation, conditional on individual age variation ("fixed parameters") and year- and prefecture-level variations ("random parameters"). They also enable an estimation of the extent to which the relationship between mortality and occupation varies across years and prefectures (random parameters) and the degree to which prefecture-level socioeconomic status explains this variation (fixed parameters). The unit of analysis was "cells", and structurally, our models were identical to models with individuals at level 1.[23]

The response variable, proportion of deaths in each cell, was modeled with allowances made for the varying denominator in each cell. The fixed and random parameter estimates (along with their standard errors) for the multilevel binomial logit link model were calibrated using predictive/penalized quasi-likelihood procedures with second order Taylor series expansion, as implemented within the MLwiN 2.22.[24] Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). A *p* value of less than 0.05 (two-sided test) was considered statistically significant.

First, we conducted three-level analysis as an overall model, with cells at level 1, years at level 2, and prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality. Prefectures were ranked by ORs having the whole country of Japan as reference (value = 1), and uncertainty was estimated by 95% CIs. Further, to examine the temporal patterns of occupational and geographic inequality of mortality across years, we also conducted two-level analysis, with cells at level 1 and prefectures at level 2 separately for each year.

Then, to explore the temporal change of occupational inequality, we ran a three-level multilevel model including a fixed cross-level interaction effect between the 11 occupations (at level 1) and year (at level 2). In this analysis, we modeled the year as a continuous variable, and we calculated mean predicted probabilities for mortality among those aged 25 to 29 (referent category).

To present the results of geographic inequality in all-cause mortality, we created maps showing prefecture-level residuals by using the ArcGIS (ESRI Japan Inc., version 9.3).

RESULTS

Social inequality of mortality

Table 1 shows the results of social inequality of all-cause mortality in terms of occupation from overall model as well as year-specific models. Excluding workers not classifiable by occupation and non-employed, there were substantial health disparities by occupations in both sexes. Adjusting for age and time-trends in the overall model, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (95% CI 2.19 to 2.24) among service workers in men. Among women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (95% CI 11.40 to 13.10) among security workers.

The degree of occupational inequality increased in both sexes. Among men, in 1970, the lowest OR was 0.54 (95% CI 0.53 to 0.56) among administrative and managerial workers while the highest OR was 1.34 (95% CI 1.32 to 1.37) among agriculture, forestry and fishery workers. In 2005, however, the lowest odds for mortality was observed among production process and related workers (reference) whereas the highest OR was 3.97 (95% CI 3.84 to 4.11) among service workers. Among women, the lowest odds for mortality was observed among production process and related workers (reference) throughout the follow-up period, and the highest ORs in 1970 and 2005 were 11.43 (95% CI 9.14 to 14.29) and 16.25 (95% CI 13.65 to 19.34), respectively, among security workers.

Figures 1 and 2 show the temporal pattern of these occupational inequalities across years. We excluded workers not classifiable by occupation and non-employed from these Figures to enhance readability although they were included in the analysis. Among men, the mortality risk among three occupations (specialist and technical workers, administrative and managerial workers, and service workers) remained unchanged, whereas those of other occupation groups declined more or less. Especially, in addition to the workers not classifiable by occupation, three occupations (clerical workers, sales workers, and product process and related workers) experienced a considerable decline in mortality risk between 1970 and 2005.

By contrast, trends in mortality by occupational groups were more stable for women. Most occupations experienced the comparable trajectories during the period although administrative and managerial workers experienced relatively small declines in mortality risk. Specialist and technical workers and service workers also experienced declines in mortality risk among women although they remained on a plateau among men.

Geographic inequality of mortality

Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small across prefectures in both sexes, with slightly larger geographic inequality among women than men (Table 2). Prefecture-specific ORs ranged from 0.87 (Okinawa prefecture) to 1.13 (Aomori prefecture) for men and from 0.84 (Kanagawa prefecture) to 1.11 (Kagoshima prefecture) for women (Supplementary Tables 6 and 7). Figure 3 shows the results of geographic inequalities in mortality. We observed similar patterns in both sexes although they led to opposite results between the sexes in Akita and Fukui prefectures; in Akita, the mortality risk was higher in men whereas it was lower in women. In Fukui, however, the pattern was reversed.

Although overall geographic inequalities of mortality were relatively small, they appear to have increased over time (Table 2). In men, although prefecture-level variance was less pronounced until 1990 (around 0.003 on logit scale), it began to increase since 1995 steadily to 0.011 in 2005. By contrast, in women the prefecture-level variance (on logit scale) was 0.007 in 1970s, and it declined to 0.004

in 1990, and then increased up to 0.012 in 2005. The adjusted ORs and 95% CIs for mortality in each prefecture across years are shown in Supplementary Tables 6 and 7. In 1970, ORs ranged from 0.89 (Gifu prefecture) to 1.12 (Akita prefecture) for men and from 0.79 (Tokyo) to 1.14 (Kagoshima prefecture) for women. In 2005, the ranges were widened, and ORs ranged from 0.81 (Nara prefecture) to 1.27 (Aomori prefecture) for men and from 0.75 (Nara prefecture) to 1.18 (Kochi prefecture) for women. We show geographic and temporal variation in mortality, suggesting an increase in geographic inequalities across prefectures since 1995 in both sexes (Supplementary Figures 2 and 3 and Video).

Supplementary analyses

We examined two additional issues to further explore the occupational and geographic inequalities in premature mortality; (i) the patterns of geographic inequalities in mortality by occupations, and (ii) the presence of contextual effects of prefecture-level socioeconomic status on mortality risk (Supplementary Text, Supplementary Figures 4 and 5, Supplementary Tables 8 and 9).

DISCUSSION

Summary of findings

The findings of the present study suggest that the economic trends during the past 35 years have been accompanied by a widening of health inequalities between occupational classes as well as geographic areas of the country. The post-bubble economy has been characterized by lackluster growth combined with a dramatic shift in the work-force away from life-long employment towards more precarious employment.[4] This economic restructuring has increased pressure on workers in managerial and professional workers (primarily men) who are being squeezed to raise their productivity. The changing pattern of health inequalities across occupational groups is consistent with this interpretation, i.e., the stalled decline in premature mortality among white collar workers relative to other occupational classes.

Comparison with other studies

The present findings suggest that the health effects of the changing economic conditions depend on individual's socioeconomic circumstances. A previous study in Japan demonstrated that, although self-rated health improved for both sexes throughout the economic crisis of the 1990s, health disparities in relation to occupations widened, especially among men.[25] They also reported that middle-class male workers and female homemakers seemed to be particularly adversely affected by the crisis.[25] The present study, however, provides a different pattern of widening health disparities in both sexes.

For men, absolute health status improvement was observed only among some lower occupational groups (e.g., production process and related workers, sales workers, and clerical workers), whereas higher occupational classes (e.g., specialist and technical workers and administrative and managerial workers) apparently obtained no benefit throughout the period. Indeed, although they were advantaged with regard to mortality risk in 1970s and 1980s, they were overtaken in the 1990s by those in lower occupational classes who benefited more during the same period. Of note, this "cross-over" almost coincided with the collapse of the economic bubble in the early 1990s. We note at the same time that neither male service workers nor agricultural, forestry and fishery workers experienced improvements in premature mortality throughout the period.

By contrast, for women, we observe that absolute health status improved roughly to the same extent across occupational groups, and that changes in ranking were less pronounced in women compared to men. We should note that relatively few women were represented in the three occupational groups with higher risk of mortality (i.e., administrative and managerial workers, security workers, and transport and communication workers). Even excluding these occupational groups, however, health inequalities appeared to have increased in women. These findings may be explained by differences between men and women according to the type of work and industrial sector of employment. Men are more likely to be engaged in work in the private sector as well as in parts of the economy that are more vulnerable to economic downturns (such as finance and business services, manufacturing, construction).[26]

Potential mechanisms of social inequalities in mortality

The present findings provide a marked contrast to the evolution of health inequalities described in other industrialized countries. In industrialized western European and north American countries, health status typically follows a hierarchical pattern: i.e., the lower the socioeconomic position, the worse the health status.[5 8 10 11] We show that this "typical" pattern of health inequalities does not necessarily apply to Japan. In contrast to Western countries, previous studies in Japan have yielded inconsistent results with regard to the relationship between socioeconomic status and health outcomes, and lower non-manual or manual workers do not necessarily exhibit less healthy behaviors compared with those in higher occupational classes.[27-32] Nevertheless, a recent study of a nationally representative sample in 2001 showed that men in lower occupational classes, such as service work, transportation, and labor work, were significantly more likely to engage in health risk behaviors compared with professional workers.[33] They also showed that there is a cumulation of risky behaviors in lower female occupational classes.[33] Further, another cross-sectional study in Japan demonstrated that occupation was not significantly associated with psychological distress among men or women by using a nationally representative sample in 2007.[34] Thus, the pattern of health inequalities in the present analysis is not consistent with occupational class differences in health behaviors or psychosocial stress.

Geographic and temporal variation in mortality

By applying the novel multilevel methods, the present study shows that geographic inequalities in premature mortality have also widened since 1995, In an ecological study, Fukuda et al.[35] assessed the time trend of geographic health inequality in Japan, by examining the association of life expectancy and age-adjusted mortality with per capita income of prefectures and municipalities. While excluding Okinawa prefecture from the analyses, they found a possible increase in geographic health inequalities from 1995 to 2000, following a decrease from 1955 to 1995.[35] Note that the present study examined geographic inequalities, conditional on individual age and occupation, providing suggestive evidence of "common ecologic effects" of place where people live.[36] Broadly speaking, since 1995, higher mortality risk has been consistently observed in the northeastern region in the main island (Tohoku region) for both sexes. Overall, the economic conditions of the predominantly rural areas in the region may be characterized by population decline, population aging, and lower per capita income.[19, 37] Notably, however, not all rural prefectures have undergone the same transition; indeed some rural prefectures (such as Nara and Okayama) had moved up through the ranks as having significantly lower mortality for both sexes in 2005. In the supplementary analysis, no clear associations were found with prefecture-level socioeconomic variables, and it remains unknown what contributed to these distinct patterns. These patterns deserve further attention in future studies.

Limitations of the study

There are some limitations of our analysis. First, although we were able to conduct a fairly detailed analysis of trends by occupational class, neither the status in employment nor the predominant type of employment contract was available, and in particular, we lacked information on whether the individuals were in standard jobs or precarious jobs. Given the conspicuous increase in the proportion of the labor force engaged in non-standard work,[4] as well as mounting evidence that precarious work is associated with worse health,[38] future work needs to examine whether the changing character of the workforce in Japan is contributing to widening health inequalities.

Second, occupation at the time of death was used in our numerator data, which may not necessarily reflect the individual's life-course socioeconomic position.[39 40] If unhealthy workers selectively exited some occupations, this would have led to an under-estimation of mortality in those sectors. The proportion of agricultural workers significantly decreased during the study period for both sexes, as well as that of administrative and managerial workers (for men). However, this may reflect real trends in the work-force.

Third, considering the possible discrepancies of the respondents on the two occasions (i.e., the notification of deaths and the census), we should note the potential for numerator denominator bias between the two sources of information. In particular, the possibility of measurement error in occupation at the time of death cannot be ruled out – the person recording the notification of deaths may either promotes the deceased to a higher status job or demotes them because the respondents did not know the details of the deceased's job.

Fourth, the smallest geographic unit available was the prefecture (of which there are 47), and we could not explore geographic inequalities in finer detail. However, the prefecture may be a useful and valid unit of analysis since it is the unit that has direct administrative authority in the economic, education, and health sectors.[1] Furthermore, the prefecture has specific jurisdiction over health centers, which is the locus of preventive health care activity in Japan.[1] Note also that the boundaries between prefectures have not changed since the Meiji Restoration (1867), enabling long-term analysis.[1] Since previous studies demonstrated that the choice of geographic units as well as area-based measures is critical in the investigation of geographic inequalities,[41 42] these issues warrant further examination.

Conclusions

The present findings demonstrate that both social and geographic inequalities in premature adult mortality have increased during Japan's "Lost Two Decades" following the collapse of the asset bubble. As a nation, Japan must grapple with the triple demographic trends of declining fertility, population aging, and overall population decline. These trends threaten to further dampen economic activity, escalating the load on the social security system. In addition, Japan now faces multiple challenges in the wake of the earthquake and tsunami on March 11, 2011, and this may further place downward momentum on the nation's struggling economy. Given these momentous challenges, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

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no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: Ethical approval was not required.

Data sharing: No additional data available.

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Figure legends

Figure 1. Predicted mortality by occupations in men, Japan, 1970-2005.

We show mean predicted probabilities for all-cause mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed.

Figure 2. Predicted mortality by occupations in women, Japan, 1970-2005.

We show mean predicted probabilities for all-cause mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed.

Figure 3. Geographic inequality of all-cause mortality, Japan, 1970-2005.

We show the overall geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Table 1. Odds ratios for all-cause mortality in each occupation, Japan, 1970-2005 [a]

	Overall		1970		1975		1980	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Men								
Specialist and technical workers	1.31	(1.30 to 1.33)	0.74	(0.72 to 0.77)	0.80	(0.77 to 0.82)	1.18	(1.14 to 1.21)
Administrative and managerial workers	0.97	(0.96 to 0.98)	0.54	(0.53 to 0.56)	0.66	(0.64 to 0.68)	0.76	(0.74 to 0.78)
Clerical workers	1.20	(1.19 to 1.21)	1.05	(1.03 to 1.08)	1.09	(1.06 to 1.12)	1.18	(1.15 to 1.21)
Sales workers	1.26	(1.25 to 1.27)	1.25	(1.23 to 1.28)	1.26	(1.24 to 1.29)	1.38	(1.35 to 1.41)
Service workers	2.22	(2.19 to 2.24)	1.22	(1.18 to 1.27)	1.20	(1.16 to 1.25)	1.93	(1.86 to 1.99)
Security workers	1.05	(1.03 to 1.08)	0.67	(0.63 to 0.72)	0.76	(0.72 to 0.81)	0.94	(0.88 to 1.00)
Agriculture, forestry and fishery workers	1.89	(1.87 to 1.91)	1.34	(1.32 to 1.37)	1.48	(1.45 to 1.51)	1.74	(1.71 to 1.78)
Transport and communication workers	1.29	(1.28 to 1.31)	1.06	(1.02 to 1.09)	0.98	(0.95 to 1.02)	1.17	(1.13 to 1.21)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	29.61	(29.28 to 29.94)	41.44	(37.93 to 45.28)	59.25	(56.07 to 62.61)	115.11	(110.66 to 119.75)
Non-employed	7.78	(7.73 to 7.82)	5.83	(5.73 to 5.93)	6.18	(6.07 to 6.28)	6.68	(6.56 to 6.80)
Women								
Specialist and technical workers	1.85	(1.81 to 1.89)	1.64	(1.54 to 1.74)	1.54	(1.44 to 1.63)	1.88	(1.77 to 2.00)
Administrative and managerial workers	4.91	(4.76 to 5.06)	3.57	(3.26 to 3.91)	3.54	(3.23 to 3.87)	3.17	(2.88 to 3.50)
Clerical workers	1.23	(1.20 to 1.25)	1.63	(1.55 to 1.72)	1.35	(1.28 to 1.42)	1.45	(1.38 to 1.53)
Sales workers	1.80	(1.77 to 1.83)	1.35	(1.29 to 1.41)	1.45	(1.38 to 1.52)	1.87	(1.78 to 1.97)
Service workers	1.65	(1.62 to 1.68)	1.11	(1.06 to 1.17)	1.04	(0.99 to 1.10)	1.77	(1.68 to 1.86)
Security workers	12.22	(11.40 to 13.10)	11.43	(9.14 to 14.29)	9.24	(7.30 to 11.69)	11.57	(9.07 to 14.76)
Agriculture, forestry and fishery workers	2.25	(2.22 to 2.29)	1.65	(1.60 to 1.71)	1.88	(1.80 to 1.95)	2.18	(2.09 to 2.28)
Transport and communication workers	6.88	(6.59 to 7.18)	4.01	(3.53 to 4.55)	3.89	(3.42 to 4.43)	7.07	(6.31 to 7.91)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	42.07	(41.22 to 42.93)	41.07	(35.48 to 47.54)	14.58	(13.19 to 16.12)	110.06	(103.28 to 117.29)
Non-employed	4.81	(4.75 to 4.88)	3.39	(3.29 to 3.50)	3.45	(3.34 to 3.56)	4.48	(4.32 to 4.65)

CI; confidence interval, OR; odds ratio

[a] We adjusted for age (five year categories) and year in the overall model. We adjusted for only age (five year categories) in other models.

Table 1. Odds ratios for all-cause mortality in each occupation, Japan, 1970-2005 (cont.)

1985		1990		1995		2000		2005	
OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
1.14	(1.10 to 1.17)	1.25	(1.21 to 1.28)	1.35	(1.32 to 1.39)	2.83	(2.75 to 2.90)	2.50	(2.43 to 2.57)
1.01	(0.98 to 1.04)	1.04	(1.01 to 1.07)	1.08	(1.05 to 1.11)	2.26	(2.19 to 2.34)	2.50	(2.41 to 2.60)
1.25	(1.22 to 1.28)	1.40	(1.37 to 1.44)	1.34	(1.31 to 1.38)	1.42	(1.37 to 1.46)	1.07	(1.03 to 1.11)
1.38	(1.35 to 1.41)	1.26	(1.23 to 1.29)	1.15	(1.12 to 1.18)	1.37	(1.33 to 1.41)	1.27	(1.23 to 1.31)
1.97	(1.91 to 2.04)	2.64	(2.56 to 2.72)	2.90	(2.81 to 2.99)	3.93	(3.81 to 4.06)	3.97	(3.84 to 4.11)
1.05	(0.99 to 1.11)	1.28	(1.21 to 1.36)	1.21	(1.15 to 1.29)	1.53	(1.45 to 1.62)	1.77	(1.68 to 1.87)
1.97	(1.92 to 2.01)	2.21	(2.16 to 2.27)	2.37	(2.30 to 2.44)	3.32	(3.21 to 3.43)	3.12	(3.00 to 3.24)
1.20	(1.17 to 1.24)	1.33	(1.29 to 1.37)	1.43	(1.39 to 1.48)	1.88	(1.82 to 1.94)	1.92	(1.85 to 2.00)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
49.01	(47.39 to 50.69)	34.66	(33.64 to 35.72)	54.18	(52.82 to 55.58)	52.73	(51.40 to 54.08)	9.13	(8.80 to 9.48)
6.94	(6.82 to 7.06)	8.15	(8.01 to 8.30)	8.59	(8.44 to 8.74)	11.16	(10.93 to 11.39)	14.21	(13.90 to 14.52)
1.82	(1.71 to 1.93)	1.85	(1.74 to 1.96)	2.02	(1.89 to 2.15)	2.83	(2.65 to 3.01)	2.63	(2.45 to 2.82)
3.68	(3.37 to 4.02)	5.16	(4.77 to 5.58)	6.08	(5.60 to 6.61)	10.16	(9.31 to 11.09)	12.21	(11.07 to 13.47)
1.26	(1.20 to 1.33)	1.17	(1.11 to 1.23)	1.32	(1.25 to 1.40)	1.31	(1.23 to 1.39)	1.26	(1.17 to 1.35)
2.03	(1.93 to 2.13)	1.89	(1.80 to 1.98)	1.94	(1.83 to 2.05)	2.20	(2.06 to 2.34)	2.32	(2.16 to 2.50)
1.67	(1.58 to 1.76)	1.86	(1.77 to 1.95)	2.21	(2.09 to 2.33)	2.42	(2.28 to 2.57)	2.49	(2.33 to 2.67)
19.51	(16.24 to 23.43)	17.07	(14.34 to 20.33)	13.22	(10.88 to 16.05)	12.49	(10.34 to 15.09)	16.25	(13.65 to 19.34)
2.08	(1.98 to 2.18)	2.10	(2.00 to 2.20)	2.63	(2.47 to 2.79)	3.15	(2.93 to 3.39)	3.42	(3.14 to 3.73)
7.52	(6.73 to 8.40)	9.54	(8.59 to 10.61)	8.17	(7.20 to 9.28)	9.65	(8.45 to 11.01)	11.54	(10.06 to 13.24)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
48.48	(45.76 to 51.37)	51.39	(48.69 to 54.24)	90.68	(86.15 to 95.46)	80.79	(76.53 to 85.29)	14.45	(13.33 to 15.67)
4.38	(4.23 to 4.54)	4.46	(4.30 to 4.62)	6.29	(6.04 to 6.55)	7.91	(7.55 to 8.29)	9.62	(9.10 to 10.16)

1 Table 2. Adjusted prefecture-level variance for all-cause mortality, Japan, 1970-2005 [a]

	Men			Women		
	Variance (on logit scale)			Variance (on logit scale)		
	Estimate	(95% CI)	Range of OR [b]	Estimate	(95% CI)	Range of OR [b]
Overall	0.003	(0.001 to 0.004)	0.87 to 1.13	0.005	(0.003 to 0.007)	0.84 to 1.11
1970 [c]	0.003	(0.002 to 0.005)	0.89 to 1.12	0.007	(0.004 to 0.010)	0.79 to 1.14
1975	0.003	(0.001 to 0.004)	0.88 to 1.09	0.007	(0.004 to 0.010)	0.82 to 1.19
1980	0.004	(0.002 to 0.005)	0.82 to 1.11	0.005	(0.003 to 0.008)	0.85 to 1.15
1985	0.003	(0.001 to 0.004)	0.85 to 1.09	0.005	(0.002 to 0.007)	0.86 to 1.13
1990	0.003	(0.002 to 0.004)	0.89 to 1.11	0.004	(0.002 to 0.006)	0.88 to 1.10
1995	0.006	(0.003 to 0.009)	0.85 to 1.22	0.008	(0.004 to 0.012)	0.80 to 1.15
2000	0.007	(0.004 to 0.010)	0.84 to 1.25	0.010	(0.005 to 0.015)	0.76 to 1.15
2005	0.011	(0.007 to 0.016)	0.81 to 1.27	0.012	(0.007 to 0.017)	0.75 to 1.18

2 CI; confidence interval, OR; odds ratio

3 [a] We adjusted for age (five year categories) and occupations. We further adjusted for year in the overall model.

4 [b] The range of adjusted odds ratios for mortality in each prefecture is shown. The reference is the grand mean of all the prefectures.

5 [c] The variance between 46 prefectures is shown because the data for Okinawa prefecture were not available in 1970.

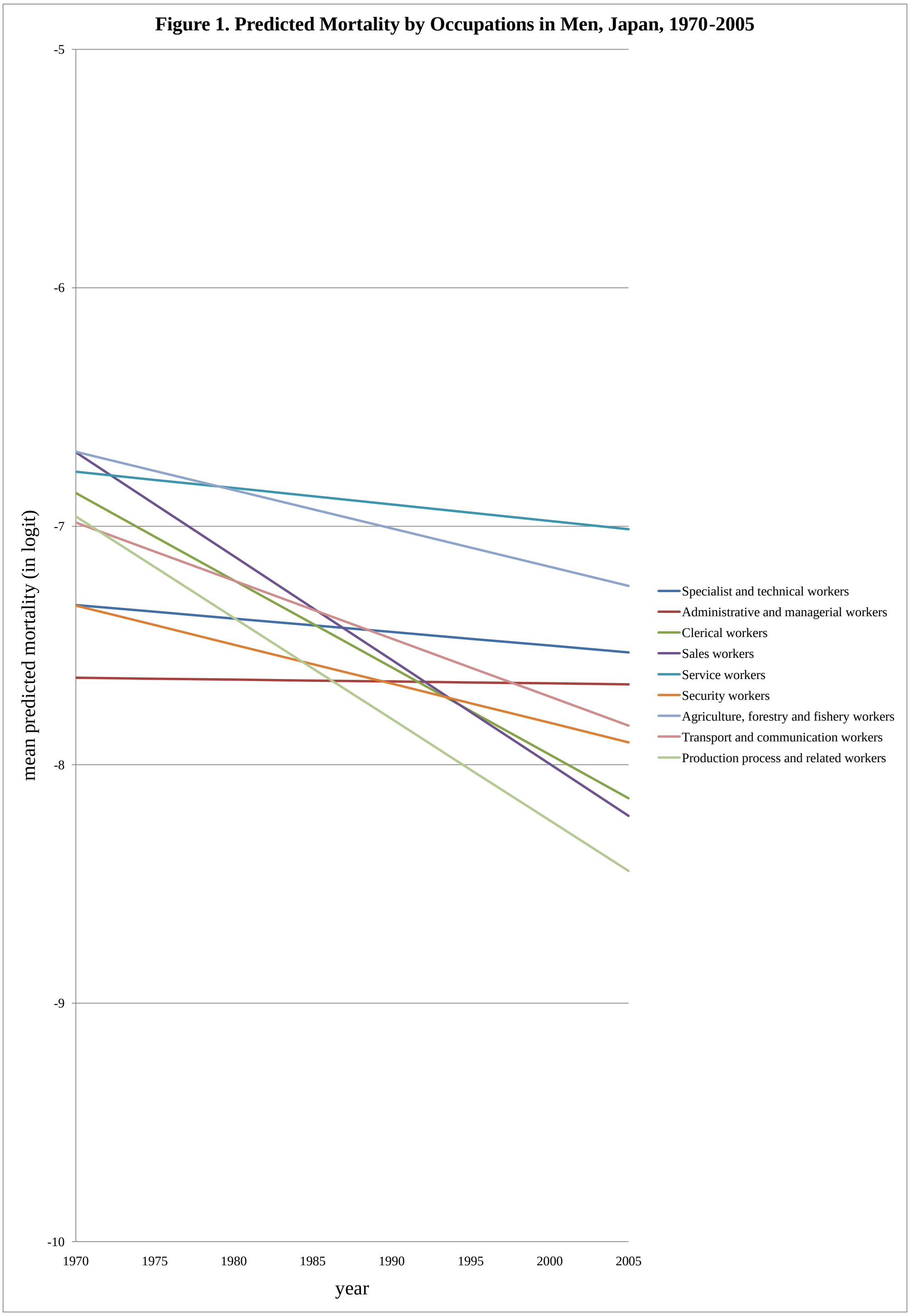
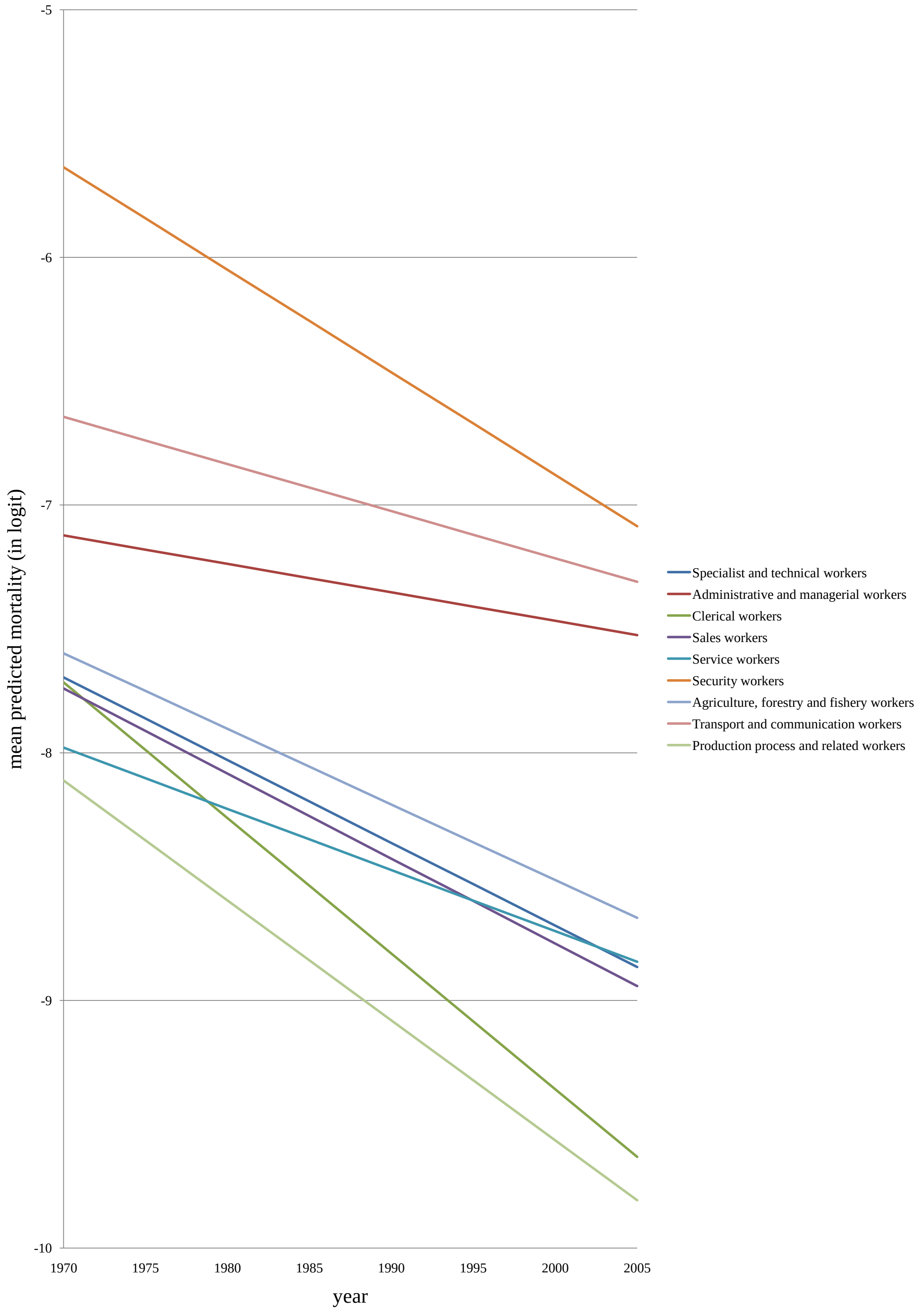
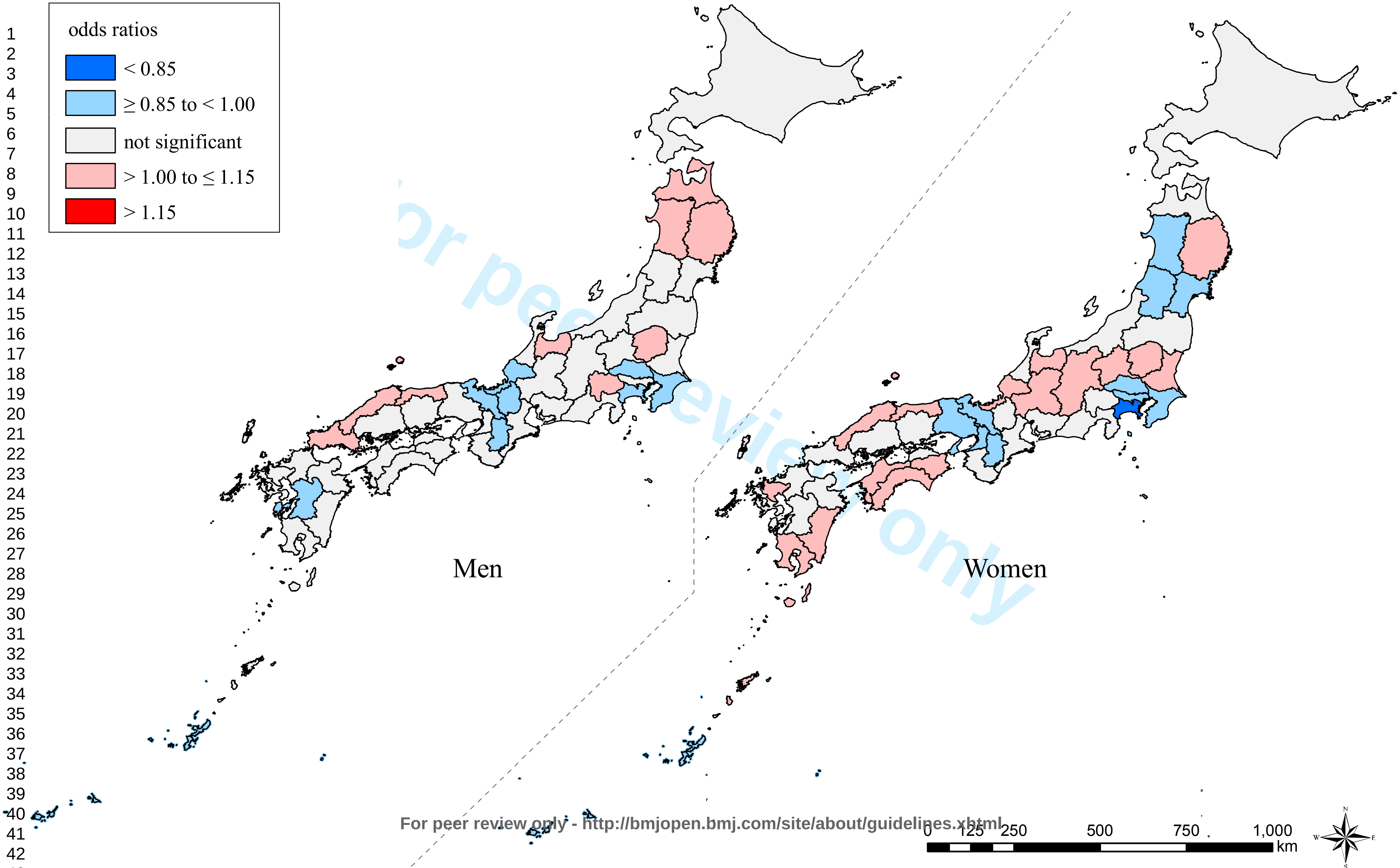


Figure 1. Predicted Mortality by Occupations in Men, Japan, 1970-2005
mean predicted mortality (in logit)
-5
-6
-7
-8
-9
-10
1970
1975
1980
1985
1990
1995
2000
2005
year
Specialist and technical workers
Administrative and managerial workers
Clerical workers
Sales workers
Service workers
Security workers
Agriculture, forestry and fishery workers
Transport and communication workers
Production process and related workers

Figure 2. Predicted Mortality by Occupations in Women, Japan, 1970-2005




odds ratios
< 0.85
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Men
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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes
Methods			
Study design	4	Present key elements of study design early in the paper	Yes
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Yes
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	Yes
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes
		(*b*) Describe any methods used to examine subgroups and interactions	Yes
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	Yes
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which	Yes

		confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Yes
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Yes
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Social and Geographic Inequalities in Premature Adult Mortality in Japan: Observational Study from 1970 to 2005

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Abstract

Objectives: To examine trends in social and geographic inequalities in all-cause premature adult mortality in Japan from 1970 through 2005.

Design: Data were derived from the Vital Statistics and the Census. The participants were entire population aged 25 or older and less than 65 in 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. The total number of decedents was 984,022 and 532,223 in men and women, respectively. For each sex, odds ratios (ORs) and 95% confidence intervals (CIs) for mortality were estimated by using multilevel logistic regression models with "cells" (cross-tabulated by age and occupation) at level 1, eight years at level 2, and 47 prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality.

Results: Adjusting for age and time-trends, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (2.19 to 2.24) among service workers in men. By contrast, in women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (11.40 to 13.10) among security workers. The degree of occupational inequality increased in both sexes. Higher occupational groups did not experience reductions in mortality

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throughout the period and was overtaken by lower occupational groups in the early 1990s, among men. Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small in both sexes; the ORs ranged from 0.87 (Okinawa) to 1.13 (Aomori) for men and from 0.84 (Kanagawa) to 1.11 (Kagoshima) for women, even though there is a suggestion of increasing inequalities across prefectures since 1995 in both sexes.

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Conclusion: The present findings demonstrate that both social and geographic inequalities in all-cause mortality have increased in Japan during the last three decades.

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Article summary

Article focus:

While Japan enjoys the highest average life expectancy in the world, less has been documented on the trends and patterns of health inequalities within the nation.

We examined trends in social and geographic inequalities in all-cause premature adult mortality from 1970 through 2005.

Key messages:

This is the first study that simultaneously examines time trends in premature mortality by occupational class as well as geographic locality, and the results of our study indicate that health disparities have widened during the decades following the collapse of the asset bubble in the early 1990s.

Given the multiple challenges that threaten to further dampen economic activity of the nation, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

Strengths and limitations of this study:

The data are census based and cover the whole of Japan from 1970 through 2005.

This study uses multilevel methods to properly adjust for micro- and macro-level bias simultaneously.

We lacked information on whether the individuals were in standard jobs or precarious jobs.

INTRODUCTION

The postwar Constitution (1946) of Japan made equality a primary objective of the health system, and by 1961, the country achieved universal and compulsory health insurance coverage.[1] Although Japanese longevity was well below that of most European countries in 1960, subsequent health gains enabled the country to overtake other nations to the point where Japan reached the top of the national life expectancy rankings by 1985.[1 2] During the period of rapid economic growth (mid-1960s to 1989), Japan's social and economic policies helped to create a broad middle class with secure (often life-long) employment and comparatively egalitarian growth in living standards across the income spectrum.[1 3] Following the collapse of the asset bubble in the early 1990s, however, Japan's economy has been characterized by persistently low growth accompanied by a marked increase in the number of precarious workers (i.e., non-standard jobs such as part-time and contingent workers), from 1 in 5 employees in the 1990s to 1 in 3 employees by 2005.[4] The period since the collapse of the asset bubble – now referred to as the "Lost Two Decades" – has been characterized by a widening of income disparities and the emergence of a new class of "working poor" hitherto unrecognized in Japanese society.[5] In retrospect, the post-War period of comparatively egalitarian economic growth appears to have lasted about forty years,

and today, Japan ranks closer to countries such as the United States and the UK in terms of indicators of relative poverty, such as poverty rate and poverty gap.[6]

While there are considerable studies documenting social and geographic inequalities in mortality in other industrialized countries,[7-12] we are not aware of a similar comprehensive assessment of the trends in health inequalities in Japan that may have accompanied the major macroeconomic changes.[13] In this study, by using occupations as an indicator of socioeconomic position,[14] we examine the trends in occupational and geographic inequalities of all-cause premature adult mortality from 1970 through 2005. Since premature adult mortality focuses on death occurring at younger ages, they constitute a useful measure in public health as well as preventive medicine.[15]

METHODS

Data

Data on deaths were obtained from the "Report of Vital Statistics: Occupational and Industrial Aspects",[16] which has been conducted by the Ministry of Health, Labour and Welfare every five years since 1970, coinciding with the years of the Population Census. The latest year for which data are available is 2005. In the notification of

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deaths, the respondents are asked to fill in the occupation of decedent at the time of death,[17] and one of the following persons is obliged to submit the notification: (1) relatives who live together with decedents, (2) other housemates, (3) landlord, estate owner, land/house agent, or (4) relatives who do not live together with decedents. The occupation at the time of death is recorded for each decedent following the Japan Standard Occupational Classification.[18] During the follow-up period, the occupational classification scheme underwent four revisions (Supplementary Table 1).[18] In this study, we used the fourth revision of the Occupational Classification, which includes the following 11 groups[18]: (1) specialist and technical workers, (2) administrative and managerial workers, (3) clerical workers, (4) sales workers, (5) service workers, (6) security workers, (7) agriculture, forestry and fishery workers, (8) transport and communication workers, (9) production process and related workers, (10) workers not classifiable by occupation, and (11) non-employed. Note that the group "production process and related workers" includes mining workers. Note also that the group "non-employed" includes the unemployed as well as non-labor force (e.g., home-makers, students, and the retired). Although the Census distinguishes the unemployed from home-makers, the vital records combine these categories as "non-employed".[18] We restricted the analysis to those who are aged 25 or older and

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less than 65 to exclude students as well as the retired. The total number of decedents was 984,022 and 532,223 in men and women, respectively (Supplementary Figure 1 and Supplementary Table 2).

Denominator data for the calculation of mortality rates were obtained from the Population Census which has been conducted by Ministry of Internal Affairs and Communications every five years since 1920.[19] In the questionnaire for the Census, the occupation was assessed by asking a following question: "Description of work – Describe in detail the duties you are assigned to perform".[19] The questionnaires are delivered to each household, and someone in each household answers the question. We used "production process and related workers" as the referent category since they were the largest occupational category in a majority of the time periods (Supplementary Table 3).

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Analysis

The data had a three-level multilevel structure of 32,590 cells for men and 32,542 cells for women at level 1, nested within eight years at level 2, nested within 47 prefectures at level 3. The eight years comprised of 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Each year had a maximum 88 cells (eight age groups times 11 occupational groups) (Supplementary Table 4). Note that the numbers of deaths for each cell are

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recorded during one fiscal year. For the descriptive purpose, we first calculated age-adjusted mortality rates by occupational class by year and sex (Supplementary Table 5). We used the direct method, using the model population of 1985 as a reference.[20] The model population of 1985 is based on the Japanese population under census of 1985 and it is created on the basis of 1,000 persons as 1 unit, after adjusting radical increase or decrease such as baby boom.[21] We then employed multilevel statistical procedures because of their ability to model complex variance structures at multiple levels.[22] In the present analysis, they allow estimation of the relationship between mortality and occupation, conditional on individual age variation ("fixed parameters") and year- and prefecture-level variations ("random parameters"). They also enable an estimation of the extent to which the relationship between mortality and occupation varies across years and prefectures (random parameters) and the degree to which prefecture-level socioeconomic status explains this variation (fixed parameters). The unit of analysis was "cells", and structurally, our models were identical to models with individuals at level 1.[23]

The response variable, proportion of deaths in each cell, was modeled with allowances made for the varying denominator in each cell. The fixed and random parameter estimates (along with their standard errors) for the multilevel binomial logit link model were calibrated using predictive/penalized quasi-likelihood procedures with second order Taylor series expansion, as implemented within the MLwiN 2.22.[24] Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). A *p* value of less than 0.05 (two-sided test) was considered statistically significant.

First, we conducted three-level analysis as an overall model, with cells at level 1, years at level 2, and prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality. Prefectures were ranked by ORs having the whole country of Japan as reference (value = 1), and uncertainty was estimated by 95% CIs. Further, to examine the temporal patterns of occupational and geographic inequality of mortality across years, we also conducted two-level analysis, with cells at level 1 and prefectures at level 2 separately for each year.

Then, to explore the temporal change of occupational inequality, we ran a three-level multilevel model including a fixed cross-level interaction effect between the 11 occupations (at level 1) and year (at level 2). In this analysis, we modeled the year as a continuous variable, and we calculated mean predicted probabilities for mortality among those aged 25 to 29 (referent category).

To present the results of geographic inequality in all-cause mortality, we created maps showing prefecture-level residuals by using the ArcGIS (ESRI Japan Inc.,

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RESULTS

Social inequality of mortality

Table 1 shows the results of social inequality of all-cause mortality in terms of occupation from overall model as well as year-specific models. Excluding workers not classifiable by occupation and non-employed, there were substantial health disparities by occupations in both sexes. Adjusting for age and time-trends in the overall model, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (95% CI 2.19 to 2.24) among service workers in men. Among women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (95% CI 11.40 to 13.10) among security workers.

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The degree of occupational inequality increased in both sexes. Among men, in 1970, the lowest OR was 0.54 (95% CI 0.53 to 0.56) among administrative and managerial workers while the highest OR was 1.34 (95% CI 1.32 to 1.37) among agriculture, forestry and fishery workers. In 2005, however, the lowest odds for mortality was observed among production process and related workers (reference)

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whereas the highest OR was 3.97 (95% CI 3.84 to 4.11) among service workers. Among women, the lowest odds for mortality was observed among production process and related workers (reference) throughout the follow-up period, and the highest ORs in 1970 and 2005 were 11.43 (95% CI 9.14 to 14.29) and 16.25 (95% CI 13.65 to 19.34), respectively, among security workers.

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Figures 1 and 2 show the temporal pattern of these occupational inequalities across years. We excluded workers not classifiable by occupation and non-employed from these Figures to enhance readability although they were included in the analysis. Among men, the mortality risk among three occupations (specialist and technical workers, administrative and managerial workers, and service workers) remained unchanged, whereas those of other occupation groups declined more or less. Especially, in addition to the workers not classifiable by occupation, three occupations (clerical workers, sales workers, and product process and related workers) experienced a considerable decline in mortality risk between 1970 and 2005.

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By contrast, trends in mortality by occupational groups were more stable for women. Most occupations experienced the comparable trajectories during the period although administrative and managerial workers experienced relatively small declines in mortality risk. Specialist and technical workers and service workers also experienced declines in mortality risk among women although they remained on a plateau among men.

Geographic inequality of mortality

Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small across prefectures in both sexes, with slightly larger geographic inequality among women than men (Table 2). Prefecture-specific ORs ranged from 0.87 (Okinawa prefecture) to 1.13 (Aomori prefecture) for men and from 0.84 (Kanagawa prefecture) to 1.11 (Kagoshima prefecture) for women (Supplementary Tables 6 and 7). Figure 3 shows the results of geographic inequalities in mortality. We observed similar patterns in both sexes although they led to opposite results between the sexes in Akita and Fukui prefectures; in Akita, the mortality risk was higher in men whereas it was lower in women. In Fukui, however, the pattern was reversed.

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Although overall geographic inequalities of mortality were relatively small, they appear to have increased over time (Table 2). In men, although prefecture-level variance was less pronounced until 1990 (around 0.003 on logit scale), it began to increase since 1995 steadily to 0.011 in 2005. By contrast, in women the prefecture-level variance (on logit scale) was 0.007 in 1970s, and it declined to 0.004

in 1990, and then increased up to 0.012 in 2005. The adjusted ORs and 95% CIs for mortality in each prefecture across years are shown in Supplementary Tables 6 and 7. In 1970, ORs ranged from 0.89 (Gifu prefecture) to 1.12 (Akita prefecture) for men and from 0.79 (Tokyo) to 1.14 (Kagoshima prefecture) for women. In 2005, the ranges were widened, and ORs ranged from 0.81 (Nara prefecture) to 1.27 (Aomori prefecture) for men and from 0.75 (Nara prefecture) to 1.18 (Kochi prefecture) for women. We show geographic and temporal variation in mortality, suggesting an increase in geographic inequalities across prefectures since 1995 in both sexes (Supplementary Figures 2 and 3 and Video).

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Supplementary analyses

We examined two additional issues to further explore the occupational and geographic inequalities in premature mortality; (i) the patterns of geographic inequalities in mortality by occupations, and (ii) the presence of contextual effects of prefecture-level socioeconomic status on mortality risk (Supplementary Text, Supplementary Figures 4 and 5, Supplementary Tables 8 and 9).

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DISCUSSION

Summary of findings

The findings of the present study suggest that the economic trends during the past 35 years have been accompanied by a widening of health inequalities between occupational classes as well as geographic areas of the country. The post-bubble economy has been characterized by lackluster growth combined with a dramatic shift in the work-force away from life-long employment towards more precarious employment.[4] This economic restructuring has increased pressure on workers in managerial and professional workers (primarily men) who are being squeezed to raise their productivity. The changing pattern of health inequalities across occupational groups is consistent with this interpretation, i.e., the stalled decline in premature mortality among white collar workers relative to other occupational classes.

Comparison with other studies

The present findings suggest that the health effects of the changing economic conditions depend on individual's socioeconomic circumstances. A previous study in Japan demonstrated that, although self-rated health improved for both sexes throughout the economic crisis of the 1990s, health disparities in relation to occupations widened, especially among men.[25] They also reported that middle-class male workers and female homemakers seemed to be particularly adversely affected by the crisis.[25] The present study, however, provides a different pattern of widening health disparities in both sexes.

For men, absolute health status improvement was observed only among some lower occupational groups (e.g., production process and related workers, sales workers, and clerical workers), whereas higher occupational classes (e.g., specialist and technical workers and administrative and managerial workers) apparently obtained no benefit throughout the period. Indeed, although they were advantaged with regard to mortality risk in 1970s and 1980s, they were overtaken in the 1990s by those in lower occupational classes who benefited more during the same period. Of note, this "cross-over" almost coincided with the collapse of the economic bubble in the early 1990s. We note at the same time that neither male service workers nor agricultural, forestry and fishery workers experienced improvements in premature mortality throughout the period.

By contrast, for women, we observe that absolute health status improved roughly to the same extent across occupational groups, and that changes in ranking were less pronounced in women compared to men. We should note that relatively few women were represented in the three occupational groups with higher risk of mortality (i.e., administrative and managerial workers, security workers, and transport and communication workers). Even excluding these occupational groups, however, health inequalities appeared to have increased in women. These findings may be explained by differences between men and women according to the type of work and industrial sector of employment. Men are more likely to be engaged in work in the private sector as well as in parts of the economy that are more vulnerable to economic downturns (such as finance and business services, manufacturing, construction).[26]

Potential mechanisms of social inequalities in mortality

The present findings provide a marked contrast to the evolution of health inequalities described in other industrialized countries. In industrialized western European and north American countries, health status typically follows a hierarchical pattern: i.e., the lower the socioeconomic position, the worse the health status.[5 8 10 11] We show that this "typical" pattern of health inequalities does not necessarily apply to Japan. In contrast to Western countries, previous studies in Japan have yielded inconsistent results with regard to the relationship between socioeconomic status and health outcomes, and lower non-manual or manual workers do not necessarily exhibit less healthy behaviors compared with those in higher occupational classes.[27-32] Nevertheless, a recent study of a nationally representative sample in 2001 showed that men in lower occupational classes, such as service work, transportation, and labor work, were significantly more likely to engage in health risk behaviors compared with professional workers.[33] They also showed that there is a cumulation of risky behaviors in lower female occupational classes.[33] Further, another cross-sectional study in Japan demonstrated that occupation was not significantly associated with psychological distress among men or women by using a nationally representative sample in 2007.[34] Thus, the pattern of health inequalities in the present analysis is not consistent with occupational class differences in health behaviors or psychosocial stress.

Geographic and temporal variation in mortality

By applying the novel multilevel methods, the present study shows that geographic inequalities in premature mortality have also widened since 1995, In an ecological study, Fukuda et al.[35] assessed the time trend of geographic health inequality in Japan, by examining the association of life expectancy and age-adjusted mortality with per capita income of prefectures and municipalities. While excluding Okinawa prefecture from the analyses, they found a possible increase in geographic health inequalities from 1995 to 2000, following a decrease from 1955 to 1995.[35] Note that the present study examined geographic inequalities, conditional on individual age and occupation, providing suggestive evidence of "common ecologic effects" of place where people live.[36] Broadly speaking, since 1995, higher mortality risk has been consistently observed in the northeastern region in the main island (Tohoku region) for both sexes. Overall, the economic conditions of the predominantly rural areas in the region may be

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characterized by population decline, population aging, and lower per capita income.[19] [37] Notably, however, not all rural prefectures have undergone the same transition; indeed some rural prefectures (such as Nara and Okayama) had moved up through the ranks as having significantly lower mortality for both sexes in 2005. In the supplementary analysis, no clear associations were found with prefecture-level socioeconomic variables, and it remains unknown what contributed to these distinct patterns. These patterns deserve further attention in future studies.

Limitations of the study

There are some limitations of our analysis. First, although we were able to conduct a fairly detailed analysis of trends by occupational class, neither the status in employment nor the predominant type of employment contract was available, and in particular, we lacked information on whether the individuals were in standard jobs or precarious jobs. Given the conspicuous increase in the proportion of the labor force engaged in non-standard work,[4] as well as mounting evidence that precarious work is associated with worse health,[38] future work needs to examine whether the changing character of the workforce in Japan is contributing to widening health inequalities.

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Second, occupation at the time of death was used in our numerator data, which may not necessarily reflect the individual's life-course socioeconomic

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position.[39 40] If unhealthy workers selectively exited some occupations, this would have led to an under-estimation of mortality in those sectors. The proportion of agricultural workers significantly decreased during the study period for both sexes, as well as that of administrative and managerial workers (for men). However, this may reflect real trends in the work-force.

Third, considering the possible discrepancies of the respondents on the two occasions (i.e., the notification of deaths and the census), we should note the potential for numerator denominator bias between the two sources of information. In particular, the possibility of measurement error in occupation at the time of death cannot be ruled out – the person recording the notification of deaths may either promotes the deceased to a higher status job or demotes them because the respondents did not know the details of the deceased's job.

Fourth, the smallest geographic unit available was the prefecture (of which there are 47), and we could not explore geographic inequalities in finer detail. However, the prefecture may be a useful and valid unit of analysis since it is the unit that has direct administrative authority in the economic, education, and health sectors.[1] Furthermore, the prefecture has specific jurisdiction over health centers, which is the locus of preventive health care activity in Japan.[1] Note also that the boundaries

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between prefectures have not changed since the Meiji Restoration (1867), enabling long-term analysis.[1] Since previous studies demonstrated that the choice of geographic units as well as area-based measures is critical in the investigation of geographic inequalities,[41 42] these issues warrant further examination.

Conclusions

The present findings demonstrate that both social and geographic inequalities in premature adult mortality have increased during Japan's "Lost Two Decades" following the collapse of the asset bubble. As a nation, Japan must grapple with the triple demographic trends of declining fertility, population aging, and overall population decline. These trends threaten to further dampen economic activity, escalating the load on the social security system. In addition, Japan now faces multiple challenges in the wake of the earthquake and tsunami on March 11, 2011, and this may further place downward momentum on the nation's struggling economy. Given these momentous challenges, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

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A recent review article discussed the impact of individuals' socioeconomic position on health in Japan with regard to educational attainment, occupational gradient/class, income level, and unemployment.¶
Taken together, the results of these studies show that the patterns of health inequalities in Japan are not necessarily the same in terms of size, pattern, distribution, magnitude, and impact compared to Western countries.¶
While Japan enjoys the highest average life expectancy in the world, less has been documented on the trends and patterns of health inequalities within the nation.¶
What this study adds:¶
This is the first study that simultaneously examines time trends in premature mortality by occupational class as well as geographic locality, and the results of our study indicate that health disparities have widened during the decades following the collapse of the asset bubble in the early 1990s.¶
Given the multiple challenges that threaten to further dampen economic activity of the nation, it is imperative to continue to ... [1]

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Data sharing: No additional data available.

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Figure legends

Figure 1. Predicted mortality by occupations in men, Japan, 1970-2005.

We show mean predicted probabilities for all-cause mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed.

Figure 2. Predicted mortality by occupations in women, Japan, 1970-2005.

We show mean predicted probabilities for all-cause mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed.

Figure 3. Geographic inequality of all-cause mortality, Japan, 1970-2005.

We show the overall geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

1 Table 1. Odds ratios for all-cause mortality in each occupation, Japan, 1970-2005 [a]

	Overall		1970		1975		1980	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Men								
Specialist and technical workers	1.31	(1.30 to 1.33)	0.74	(0.72 to 0.77)	0.80	(0.77 to 0.82)	1.18	(1.14 to 1.21)
Administrative and managerial workers	0.97	(0.96 to 0.98)	0.54	(0.53 to 0.56)	0.66	(0.64 to 0.68)	0.76	(0.74 to 0.78)
Clerical workers	1.20	(1.19 to 1.21)	1.05	(1.03 to 1.08)	1.09	(1.06 to 1.12)	1.18	(1.15 to 1.21)
Sales workers	1.26	(1.25 to 1.27)	1.25	(1.23 to 1.28)	1.26	(1.24 to 1.29)	1.38	(1.35 to 1.41)
Service workers	2.22	(2.19 to 2.24)	1.22	(1.18 to 1.27)	1.20	(1.16 to 1.25)	1.93	(1.86 to 1.99)
Security workers	1.05	(1.03 to 1.08)	0.67	(0.63 to 0.72)	0.76	(0.72 to 0.81)	0.94	(0.88 to 1.00)
Agriculture, forestry and fishery workers	1.89	(1.87 to 1.91)	1.34	(1.32 to 1.37)	1.48	(1.45 to 1.51)	1.74	(1.71 to 1.78)
Transport and communication workers	1.29	(1.28 to 1.31)	1.06	(1.02 to 1.09)	0.98	(0.95 to 1.02)	1.17	(1.13 to 1.21)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	29.61	(29.28 to 29.94)	41.44	(37.93 to 45.28)	59.25	(56.07 to 62.61)	115.11	(110.66 to 119.75)
Non-employed	7.78	(7.73 to 7.82)	5.83	(5.73 to 5.93)	6.18	(6.07 to 6.28)	6.68	(6.56 to 6.80)
Women								
Specialist and technical workers	1.85	(1.81 to 1.89)	1.64	(1.54 to 1.74)	1.54	(1.44 to 1.63)	1.88	(1.77 to 2.00)
Administrative and managerial workers	4.91	(4.76 to 5.06)	3.57	(3.26 to 3.91)	3.54	(3.23 to 3.87)	3.17	(2.88 to 3.50)
Clerical workers	1.23	(1.20 to 1.25)	1.63	(1.55 to 1.72)	1.35	(1.28 to 1.42)	1.45	(1.38 to 1.53)
Sales workers	1.80	(1.77 to 1.83)	1.35	(1.29 to 1.41)	1.45	(1.38 to 1.52)	1.87	(1.78 to 1.97)
Service workers	1.65	(1.62 to 1.68)	1.11	(1.06 to 1.17)	1.04	(0.99 to 1.10)	1.77	(1.68 to 1.86)
Security workers	12.22	(11.40 to 13.10)	11.43	(9.14 to 14.29)	9.24	(7.30 to 11.69)	11.57	(9.07 to 14.76)
Agriculture, forestry and fishery workers	2.25	(2.22 to 2.29)	1.65	(1.60 to 1.71)	1.88	(1.80 to 1.95)	2.18	(2.09 to 2.28)
Transport and communication workers	6.88	(6.59 to 7.18)	4.01	(3.53 to 4.55)	3.89	(3.42 to 4.43)	7.07	(6.31 to 7.91)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	42.07	(41.22 to 42.93)	41.07	(35.48 to 47.54)	14.58	(13.19 to 16.12)	110.06	(103.28 to 117.29)
Non-employed	4.81	(4.75 to 4.88)	3.39	(3.29 to 3.50)	3.45	(3.34 to 3.56)	4.48	(4.32 to 4.65)

2 CI; confidence interval, OR; odds ratio

3 [a] We adjusted for age (five year categories) and year in the overall model. We adjusted for only age (five year categories) in other models.

Table 1. Odds ratios for all-cause mortality in each occupation, Japan, 1970-2005 (cont.)

1985		1990		1995		2000		2005	
OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
1.14	(1.10 to 1.17)	1.25	(1.21 to 1.28)	1.35	(1.32 to 1.39)	2.83	(2.75 to 2.90)	2.50	(2.43 to 2.57)
1.01	(0.98 to 1.04)	1.04	(1.01 to 1.07)	1.08	(1.05 to 1.11)	2.26	(2.19 to 2.34)	2.50	(2.41 to 2.60)
1.25	(1.22 to 1.28)	1.40	(1.37 to 1.44)	1.34	(1.31 to 1.38)	1.42	(1.37 to 1.46)	1.07	(1.03 to 1.11)
1.38	(1.35 to 1.41)	1.26	(1.23 to 1.29)	1.15	(1.12 to 1.18)	1.37	(1.33 to 1.41)	1.27	(1.23 to 1.31)
1.97	(1.91 to 2.04)	2.64	(2.56 to 2.72)	2.90	(2.81 to 2.99)	3.93	(3.81 to 4.06)	3.97	(3.84 to 4.11)
1.05	(0.99 to 1.11)	1.28	(1.21 to 1.36)	1.21	(1.15 to 1.29)	1.53	(1.45 to 1.62)	1.77	(1.68 to 1.87)
1.97	(1.92 to 2.01)	2.21	(2.16 to 2.27)	2.37	(2.30 to 2.44)	3.32	(3.21 to 3.43)	3.12	(3.00 to 3.24)
1.20	(1.17 to 1.24)	1.33	(1.29 to 1.37)	1.43	(1.39 to 1.48)	1.88	(1.82 to 1.94)	1.92	(1.85 to 2.00)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
49.01	(47.39 to 50.69)	34.66	(33.64 to 35.72)	54.18	(52.82 to 55.58)	52.73	(51.40 to 54.08)	9.13	(8.80 to 9.48)
6.94	(6.82 to 7.06)	8.15	(8.01 to 8.30)	8.59	(8.44 to 8.74)	11.16	(10.93 to 11.39)	14.21	(13.90 to 14.52)
1.82	(1.71 to 1.93)	1.85	(1.74 to 1.96)	2.02	(1.89 to 2.15)	2.83	(2.65 to 3.01)	2.63	(2.45 to 2.82)
3.68	(3.37 to 4.02)	5.16	(4.77 to 5.58)	6.08	(5.60 to 6.61)	10.16	(9.31 to 11.09)	12.21	(11.07 to 13.47)
1.26	(1.20 to 1.33)	1.17	(1.11 to 1.23)	1.32	(1.25 to 1.40)	1.31	(1.23 to 1.39)	1.26	(1.17 to 1.35)
2.03	(1.93 to 2.13)	1.89	(1.80 to 1.98)	1.94	(1.83 to 2.05)	2.20	(2.06 to 2.34)	2.32	(2.16 to 2.50)
1.67	(1.58 to 1.76)	1.86	(1.77 to 1.95)	2.21	(2.09 to 2.33)	2.42	(2.28 to 2.57)	2.49	(2.33 to 2.67)
19.51	(16.24 to 23.43)	17.07	(14.34 to 20.33)	13.22	(10.88 to 16.05)	12.49	(10.34 to 15.09)	16.25	(13.65 to 19.34)
2.08	(1.98 to 2.18)	2.10	(2.00 to 2.20)	2.63	(2.47 to 2.79)	3.15	(2.93 to 3.39)	3.42	(3.14 to 3.73)
7.52	(6.73 to 8.40)	9.54	(8.59 to 10.61)	8.17	(7.20 to 9.28)	9.65	(8.45 to 11.01)	11.54	(10.06 to 13.24)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
48.48	(45.76 to 51.37)	51.39	(48.69 to 54.24)	90.68	(86.15 to 95.46)	80.79	(76.53 to 85.29)	14.45	(13.33 to 15.67)
4.38	(4.23 to 4.54)	4.46	(4.30 to 4.62)	6.29	(6.04 to 6.55)	7.91	(7.55 to 8.29)	9.62	(9.10 to 10.16)

1 Table 2. Adjusted prefecture-level variance for all-cause mortality, Japan, 1970-2005 [a]

	Men			Women		
	Variance (on logit scale)			Variance (on logit scale)		
	Estimate	(95% CI)	Range of OR [b]	Estimate	(95% CI)	Range of OR [b]
Overall	0.003	(0.001 to 0.004)	0.87 to 1.13	0.005	(0.003 to 0.007)	0.84 to 1.11
1970 [c]	0.003	(0.002 to 0.005)	0.89 to 1.12	0.007	(0.004 to 0.010)	0.79 to 1.14
1975	0.003	(0.001 to 0.004)	0.88 to 1.09	0.007	(0.004 to 0.010)	0.82 to 1.19
1980	0.004	(0.002 to 0.005)	0.82 to 1.11	0.005	(0.003 to 0.008)	0.85 to 1.15
1985	0.003	(0.001 to 0.004)	0.85 to 1.09	0.005	(0.002 to 0.007)	0.86 to 1.13
1990	0.003	(0.002 to 0.004)	0.89 to 1.11	0.004	(0.002 to 0.006)	0.88 to 1.10
1995	0.006	(0.003 to 0.009)	0.85 to 1.22	0.008	(0.004 to 0.012)	0.80 to 1.15
2000	0.007	(0.004 to 0.010)	0.84 to 1.25	0.010	(0.005 to 0.015)	0.76 to 1.15
2005	0.011	(0.007 to 0.016)	0.81 to 1.27	0.012	(0.007 to 0.017)	0.75 to 1.18

2 CI; confidence interval, OR; odds ratio

3 [a] We adjusted for age (five year categories) and occupations. We further adjusted for year in the overall model.

4 [b] The range of adjusted odds ratios for mortality in each prefecture is shown. The reference is the grand mean of all the prefectures.

5 [c] The variance between 46 prefectures is shown because the data for Okinawa prefecture were not available in 1970.

Page 22: [1] Deleted Etsuji Suzuki 10/2/2011 4:10:00 PM

What is already known on this subject:

A recent review article discussed the impact of individuals' socioeconomic position on health in Japan with regard to educational attainment, occupational gradient/class, income level, and unemployment.

Taken together, the results of these studies show that the patterns of health inequalities in Japan are not necessarily the same in terms of size, pattern, distribution, magnitude, and impact compared to Western countries.

While Japan enjoys the highest average life expectancy in the world, less has been documented on the trends and patterns of health inequalities within the nation.

What this study adds:

This is the first study that simultaneously examines time trends in premature mortality by occupational class as well as geographic locality, and the results of our study indicate that health disparities have widened during the decades following the collapse of the asset bubble in the early 1990s.

Given the multiple challenges that threaten to further dampen economic activity of the nation, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

Page Break

Responses to Reviewers' Comments

Dear Professor Goldblatt,

Thank you very much for your thoughtful review and positive evaluation of our article. We revised our manuscript according to your helpful suggestions.

1. **This paper is welcome in bringing together information on occupation and prefecture of residence from death registration at working ages across a 35 year period for the whole of Japan. Trend data presented on the change in occupational distribution and in patterns of mortality over this period are extremely valuable, as is the analysis of the inter-relationship between occupation, prefecture and social factors. However the findings are difficult to interpret and there are some key questions about the methods used and definitions which are not clear from the paper. These issues are explained in more detail below. Greater clarity about these issues is required before publishing what are on the face of it some extraordinary findings.**

Response:
Thank you very much for your positive evaluation of our article. We thoroughly revised the manuscript following your helpful suggestions. We hope that the revision provides the findings more clearly.

2. **Methods and definitions: The social information in this study appears to derive from a comparison of major occupational groups as recorded at death and compared with Census denominators. There are two issues here. First occupational classifications, on their own do not equate to social classifications. To arrive at a social classification from an occupational classification requires two further steps. Firstly, identifying the status in employment of the individual - do they manage or supervise others in the occupational group. Secondly, the occupation and status combination needs to be graded according to the predominant type of employment contract for that combination (e.g. salaried, weekly wage, etc.). It does not appear that this has been carried out for the data used in the article. Clarification of this is essential - is this purely an occupation mortality analysis or is it an analysis according to social position?**

Response:
Thank you for your thoughtful comment. One of the aims of this study was to examine the social inequality of all-cause mortality in Japan, and we intended to use occupations as an indicator of socioeconomic position. Generally, previous studies have used occupations, income, education, or

wealth as indicators of socioeconomic position, and we understand that there is no single best indicator. Unfortunately, neither the status in employment nor the predominant type of employment contract was available in the present data set, and we briefly mentioned this as a limitation in the DISCUSSION section of the original version. In accordance with your suggestion, we changed "social inequality" to "occupational inequality" throughout the main text when appropriate. Furthermore, we modified sentences in the INTRODUCTION and DISCUSSION section as follows:

(Page 6, lines 6-9)
In this study, by using occupations as an indicator of socioeconomic position,[14] we examine the trends in occupational and geographic inequalities of all-cause premature adult mortality from 1970 through 2005.

(Page 19, lines 9-13)
First, although we were able to conduct a fairly detailed analysis of trends by occupational class, neither the status in employment nor the predominant type of employment contract was available, and in particular, we lacked information on whether the individuals were in standard jobs or precarious jobs.

The second issue concerns the method of data collection. Is there any potential for numerator denominator bias between the two sources of information (census and death)? Specifically, what questions are asked on the two occasions and who are the respondents on the two occasions? In most cross-sectional occupational studies, discrepancies in either or both of these respects lead to numerator denominator bias. The extent of this is not clear from the paper. Nor is it clear from the paper whether any studies have been carried out in Japan to quantify any biases (either longitudinal follow up of census or retrospective in-depth surveys based on death records). Specific issues are whether, by the time a person dies they are either no longer in the occupation recorded for them at Census or whether the person recording the death either promotes the deceased to a higher status job or demotes them because they did not know the details of their job). As a simple example, it is not uncommon for those in lower status jobs to be selected out of the workforce due to ill health and be recorded as not employed or not classified at death, depending on the question asked at death.

Response:
Thank you for your helpful comment. We agree that the potential for numerator denominator bias is an important issue. In the notification of deaths, the respondents are asked to fill in the occupation of decedent at the time of death, and one of the following persons are obliged to submit the notification: (1) relatives who live together with decedents, (2) other housemates, (3) landlord, estate owner,

land/house agent, or (4) relatives who do not live together with decedents. In the questionnaire for the Census, the occupation was assessed by asking a following question: "Description of work – Describe in detail the duties you are assigned to perform." The questionnaires are delivered to each household, and someone of each household answers the question. In accordance with your comment, we added sentences as follows:

(Page 6, line 18 – page 7, line 4)
In the notification of deaths, the respondents are asked to fill in the occupation of decedent at the time of death,[17] and one of the following persons is obliged to submit the notification: (1) relatives who live together with decedents, (2) other housemates, (3) landlord, estate owner, land/house agent, or (4) relatives who do not live together with decedents.

(Page 8, lines 6-9)
In the questionnaire for the Census, the occupation was assessed by asking a following question: "Description of work – Describe in detail the duties you are assigned to perform".[19] The questionnaires are delivered to each household, and someone in each household answers the question.

We are not aware of any studies from Japan that have quantified the numerator denominator bias. We also agree that the possibility of measurement error of occupation at the time of death cannot be ruled out. In accordance with your comment, we added sentences to mention this as a limitation of the present study as follows:

(Page 20, lines 6-12)
Third, considering the possible discrepancies of the respondents on the two occasions (i.e., the notification of deaths and the census), we should note the potential for numerator denominator bias between the two sources of information. In particular, the possibility of measurement error in occupation at the time of death cannot be ruled out – the person recording the notification of deaths may either promotes the deceased to a higher status job or demotes them because the respondents did not know the details of the deceased's job.

3. **Mortality levels: The odds ratios shown in Table 1 are startling. A four-fold difference in mortality for men classified to an occupation and a 16-fold difference for women. Furthermore, most of the substantial differences recorded are in the opposite direction to those seen in longitudinal data in the West. If true, this would imply a catastrophic loss of life in higher status social groups in Japan. However, although the paper looks at several possible explanations (stress, lifestyles, behaviours) it does not identify any biologically plausible explanation for this phenomenon. In terms of previous knowledge, is there a**

major threat to job security among the best-off in Japanese society? Do they suffer from effort-reward imbalance or a lack of control in their lives or jobs? No evidence or plausible hypothesis is proposed in the paper.

Response:

We agree that the present findings may well imply a catastrophic loss of life in higher status social groups in Japan. We thoroughly reviewed previous studies from Japan using nationally representative samples. As we explain in the main text, however, the pattern of health inequality in the present analysis is not consistent with previous findings of occupational class differences in health behaviors or psychosocial stress. Although we agree that biologically plausible explanations could strengthen our discussion, we refrained from making specific biologic explanations given our overall outcome (i.e., all-cause mortality). We hope that our discussion reflects properly the present findings.

4. **Geographic differences: The paper identifies some significant differences in mortality across Japan, with some interesting time trends. However, it does not present clear social and other correlations to help explain these patterns and trends. Part of the difficulty may be that, as the paper suggests, the prefectures are so large that they subsume as much within area social and mortality variation as exists between prefectures. If so, the observed patterns may simply be an illustration of the well-known ecological fallacy. A second problem may be that the paper, as noted above, has not identified a biologically plausible explanation for overall social inequalities in mortality. Without this modelling of the interaction between social factors, geography and mortality may be over-ambitious.**

Response:

We fully agree that the prefectures could be so large to explore geographic inequalities. As we explain in the main text, however, the prefecture may be a useful and valid unit of analysis since it is the unit that has direct administrative authority in the economic, education, and health sectors. Furthermore, the prefecture has specific jurisdiction over health centers, which is the locus of preventive health care activity in Japan. We also note that the boundaries between prefectures have not changed since 1867, enabling long-term analysis. In addition, as we explain in the supplementary text, a previous review article suggested that the studies in income inequality are more supportive in larger areas. As you indicated, the potential ecological fallacy could be generally a critical issue in ecological studies. As we explain in the main text, however, the unit of analysis of the present study was “cell” (tabulated by sex, age, occupation, year, and prefecture), and we used proportion of mortality in each cell as an outcome variable. By so doing, the present study examined the population-level association between occupation and mortality and how it varies across prefectures. In other words, we have no ecological X and Y and only individual X and Y. Therefore, we think that the observed patterns are not an illustration of the ecological fallacy.

Dear Dr. Strand,

Thank you very much for your thoughtful review and positive evaluation of our article. We revised our manuscript according to your helpful suggestions.

1. **This is an interesting and well written piece of work extending the existing literature on social inequality mortality trends to also cover Japan. Previous studies on this topic have mainly focused on Western populations. This work is of importance to researchers and policymakers and might be well suited for a general medical journal like BMJ. Research questions are clearly defined. Furthermore, the design of the study is appropriate and by using multilevel methods they ensure to properly adjust for micro- macrolevel bias, as the author Subramanian earlier have described in his paper with Duncan and Jones (Environment and Planning A 2001, volume 33, pages 399-417). Nevertheless, I still miss some basic numbers; for example age adjusted mortality rates by occupational class by year and gender. Such numbers are modeled in Figure 1 and 2, but I suspect the linear trends might be too simplistic, and would like to get an idea of the background numbers before they are run through complicated models. I believe some readers of BMJ will find such multilevel models rather complicated. Data is census based and covers the whole of Japan so exclusion criteria are not highly relevant here. Participants are adequately described.**

Response:

Thank you very much for your positive evaluation of our article. We also appreciate your comment on our analytic methods to properly adjust for micro- and macro-level bias. We thoroughly revised the manuscript following your suggestions, and we created a new table showing the age-adjusted mortality rates by occupational class by year and gender (Supplementary Table 5). We hope that the revision provides the reader with better understanding of the findings.

2. **The multilevel approach is a nice one as commented on above, but the choice of logit link function limits the results to the relative scale presented to the reader as odds ratios. The inequality literature has stressed the importance to also investigate absolute inequalities (see for example Oakes & Kaufman, Methods in social epidemiology, 2006). This is of special importance when looking at mortality trends as rates tend to decline over time and one can have the situation that all socioeconomic groups decrease their rate at similar pace, thus absolute differences are constant, but the relative rate will increase. Table 1 shows increasing ORs, but I suspect this fallacy just described could be the reason for this? Would it be possible to run the model using identity link and get RD?**

Response:

We fully agree with the importance of investigating absolute as well as relative inequalities. As indicated in your comment No. 7, our intention of showing Figures 1 and 2 was to visualize the absolute inequality across occupations. In accordance with your comment, we calculated the age-adjusted mortality rates by occupational class by year and gender (Supplementary Table 5), which we believe will help readers to understand the present findings from absolute as well as relative perspectives. Although we appreciate your suggestion to run the model using identity link function, we think that logit link function is more appropriate in the present analysis, considering that the outcome of interest is the proportion of mortality in each cell. In accordance with your comment, we added sentences as follows:

> (Page 9, lines 1-6)
> For the descriptive purpose, we first calculated age-adjusted mortality rates by occupational class by year and sex (Supplementary Table 5). We used the direct method, using the model population of 1985 as a reference.[20] The model population of 1985 is based on the Japanese population under census of 1985 and it is created on the basis of 1,000 persons as 1 unit, after adjusting radical increase or decrease such as baby boom.[21]

3. **I have a concern regarding the revision of the classification of occupations and comparability of the 11 groups over time. For example, in group 9 "Production process and related workers" mining workers were included until 1986, but not in the last revision. I suspect mining workers have high mortality rate which could result in group 9 getting higher mortality in the earlier periods. Could this and other changes in the classification affect the results? I especially think of the pattern seen in Figure 1, where some groups, among them group 9, have a rather steep mortality decline. The pattern in men is somewhat strange as lines cross, putting high mortality occupational groups in 1970 among the lowest in 2005 (Sales workers). In women the picture is more harmonized, with decline in mortality in all groups (fig 2). I wonder if this pattern is a true picture or if some data issues described above might have played a role? I wonder if a less fine grouping of occupations could tackle this potential problem of comparability of occupational groups over time? Figure 1 is based on a linear slope over time – are there in fact linear trends? In the case of group 9 in men I would suspect a drop when the 4th revision is used.**

Response:

We agree that mining workers are expected to have a high mortality rate. Indeed, in the fourth revision of the Japan Standard Occupational Classification (Supplementary Table 1), "Production process and related workers" includes mining workers. Please note that, as we cite in the main text, this point is clearly explained in the following website.

(Reference No. 18)
Ministry of Internal Affairs and Communications. Japan Standard Occupational Classification. http://www.stat.go.jp/english/index/seido/shokgyou/index-co.htm.

To clarify this, we added a following sentence in accordance with your comment:

(Page 7, lines 13-14)
Note that the group "production process and related workers" includes mining workers.

We also agree that the time trend of social inequalities among men could be surprising since lines cross (Figure 1), and we appreciate your suggestion of using a less fine grouping of occupations. As explained in the main text, however, our study used occupation (major group) of the Japan Standard Occupational Classification, which yields reasonably consistent occupational grouping throughout the study period. (As noted above, mining workers are consistently categorized as production process and related workers.) We are thus concerned that using a less fine grouping of occupations does not necessarily present a true picture of the trend of social inequalities. In line with this, Greenland and Rothman suggested that "some categories may be collapsed together when data are sparse, provided these combinations do not merge groups that are very disparate with respect to the phenomena under study" (Greenland S, Rothman KJ. Fundamentals of epidemiologic data analysis. In: Rothman KJ, Greenland S, Lash TL, editors. *Modern Epidemiology*. 3rd ed. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins, 2008:213-37). After considering your comment very carefully, we decided to use the current occupational grouping. We hope that you agree with this revision.

4. **Occupational groups 10 and 11 are left out of some analyses without much rationale. Could this bias the results as some areas might have a larger % of these two groups? Especially group 10 "unclassifiable" has a remarkably high mortality. This group is small (less than 1.52%) so possibly not a big problem to leave this group out, but unemployed is a very large group in women (40-50%).**

Response:
Thank you for clarifying this. In the whole analysis of the present study, we included occupational groups No. 10 (i.e., workers not classifiable by occupations) and No. 11 (i.e., non-employed). To enhance readability of Figures 1 and 2, however, we excluded them from these Figures. We apologize for the unclear explanation. In accordance with your comment, we added a sentence as follows:

(Page 12, lines 7-8)

We excluded workers not classifiable by occupation and non-employed from these Figures to enhance readability although they were included in the analysis.

5. **Age group is restricted to 25-64 to exclude students and retired. I guess some students and retired are still included? To be more sure possibly an even narrower age group (30-60) could be used?**

Response:
We agree that some students and retired are still included in the study subjects. However, almost all the university students in Japan graduate from universities in their early 20s, and it is getting common to rehire staff of retirement age. Therefore, we believe that the current age restriction reasonably succeeded in excluding students and the retired. If they should be included in the study subjects, they are categorized as "non-employed", and we deliberately avoided giving an interpretation to the result among them in the present article. Also, please note that a previous study from the US also chose age 65 as a cut-off point for premature mortality (Krieger N, Rehkopf DH, Chen JT, Waterman PD, Marcelli E, Kennedy M. The fall and rise of US inequities in premature mortality: 1960-2002. *PLoS Med* 2008;5:e46. doi:10.1371/journal.pmed.0050046). We hope that the current age restriction is appropriate to examine the premature adult mortality.

6. **Minor: Make it clearer that numbers of deaths for each cell are recorded during 1 calendar year.**

Response:
In accordance with your suggestion, we added a sentence as follows:

(Page 8, line 18 – page 9, line 1)
Note that the numbers of deaths for each cell are recorded during one fiscal year.

7. **Results answer the research question, but as earlier stressed, the results rely on relative inequalities (except from fig 1 and 2, where mean predicted mortality on logit scale is presented). Authors also have made a set of supplementary analyses accompanied of supplementary text, tables and figures. The amount of information is large and I am not sure if the supplementary analyses are needed in this paper – maybe they could be placed in a separate paper?**

Response:
Thank you for your positive evaluation of our article. In accordance with your comment, the revision provides age-adjusted mortality rates by occupations (Supplementary Table 5). Also, please note that

our analysis of geographic inequalities assessed the trend of absolute health inequalities quantitatively (Table 2). We believe that, with these modifications, readers can understand the present findings of health inequalities from absolute as well as relative perspectives. We understand that the amount of information provided in the supplementary materials may be large. In this study, we intended to assess the time trend of health inequality in Japan comprehensively (i.e., both socially and geographically). Although this information could be placed in a separate paper, we believe that the comprehensive report may well facilitate understanding of the present findings.

8. As authors say the results contrast health inequalities across occupational groups described in other industrialized western European and North American countries. It also contrasts a previous study from Japan (Fukada et al, ref no 25) using income, where absolute inequalities have narrowed since 1950s with a flattening out from 1995 to 2005 (or possibly increasing). Saying that this is consistent with findings in this paper seems odd.

Response:
We think that you are probably mentioning an ecological study by Fukuda et al. (Fukuda Y, Nakao H, Yahata Y, Imai H. Are health inequalities increasing in Japan? The trends of 1955 to 2000. *Biosci Trends* 2007;1:38-42). Please note that this paper was cited as a reference No. 31 in the original version, and currently it is cited as a reference No. 35. As you indicated, they assessed the time trend of geographic health inequalities in Japan, by examining the association of life expectancy and age-adjusted mortality with per capita income of prefectures and municipalities. We cited their work here since their results are somewhat consistent with ours in the sense that they suggested geographic health inequalities appeared to increase from 1995 to 2000. In accordance with your suggestion, we modified the sentences as follows:

(Page 18, lines 7-13)
By applying the novel multilevel methods, the present study shows that geographic inequalities in premature mortality have also widened since 1995, In an ecological study, Fukuda et al.[35] assessed the time trend of geographic health inequality in Japan, by examining the association of life expectancy and age-adjusted mortality with per capita income of prefectures and municipalities. While excluding Okinawa prefecture from the analyses, they found a possible increase in geographic health inequalities from 1995 to 2000, following a decrease from 1955 to 1995.[35]

9. References are up to date and relevant. Abstract, summary, key messages and what this paper adds reflect accurately what the paper says.

Response:

Thank you very much for your positive evaluation of our article.

We thank the reviewers again for their helpful comments, which we feel have improved our manuscript. We hope that with these modifications, our paper can now be accepted for publication.

Sincerely,

Social and geographic inequalities in premature adult mortality in Japan: an observational study from 1970 to 2005

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1970-2005_adj_animation.gif

Social and geographic inequalities in premature adult mortality in Japan: an observational study from 1970 to 2005

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Abstract

Objectives: To examine trends in social and geographic inequalities in all-cause premature adult mortality in Japan.

Design: Observational study of the Vital Statistics and the Census data.

Setting: Japan.

Participants: Entire population aged 25 or older and less than 65 in 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. The total number of decedents was 984,022 and 532,223 in men and women, respectively.

Main outcome measures: For each sex, odds ratios (ORs) and 95% confidence intervals (CIs) for mortality were estimated by using multilevel logistic regression models with "cells" (cross-tabulated by age and occupation) at level 1, eight years at level 2, and 47 prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality.

Results: Adjusting for age and time-trends, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (2.19 to 2.24) among service workers in men. By contrast, in women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (11.40 to

13.10) among security workers. The degree of occupational inequality increased in both sexes. Higher occupational groups did not experience reductions in mortality throughout the period and was overtaken by lower occupational groups in the early 1990s, among men. Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small in both sexes; the ORs ranged from 0.87 (Okinawa) to 1.13 (Aomori) for men and from 0.84 (Kanagawa) to 1.11 (Kagoshima) for women, even though there is a suggestion of increasing inequalities across prefectures since 1995 in both sexes.

Conclusions: The present findings demonstrate that both social and geographic inequalities in all-cause mortality have increased in Japan during the last three decades.

Article summary

Article focus:

While Japan enjoys the highest average life expectancy in the world, less has been documented on the trends and patterns of health inequalities within the nation.

We examined trends in social and geographic inequalities in all-cause premature adult mortality from 1970 through 2005.

Key messages:

This is the first study that simultaneously examines time trends in premature mortality by occupational class as well as geographic locality, and the results of our study indicate that health disparities have widened during the decades following the collapse of the asset bubble in the early 1990s.

Given the multiple challenges that threaten to further dampen economic activity of the nation, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

Strengths and limitations of this study:

The data are census based and cover the whole of Japan from 1970 through 2005.

This study uses multilevel methods to properly adjust for micro- and macro-level bias simultaneously.

We lacked information on whether the individuals were in standard jobs or precarious jobs.

INTRODUCTION

The postwar Constitution (1946) of Japan made equality a primary objective of the health system, and by 1961, the country achieved universal and compulsory health insurance coverage.[1] Although Japanese longevity was well below that of most European countries in 1960, subsequent health gains enabled the country to overtake other nations to the point where Japan reached the top of the national life expectancy rankings by 1985.[1 2] During the period of rapid economic growth (mid-1960s to 1989), Japan's social and economic policies helped to create a broad middle class with secure (often life-long) employment and comparatively egalitarian growth in living standards across the income spectrum.[1 3] Following the collapse of the asset bubble in the early 1990s, however, Japan's economy has been characterized by persistently low growth accompanied by a marked increase in the number of precarious workers (i.e., non-standard jobs such as part-time and contingent workers), from 1 in 5 employees in the 1990s to 1 in 3 employees by 2005.[4] The period since the collapse of the asset bubble – now referred to as the "Lost Two Decades" – has been characterized by a widening of income disparities and the emergence of a new class of "working poor" hitherto unrecognized in Japanese society.[5] In retrospect, the post-War period of comparatively egalitarian economic growth appears to have lasted about forty years,

and today, Japan ranks closer to countries such as the United States and the UK in terms of indicators of relative poverty, such as poverty rate and poverty gap.[6]

While there are considerable studies documenting social and geographic inequalities in mortality in other industrialized countries,[7-12] we are not aware of a similar comprehensive assessment of the trends in health inequalities in Japan that may have accompanied the major macroeconomic changes.[13] In this study, by using occupations as an indicator of socioeconomic position,[14] we examine the trends in occupational and geographic inequalities of all-cause premature adult mortality from 1970 through 2005. Since premature adult mortality focuses on death occurring at younger ages, they constitute a useful measure in public health as well as preventive medicine.[15]

METHODS

Data

Data on deaths were obtained from the *Report of Vital Statistics: Occupational and Industrial Aspects*,[16] which has been conducted by the Ministry of Health, Labour and Welfare every five years since 1970, coinciding with the years of the Population Census. The latest year for which data are available is 2005. In the notification of deaths, the respondents are asked to fill in the occupation of decedent at the time of death,[17] and one of the following persons is obliged to submit the notification: (1) relatives who live together with decedents, (2) other housemates, (3) landlord, estate owner, land/house agent, or (4) relatives who do not live together with decedents. The occupation at the time of death is recorded for each decedent following the Japan Standard Occupational Classification.[18] During the follow-up period, the occupational classification scheme underwent four revisions (Supplementary Table 1).[18] In this study, we used the fourth revision of the Occupational Classification, which includes the following 11 groups[18]: (1) specialist and technical workers, (2) administrative and managerial workers, (3) clerical workers, (4) sales workers, (5) service workers, (6) security workers, (7) agriculture, forestry and fishery workers, (8) transport and communication workers, (9) production process and related workers, (10) workers not classifiable by occupation, and (11) non-employed. (The full description of each occupational group is available on-line in English.[18]) Note that the group "production process and related workers" includes mining workers. Note also that the group "non-employed" includes the unemployed as well as non-labor force (e.g., home-makers, students, and the retired). Although the Census distinguishes the unemployed from home-makers, the vital records combine these categories as "non-employed".[18] We restricted the analysis to those who are aged 25 or older and less than 65 to exclude students as well as the retired. The total number of decedents was 984,022 and 532,223 in men and women, respectively (Supplementary Figure 1 and Supplementary Table 2).

Denominator data for the calculation of mortality rates were obtained from the Population Census which has been conducted by the Ministry of Internal Affairs and Communications every five years since 1920.[19] In the questionnaire for the Census, the occupation was assessed by asking a following question[19]: "Description of work – Describe in detail the duties you are assigned to perform." The questionnaires are delivered to each household, and someone in each household answers the question. We used "production process and related workers" as the referent category since they were the largest occupational category in a majority of the time periods (Supplementary Table 3).

Analysis

The data had a three-level multilevel structure of 32,590 cells for men and 32,542 cells for women at level 1, nested within eight years at level 2, nested within 47 prefectures at level 3. The eight years comprised of 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Each year had a maximum 88 cells (eight age groups times 11 occupational groups) (Supplementary Table 4). Note that the numbers of deaths for each cell are recorded during one fiscal year. For the descriptive purpose, we first calculated age-adjusted mortality rates by occupational class by year and sex (Supplementary Table 5). We used the direct method, using the model population of 1985 as a reference.[20] The model population of 1985 is based on the Japanese population under census of 1985 and it is created on the basis of 1,000 persons as 1 unit, after adjusting radical increase or decrease such as baby boom.[21] We then employed multilevel statistical procedures because of their ability to model complex variance structures at multiple levels.[22] In the present analysis, they allow estimation of the relationship between mortality and occupation, conditional on individual age variation ("fixed parameters") and year- and prefecture-level variations ("random parameters"). They also enable an estimation of the extent to which the relationship between mortality and occupation varies across years and prefectures (random parameters) and the degree to which prefecture-level socioeconomic status explains this variation (fixed parameters). The unit of analysis was "cells," and our models were structurally identical to models with individuals at level 1.[23]

The response variable, proportion of deaths in each cell, was modeled with allowances made for the varying denominator in each cell. The fixed and random parameter estimates (along with their standard errors) for the multilevel binomial logit link model were calibrated using predictive/penalized quasi-likelihood procedures with second order Taylor series expansion, as implemented within the MLwiN 2.22.[24] Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). A *p* value of less than 0.05 (two-sided test) was considered statistically significant.

First, we conducted three-level analysis as an overall model, with cells at level 1, years at level 2, and prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality. Prefectures were ranked by ORs having the whole country of Japan as reference (value = 1), and uncertainty was estimated by 95% CIs. Further, to examine the temporal patterns of occupational and geographic inequality of mortality across years, we also conducted two-level analysis, with cells at level 1 and prefectures at level 2 separately for each year.

Then, to explore the temporal change of occupational inequality, we ran a three-level multilevel model including a fixed cross-level interaction effect between the 11 occupations (at level 1) and year (at level 2). In this analysis, we modeled the year as a continuous variable, and we calculated mean predicted probabilities for mortality among those aged 25 to 29 (referent category).

To present the results of geographic inequality in all-cause mortality, we created maps showing prefecture-level residuals by using the ArcGIS (ESRI Japan Inc., version 9.3).

RESULTS

Social inequality of mortality

Table 1 shows the results of social inequality of all-cause premature mortality in terms of occupation from overall model as well as year-specific models in multilevel analyses. Excluding workers not classifiable by occupation and non-employed, there were substantial health disparities by occupations in both sexes. Adjusting for age and time-trends in the overall model, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (95% CI 2.19 to 2.24) among service workers in men. Among women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (95% CI 11.40 to 13.10) among security workers.

The degree of occupational inequality increased in both sexes. Among men, in 1970, the lowest OR was 0.54 (95% CI 0.53 to 0.56) among administrative and managerial workers while the highest OR was 1.34 (95% CI 1.32 to 1.37) among agriculture, forestry and fishery workers. In 2005, however, the lowest odds for mortality was observed among production process and related workers (reference) whereas the highest OR was 3.97 (95% CI 3.84 to 4.11) among service workers. Among women, the lowest odds for mortality was observed among production process and related workers (reference) throughout the follow-up period, and the highest ORs in 1970 and 2005 were 11.43 (95% CI 9.14 to 14.29) and 16.25 (95% CI 13.65 to 19.34), respectively, among security workers.

The widening social inequalities can be more clearly seen in Figures 1 and 2, which show the temporal pattern of these occupational inequalities across years. We excluded workers not classifiable by occupation and non-employed from these Figures to enhance readability although they were included in the analysis. Among men, the mortality risk among three occupations (specialist and technical workers, administrative and managerial workers, and service workers) remained unchanged, whereas those of other occupational groups declined more or less. Especially, in addition to the workers not classifiable by occupation, three occupations (clerical workers, sales workers, and product process and related workers) experienced a considerable decline in mortality risk between 1970 and 2005.

By contrast, trends in mortality by occupational groups were more stable for women. Most occupations experienced the comparable trajectories during the period although administrative and managerial workers experienced relatively small declines in mortality risk. Specialist and technical workers and service workers also experienced declines in mortality risk among women although they remained on a plateau among men.

Geographic inequality of mortality

Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small across prefectures in both sexes, with slightly larger geographic inequality among women than men (Table 2). Note that Tables 1 and 2 are based on the same multilevel models, showing the results of fixed and random parts, respectively. Prefecture-specific ORs ranged from 0.87 (Okinawa prefecture) to 1.13 (Aomori prefecture) for men and from 0.84 (Kanagawa prefecture) to 1.11 (Kagoshima prefecture) for women (Supplementary Tables 6 and 7). Figure 3 shows the results of geographic inequalities in mortality. We observed similar patterns in both sexes although they led to opposite results between the sexes in Akita and Fukui prefectures; in Akita, the mortality risk was higher in men whereas it was lower in women. In Fukui, however, the pattern was reversed.

Although overall geographic inequalities of mortality were relatively small, they appear to have increased over time (Table 2). In men, although prefecture-level variance was less pronounced until 1990 (around 0.003 on logit scale), it began to increase since 1995 steadily to 0.011 in 2005. By contrast, in women the prefecture-level variance (on logit scale) was 0.007 in 1970s, and it declined to 0.004 in 1990, and then increased up to 0.012 in 2005. The adjusted ORs and 95% CIs for mortality in each prefecture across years are shown in Supplementary Tables 6 and 7. In 1970, ORs ranged from 0.89 (Gifu prefecture) to 1.12 (Akita prefecture) for men and from 0.79 (Tokyo) to 1.14 (Kagoshima prefecture) for women. In 2005, the ranges were widened, and ORs ranged from 0.81 (Nara prefecture) to 1.27 (Aomori prefecture) for men and from 0.75 (Nara prefecture) to 1.18 (Kochi prefecture) for women. We show geographic and temporal variation in mortality, suggesting an increase in geographic inequalities across prefectures since 1995 in both sexes (Supplementary Figures 2 and 3 and Video).

Supplementary analyses

We examined two additional issues to further explore the occupational and geographic inequalities in premature mortality; (i) the patterns of geographic inequalities in mortality by occupations, and (ii) the presence of contextual effects of prefecture-level socioeconomic status on mortality risk (Supplementary Text, Supplementary Figures 4 and 5, Supplementary Tables 8 to 10).

DISCUSSION

Summary of findings

The findings of the present study suggest that the economic trends during the past 35 years have been accompanied by a widening of health inequalities between occupational classes as well as geographic areas of the country. The post-bubble economy has been characterized by lackluster growth combined with a dramatic shift in the work-force away from life-long employment towards more precarious employment.[4] This economic restructuring has increased pressure on workers in managerial and professional workers (primarily men) who are being squeezed to raise their productivity. The changing pattern of health inequalities across occupational groups is consistent with this interpretation, i.e., the stalled decline in premature mortality among white collar workers relative to other occupational classes.

Comparison with other studies

The present findings suggest that the health effects of the changing economic conditions depend on individual's socioeconomic circumstances. A previous study in Japan demonstrated that, although self-rated health improved for both sexes throughout the economic crisis of the 1990s, health disparities in relation to occupations widened, especially among men.[25] They also reported that middle-class male workers and female homemakers seemed to be particularly adversely affected by the crisis.[25] The present study, however, provides a different pattern of widening health disparities in both sexes. For men, absolute health status improvement was observed only among some lower occupational groups (e.g., production process and related workers, sales workers, and clerical workers), whereas higher occupational classes (e.g., specialist and technical workers and administrative and managerial workers) apparently obtained no benefit throughout the period. Indeed, although they were advantaged with regard to mortality risk in 1970s and 1980s, they were overtaken in the 1990s by those in lower occupational classes who benefited more during the same period. Of note, this "cross-over" almost coincided with the collapse of the economic bubble in the early 1990s. We note at the same time that neither male service workers nor agricultural, forestry and fishery workers experienced improvements in premature mortality throughout the period.

By contrast, for women, we observe that absolute health status improved roughly to the same extent across occupational groups, and that changes in ranking were less pronounced in women compared to men. We should note that relatively few women were represented in the three occupational groups with higher risk of mortality (i.e., administrative and managerial workers, security workers, and transport and communication workers). Even excluding these occupational groups, however, health inequalities appeared to have increased in women. These findings may be explained by differences between men and women according to the type of work and industrial sector of employment. Men are more likely to be engaged in work in the private sector as well as in parts of the economy that are more vulnerable to economic downturns (such as finance and business services, manufacturing, construction).[26]

Potential mechanisms of social inequalities in mortality

The present findings provide a marked contrast to the evolution of health inequalities described in other industrialized countries. In industrialized western European and north American countries, health status typically follows a hierarchical pattern: i.e., the lower the socioeconomic position, the worse the health status.[5 8 10 11] We show that this "typical" pattern of health inequalities does not necessarily apply to Japan. In contrast to Western countries, previous studies in Japan have yielded inconsistent results with regard to the relationship between socioeconomic status and health outcomes, and lower non-manual or manual workers do not necessarily exhibit less healthy behaviors compared with those in higher occupational classes.[27-32] Nevertheless, a recent study of a nationally representative sample in 2001 showed that men in lower occupational classes, such as service work, transportation, and labor work, were significantly more likely to engage in health risk behaviors compared with professional workers.[33] They also showed that there is a cumulation of risky behaviors in lower female occupational classes.[33] Further, another cross-sectional study in Japan demonstrated that occupation was not significantly associated with psychological distress among men or women by using a nationally representative sample in 2007.[34] Thus, the pattern of health inequalities in the present analysis is not consistent with occupational class differences in health behaviors or psychosocial stress.

As a possible explanation for the present findings, we note that occupation-based socioeconomic position may reflect social networks,[14] which enables its members to access a wide variety of resources. In this respect, recent research from Japan has emphasized the evaluation of social capital as well as social networks in the workplace to explain variations in workers' health.[35-37] We thus hypothesized a posteriori that, following the collapse of the economic bubble, workers of higher occupational classes were more likely to experience a breakdown of social cohesion within companies, which could cancel out the potential positive benefits among them. We also note that there is a possibility that the "compositions" of each occupational group went through a (substantial) change throughout the study period, which might have led to different patterns of occupational hazards, especially among lower occupational groups. In other words, there is a possibility that work environment have improved markedly among them throughout the study period, which now requires less labor load. Finally, a possibility of healthy worker effect cannot be ruled out among some lower occupational groups. This could be induced by the following two processes; (i) healthy people might have selectively entered these occupations, and (ii) unhealthy workers might have selectively exited these occupations. Further studies are warranted to examine these possible explanations of the present findings.[38]

It is worth mentioning that typical occupational hierarchy does not necessarily apply to the occupation (major group) of the Japan Standard Occupational Classification. Indeed, there is inherently more ambiguity in the ranking of occupations, compared with education and income.[39] In addition, as noted by Galobardes et al.,[14] the decrease in manual occupations with concomitant increase in low-level service occupations has altered the stratification that occupation generates in terms of socioeconomic position, and so classification such as manual and non-manual worker may lose some of their meaning in economies which include a large number of low-paid, non-manual service jobs. Importantly, the occupational classification in the present study yields reasonably consistent occupational grouping throughout the study period, and each group has a reasonably large data. We therefore examined the time trend of social inequalities by using the finest occupational classification available in the Census. By using a fairly detailed occupational classification, it is likely that we could adjust for other omitted compositional variables (e.g., education), to the extent that the cross-tabulation of age and occupation correlate with them.

Geographic and temporal variation in mortality

By applying the novel multilevel methods, the present study shows that geographic inequalities in premature mortality have also widened since 1995. In an ecological study, Fukuda et al.[40] assessed the time trend of geographic health inequality in Japan, by examining the association of life expectancy and age-adjusted mortality with per capita income of prefectures and municipalities. While excluding Okinawa prefecture from the analyses, they found a possible increase in geographic health inequalities from 1995 to 2000, following a decrease from 1955 to 1995.[40] Note that the present study examined geographic inequalities, conditional on individual age and occupation. The present findings thus provide suggestive evidence of "common ecologic effects" of place where people live,[41] although we should note that the seemingly ecologic effects might be due to an omitted compositional effect (e.g., income). Broadly speaking, since 1995, higher mortality risk has been consistently observed in the northeastern region in the main island (Tohoku region) for both sexes. Overall, the economic conditions of the predominantly rural areas in the region may be characterized by population decline, population aging, and lower per capita income.[19] [42] Notably, however, not all rural prefectures have undergone the same transition; indeed some rural prefectures (such as Nara and Okayama) had moved up through the ranks as having significantly lower mortality for both sexes in 2005. In the supplementary analysis, no clear associations were found with prefecture-level socioeconomic variables, and it remains unknown what contributed to these distinct patterns. These patterns deserve further attention in future studies.

Limitations of the study

There are some limitations of our analysis. First, although we were able to conduct a fairly detailed analysis of trends by using occupations to measure certain aspects of socioeconomic position, neither the status in employment nor the predominant type of employment contract was available, and in particular, we lacked information on whether the individuals were in standard jobs or precarious jobs. Given the conspicuous increase in the proportion of the labor force engaged in non-standard work,[4] as well as mounting evidence that precarious work is associated with worse health,[43] future work needs to examine whether the changing character of the workforce in Japan is contributing to widening health inequalities. The use of more detailed indicators of socioeconomic position would provide further insight into the social inequalities of health. Indeed, greater attention to the theoretical as well as empirical aspects of measurement of socioeconomic position will likely enhance the rigor of research on occupational health inequalities, which would increase the possibility for meaningfully comparing results across studies.[44]

Second, occupation at the time of death was used in our numerator data, which may not necessarily reflect the individual's life-course socioeconomic position.[44 45] If unhealthy workers selectively exited some occupations, this would have led to an under-estimation of mortality in those sectors. The proportion of agricultural workers significantly decreased during the study period for both sexes, as well as that of administrative and managerial workers (for men). However, this may reflect real trends in the work-force.

Third, considering the possible discrepancies of the respondents on the two occasions (i.e., the notification of deaths and the census), we should note the potential for numerator denominator bias between the two sources of information. In particular, the possibility of measurement error in occupation at the time of death cannot be ruled out – the person recording the notification of deaths may either promotes the deceased to a higher status job or demotes them because the respondents did not know the details of the deceased's job. Indeed, rapid changes in the occupational structure of Japan could give plausibility to the extremely large odds ratios resulting from the potential for numerator denominator bias.

Fourth, the smallest geographic unit available was the prefecture (of which there are 47), and we could not explore geographic inequalities in finer detail. However, the prefecture may be a useful and valid unit of analysis since it is the unit that has direct administrative authority in the economic, education, and health sectors.[1] Furthermore, the prefecture has specific jurisdiction over health centers, which is the locus of preventive health care activity in Japan.[1] Note also that the boundaries between prefectures have not changed since the Meiji Restoration (1867), enabling long-term analysis.[1] Since previous studies demonstrated that the choice of geographic units as well as area-based measures is critical in the investigation of geographic inequalities,[46 47] these issues warrant further examination.

Conclusions

The present findings demonstrate that both social and geographic inequalities in premature adult mortality have increased during Japan's "Lost Two Decades" following the collapse of the asset bubble. As a nation, Japan must grapple with the triple demographic trends of declining fertility, population aging, and overall population decline. These trends threaten to further dampen economic activity, escalating the load on the social security system. In addition, Japan now faces multiple challenges in the wake of the earthquake and tsunami on March 11, 2011, and this may further place downward momentum on the nation's struggling economy. Given these momentous challenges, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

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Figure legends

Figure 1. Predicted mortality by occupations in men, Japan, 1970-2005.

We show mean predicted probabilities for all-cause premature mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed from the Figure.

Figure 2. Predicted mortality by occupations in women, Japan, 1970-2005.

We show mean predicted probabilities for all-cause premature mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed from the Figure.

Figure 3. Geographic inequality of all-cause premature mortality, Japan, 1970-2005.

We show the overall geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were

1 not statistically significant.

Table 1. Odds ratios for all-cause premature mortality in each occupation, Japan, 1970-2005 [a]

	Overall		1970		1975		1980	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Men								
Specialist and technical workers	1.31	(1.30 to 1.33)	0.74	(0.72 to 0.77)	0.80	(0.77 to 0.82)	1.18	(1.14 to 1.21)
Administrative and managerial workers	0.97	(0.96 to 0.98)	0.54	(0.53 to 0.56)	0.66	(0.64 to 0.68)	0.76	(0.74 to 0.78)
Clerical workers	1.20	(1.19 to 1.21)	1.05	(1.03 to 1.08)	1.09	(1.06 to 1.12)	1.18	(1.15 to 1.21)
Sales workers	1.26	(1.25 to 1.27)	1.25	(1.23 to 1.28)	1.26	(1.24 to 1.29)	1.38	(1.35 to 1.41)
Service workers	2.22	(2.19 to 2.24)	1.22	(1.18 to 1.27)	1.20	(1.16 to 1.25)	1.93	(1.86 to 1.99)
Security workers	1.05	(1.03 to 1.08)	0.67	(0.63 to 0.72)	0.76	(0.72 to 0.81)	0.94	(0.88 to 1.00)
Agriculture, forestry and fishery workers	1.89	(1.87 to 1.91)	1.34	(1.32 to 1.37)	1.48	(1.45 to 1.51)	1.74	(1.71 to 1.78)
Transport and communication workers	1.29	(1.28 to 1.31)	1.06	(1.02 to 1.09)	0.98	(0.95 to 1.02)	1.17	(1.13 to 1.21)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	29.61	(29.28 to 29.94)	41.44	(37.93 to 45.28)	59.25	(56.07 to 62.61)	115.11	(110.66 to 119.75)
Non-employed	7.78	(7.73 to 7.82)	5.83	(5.73 to 5.93)	6.18	(6.07 to 6.28)	6.68	(6.56 to 6.80)
Women								
Specialist and technical workers	1.85	(1.81 to 1.89)	1.64	(1.54 to 1.74)	1.54	(1.44 to 1.63)	1.88	(1.77 to 2.00)
Administrative and managerial workers	4.91	(4.76 to 5.06)	3.57	(3.26 to 3.91)	3.54	(3.23 to 3.87)	3.17	(2.88 to 3.50)
Clerical workers	1.23	(1.20 to 1.25)	1.63	(1.55 to 1.72)	1.35	(1.28 to 1.42)	1.45	(1.38 to 1.53)
Sales workers	1.80	(1.77 to 1.83)	1.35	(1.29 to 1.41)	1.45	(1.38 to 1.52)	1.87	(1.78 to 1.97)
Service workers	1.65	(1.62 to 1.68)	1.11	(1.06 to 1.17)	1.04	(0.99 to 1.10)	1.77	(1.68 to 1.86)
Security workers	12.22	(11.40 to 13.10)	11.43	(9.14 to 14.29)	9.24	(7.30 to 11.69)	11.57	(9.07 to 14.76)
Agriculture, forestry and fishery workers	2.25	(2.22 to 2.29)	1.65	(1.60 to 1.71)	1.88	(1.80 to 1.95)	2.18	(2.09 to 2.28)
Transport and communication workers	6.88	(6.59 to 7.18)	4.01	(3.53 to 4.55)	3.89	(3.42 to 4.43)	7.07	(6.31 to 7.91)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	42.07	(41.22 to 42.93)	41.07	(35.48 to 47.54)	14.58	(13.19 to 16.12)	110.06	(103.28 to 117.29)
Non-employed	4.81	(4.75 to 4.88)	3.39	(3.29 to 3.50)	3.45	(3.34 to 3.56)	4.48	(4.32 to 4.65)

CI; confidence interval, OR; odds ratio

[a] We adjusted for age (five year categories) and year in the overall model. We adjusted for only age (five year categories) in other models.

Table 1. Odds ratios for all-cause premature mortality in each occupation, Japan, 1970-2005 (cont.)

1985		1990		1995		2000		2005	
OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
1.14	(1.10 to 1.17)	1.25	(1.21 to 1.28)	1.35	(1.32 to 1.39)	2.83	(2.75 to 2.90)	2.50	(2.43 to 2.57)
1.01	(0.98 to 1.04)	1.04	(1.01 to 1.07)	1.08	(1.05 to 1.11)	2.26	(2.19 to 2.34)	2.50	(2.41 to 2.60)
1.25	(1.22 to 1.28)	1.40	(1.37 to 1.44)	1.34	(1.31 to 1.38)	1.42	(1.37 to 1.46)	1.07	(1.03 to 1.11)
1.38	(1.35 to 1.41)	1.26	(1.23 to 1.29)	1.15	(1.12 to 1.18)	1.37	(1.33 to 1.41)	1.27	(1.23 to 1.31)
1.97	(1.91 to 2.04)	2.64	(2.56 to 2.72)	2.90	(2.81 to 2.99)	3.93	(3.81 to 4.06)	3.97	(3.84 to 4.11)
1.05	(0.99 to 1.11)	1.28	(1.21 to 1.36)	1.21	(1.15 to 1.29)	1.53	(1.45 to 1.62)	1.77	(1.68 to 1.87)
1.97	(1.92 to 2.01)	2.21	(2.16 to 2.27)	2.37	(2.30 to 2.44)	3.32	(3.21 to 3.43)	3.12	(3.00 to 3.24)
1.20	(1.17 to 1.24)	1.33	(1.29 to 1.37)	1.43	(1.39 to 1.48)	1.88	(1.82 to 1.94)	1.92	(1.85 to 2.00)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
49.01	(47.39 to 50.69)	34.66	(33.64 to 35.72)	54.18	(52.82 to 55.58)	52.73	(51.40 to 54.08)	9.13	(8.80 to 9.48)
6.94	(6.82 to 7.06)	8.15	(8.01 to 8.30)	8.59	(8.44 to 8.74)	11.16	(10.93 to 11.39)	14.21	(13.90 to 14.52)
1.82	(1.71 to 1.93)	1.85	(1.74 to 1.96)	2.02	(1.89 to 2.15)	2.83	(2.65 to 3.01)	2.63	(2.45 to 2.82)
3.68	(3.37 to 4.02)	5.16	(4.77 to 5.58)	6.08	(5.60 to 6.61)	10.16	(9.31 to 11.09)	12.21	(11.07 to 13.47)
1.26	(1.20 to 1.33)	1.17	(1.11 to 1.23)	1.32	(1.25 to 1.40)	1.31	(1.23 to 1.39)	1.26	(1.17 to 1.35)
2.03	(1.93 to 2.13)	1.89	(1.80 to 1.98)	1.94	(1.83 to 2.05)	2.20	(2.06 to 2.34)	2.32	(2.16 to 2.50)
1.67	(1.58 to 1.76)	1.86	(1.77 to 1.95)	2.21	(2.09 to 2.33)	2.42	(2.28 to 2.57)	2.49	(2.33 to 2.67)
19.51	(16.24 to 23.43)	17.07	(14.34 to 20.33)	13.22	(10.88 to 16.05)	12.49	(10.34 to 15.09)	16.25	(13.65 to 19.34)
2.08	(1.98 to 2.18)	2.10	(2.00 to 2.20)	2.63	(2.47 to 2.79)	3.15	(2.93 to 3.39)	3.42	(3.14 to 3.73)
7.52	(6.73 to 8.40)	9.54	(8.59 to 10.61)	8.17	(7.20 to 9.28)	9.65	(8.45 to 11.01)	11.54	(10.06 to 13.24)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
48.48	(45.76 to 51.37)	51.39	(48.69 to 54.24)	90.68	(86.15 to 95.46)	80.79	(76.53 to 85.29)	14.45	(13.33 to 15.67)
4.38	(4.23 to 4.54)	4.46	(4.30 to 4.62)	6.29	(6.04 to 6.55)	7.91	(7.55 to 8.29)	9.62	(9.10 to 10.16)

Table 2. Adjusted prefecture-level variance for all-cause premature mortality, Japan, 1970-2005 [a]

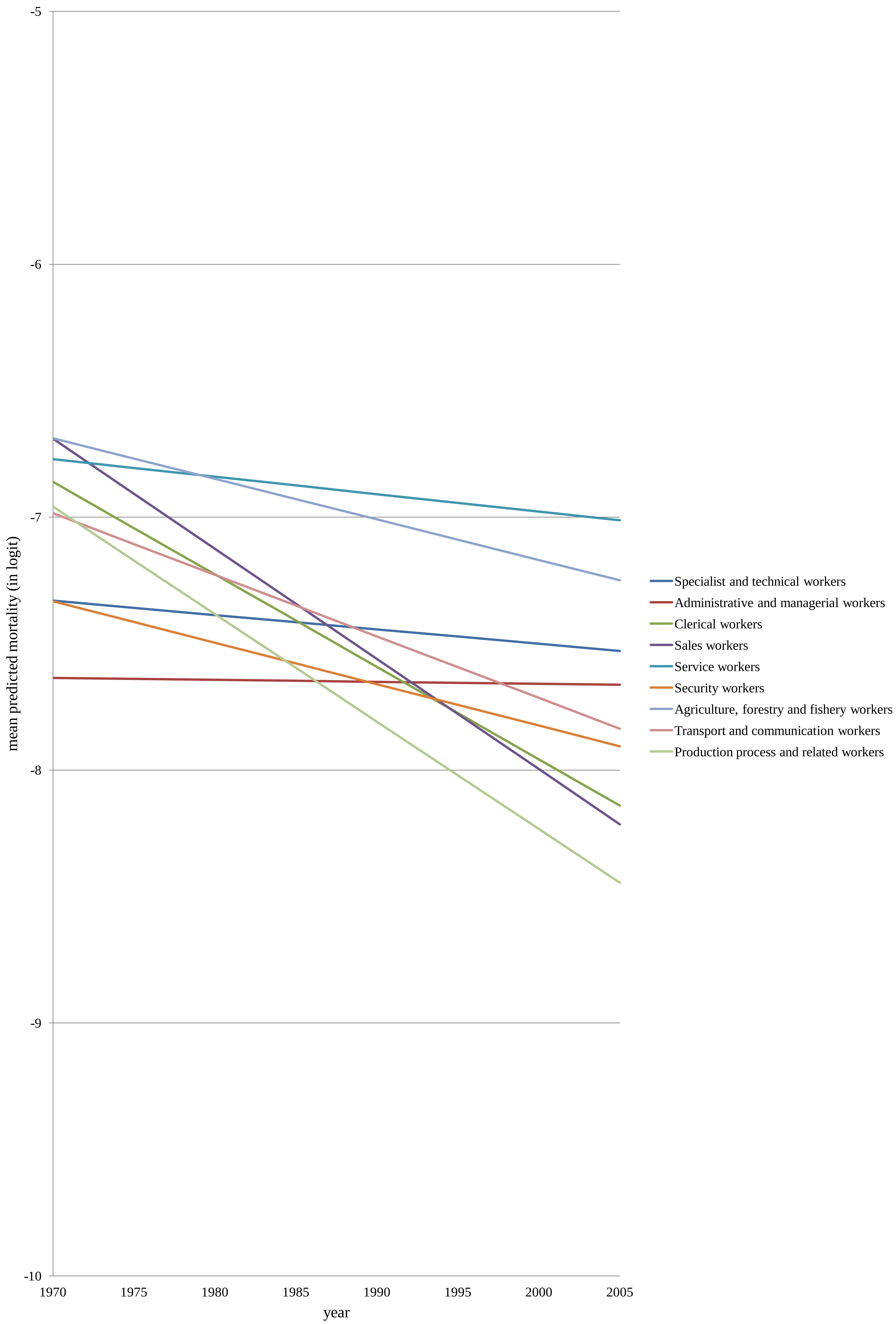
	Men			Women		
	Variance (on logit scale)			Variance (on logit scale)		
	Estimate	(95% CI)	Range of OR [b]	Estimate	(95% CI)	Range of OR [b]
Overall	0.003	(0.001 to 0.004)	0.87 to 1.13	0.005	(0.003 to 0.007)	0.84 to 1.11
1970 [c]	0.003	(0.002 to 0.005)	0.89 to 1.12	0.007	(0.004 to 0.010)	0.79 to 1.14
1975	0.003	(0.001 to 0.004)	0.88 to 1.09	0.007	(0.004 to 0.010)	0.82 to 1.19
1980	0.004	(0.002 to 0.005)	0.82 to 1.11	0.005	(0.003 to 0.008)	0.85 to 1.15
1985	0.003	(0.001 to 0.004)	0.85 to 1.09	0.005	(0.002 to 0.007)	0.86 to 1.13
1990	0.003	(0.002 to 0.004)	0.89 to 1.11	0.004	(0.002 to 0.006)	0.88 to 1.10
1995	0.006	(0.003 to 0.009)	0.85 to 1.22	0.008	(0.004 to 0.012)	0.80 to 1.15
2000	0.007	(0.004 to 0.010)	0.84 to 1.25	0.010	(0.005 to 0.015)	0.76 to 1.15
2005	0.011	(0.007 to 0.016)	0.81 to 1.27	0.012	(0.007 to 0.017)	0.75 to 1.18

CI; confidence interval, OR; odds ratio

[a] We adjusted for age (five year categories) and occupations. We further adjusted for year in the overall model.

[b] The range of adjusted odds ratios for mortality in each prefecture is shown. The reference is the grand mean of all the prefectures.

[c] The variance between 46 prefectures is shown because the data for Okinawa prefecture were not available in 1970.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mean predicted mortality (in logit)
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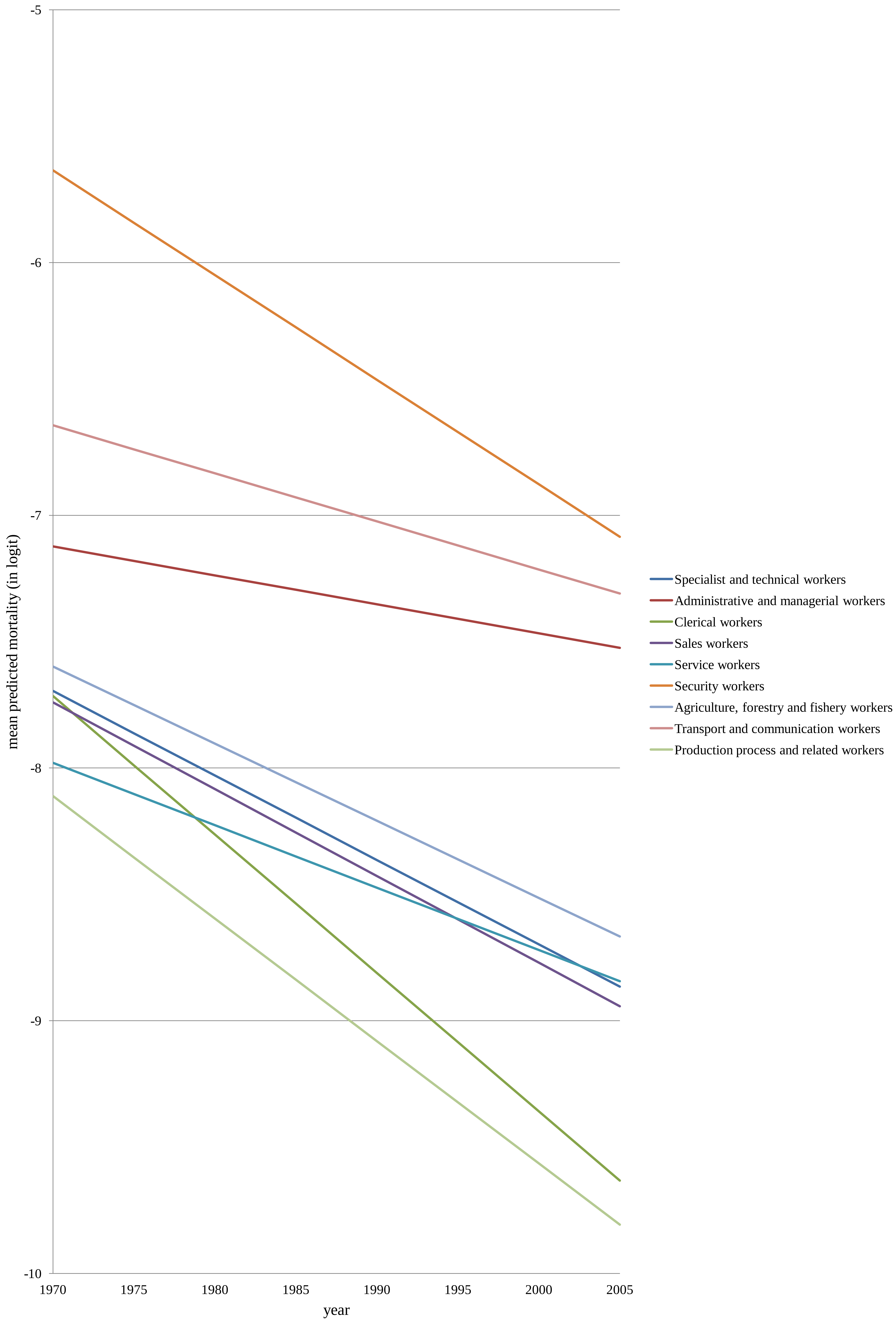
year
Specialist and technical workers
Administrative and managerial workers
Clerical workers
Sales workers
Service workers
Security workers
Agriculture, forestry and fishery workers
Transport and communication workers
Production process and related workers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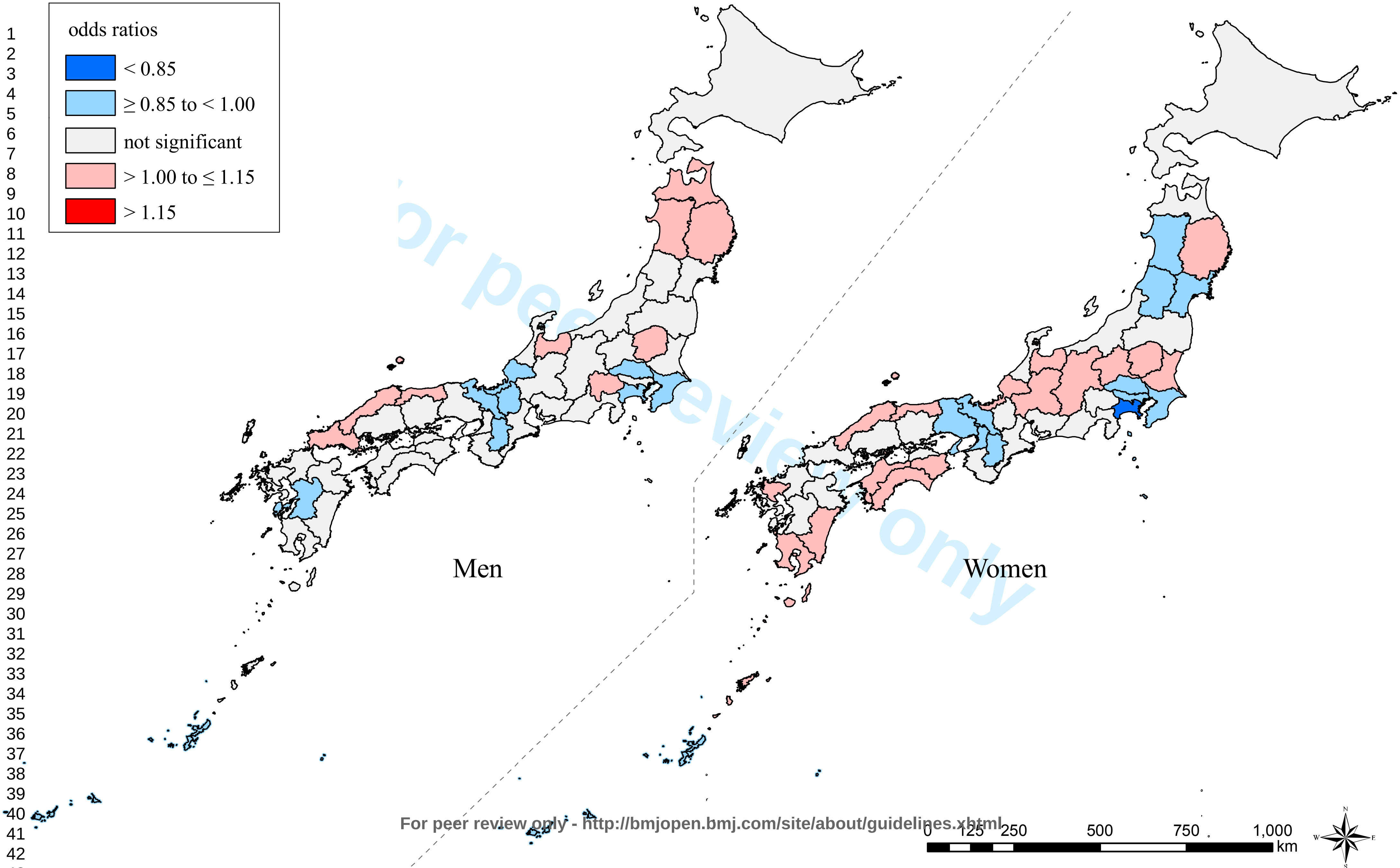
odds ratios
< 0.85
≥ 0.85 to < 1.00
not significant
> 1.00 to ≤ 1.15
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Supplementary Text

Overview of supplementary analyses

As supplementary analyses, we examined two additional issues to further explore the social and geographic inequalities in premature mortality; (i) the patterns of geographic inequalities in mortality by occupations, and (ii) the presence of contextual effects of prefecture-level socioeconomic status on mortality risk.

Geographic inequalities in all-cause premature mortality by occupations

Background and aims

Although we examined the patterns of geographic inequalities in premature mortality for all occupations in the main analysis, the patterns may vary (substantially) according to occupations. Therefore, we examined the occupation-specific geographic inequality in premature mortality for the overall study period. This analysis may further facilitate understanding of the possible pathways of emerging geographic inequalities in Japan.

Methods

Following the previous report of the Population Census,[1] we summarized the 11 occupations into six groups to increase the statistical power as follows: I. clerical, technical and managerial occupations (i.e., (1) specialist and technical workers, (2) administrative and managerial workers, and (3) clerical workers), II. sales and service occupations (i.e., (4) sales workers, (5) service workers, and (6) security workers), III. agriculture, forestry and fishery occupations (i.e., (7) agriculture, forestry and fishery workers), IV. production and transport occupations (i.e., (8) transport and communication workers and (9) production process and related workers), V. unclassifiable occupations (i.e., (10) workers not classifiable by occupation), and VI. non-employed (i.e., (11) non-employed) (Supplementary Table 1).

In this supplementary analysis, we specified six prefecture-level error terms (at level 3) corresponding to the six occupational groups, conditional on individual age, 11 occupations, and years as fixed terms. We calculated the variance and covariance of these error terms, and we also derived their correlation coefficients to explore the possible differential geographic patterns of mortality by the six occupational groups. Finally, we created maps showing prefecture-level residuals in the same methods as the main analysis.

Results

We show the results of variance and covariance of prefecture-level residuals among the six occupational groups (Supplementary Table 8). Men and women revealed a similar pattern except for the covariance between sales and service occupations and non-employed (-0.003 and 0.005 in men and women, respectively) and the covariance between agriculture, forestry and fishery occupations and unclassifiable occupations (0.006 and -0.019 in men and women, respectively). In both sexes, the variances among unclassifiable occupations were much higher than those of other occupational groups (0.317 and 0.331 in men and women, respectively). Further, excluding unclassifiable occupations and non-employed, the signs of correlation coefficients were all positive, indicating that the patterns of geographic inequalities were similar across the remaining four occupational groups. We show these geographic patterns in both sexes (Supplementary Figures 4 and 5).

Contextual effect of prefecture-level socioeconomic status

Background and aims

Previous studies in Japan have examined possible contextual effects of area-level socioeconomic status (e.g., income inequality, per-capita income) on self-rated health and health-related behaviors by using multilevel analysis.[2-4] The relationship between area-level socioeconomic status and mortality has been also investigated in ecological studies,[5-12] most of which indicated higher mortality in areas of lower socioeconomic position. Indeed, recent international comparative studies have confirmed an association between income inequality and health, which included Japan.[13-15] However, no studies have examined the association between area-level socioeconomic status and premature adult mortality in Japan, by considering both individual- and area-level socioeconomic indicators. Further, we note the possibility that contextual effects by area-level disadvantage may have changed after the collapse of asset bubble in the early 1990s. Therefore, we examined the trends of contextual effects of prefecture-level socioeconomic status on premature adult mortality.

Methods

We derived prefecture-level socioeconomic status variables from the *National Survey of Family Income and Expenditure*,[16] which has been implemented every five years since the first survey in 1959. We derived the following three variables for each prefecture and divided them into tertiles; Gini's coefficient of yearly income, average yearly income, and average savings (Supplementary Table 9). These variables were calculated among two-or-more-person households. Gini's coefficient of yearly income was available since 1979, and we imputed the values of 1979 forwardly to 1969 and 1974. Although household income and savings may follow the skewed distributions, median income or savings were not available throughout the study period. Note that a previous review article suggested that the studies in income inequality are more supportive in large areas, e.g., states, regions, and metropolitan areas, because in that context income inequality serves as a measure of the scale of social stratification.[17] As Shibuya et al.[2] noted, a prefecture is similar to a state in the United States in terms of its population size and variations in income inequality.

We linked the data set of prefecture-level variables to the data set of the Population Census and the Vital Statistics one year out, e.g., National Survey of Family Income and Expenditure in 2004 was linked with the Population Census in 2005 and the Vital Statistics in 2005 fiscal year.

In the analysis, we conducted three-level analyses as an overall model, with cells at level 1, years at level 2, and prefectures at level 3. The prefecture-level socioeconomic status variable was entered into the model as a level-2 variable separately. Furthermore, to examine the joint effects of income inequality and average income/savings, we also entered Gini's coefficient and average yearly income/savings into the model simultaneously. In like manner, to examine the temporal patterns of contextual effects, we also conducted two-level analysis, with cells at level 1 and prefectures at level 2 separately for each year.

Results

Overall, we found little evidence of the association between prefecture-level socioeconomic status and the risk of mortality in both sexes, conditional on individual age and occupation (Supplementary Table 10). Likewise, in year-specific analyses, no clear associations were found although lower average savings were associated with higher risk of mortality in some years. When we examined the joint effects of income inequality and average income/savings, no substantial differences were observed (data not shown).

Conclusions of supplementary analyses

Excluding unclassifiable occupations and non-employed, the patterns of geographic inequalities were similar across occupational groups. We found no clear associations between prefecture-level socioeconomic status and premature mortality risk throughout the period although there is suggestion of inverse association between average savings and mortality in some years.

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Supplementary Table 1. The history of the Japan Standard Occupational Classification [a]

1st revision, 1970		2nd revision, 1979		3rd revision, 1986		4th revision, 1997	
No.	Occupation (major group)	No.	Occupation (major group)	No.	Occupation (major group)	No.	Occupation (major group) [b]
(1) [1]	Professional and technical workers	(1) [1]	Professional and technical workers	(1) [1]	Professional and technical workers	(1) [1]	Specialist and technical workers
(2) [2]	Managers and officials	(2) [2]	Managers and officials	(2) [2]	Managers and officials	(2) [2]	Administrative and managerial workers
(3) [3]	Clerical and related workers	(3) [3]	Clerical and related workers	(3) [3]	Clerical and related workers	(3) [3]	Clerical workers
(4) [4]	Sales workers	(4) [4]	Sales workers	(4) [4]	Sales workers	(4) [4]	Sales workers
(5) [7]	Farmers, Lumbermen and fishermen	(5) [7]	Agricultural, forestry and fisheries workers	(5) [5]	Service workers	(5) [5]	Service workers
(6) [9]	Workers in mining and quarrying occupations	(6) [9]	Mining workers	(6) [6]	Protective service workers	(6) [6]	Security workers
(7) [8]	Workers in transport and communications occupations	(7) [8]	Workers in transport and communications occupations	(7) [7]	Agricultural, forestry and fisheries workers	(7) [7]	Agriculture, forestry and fishery workers
(8) [9]	Craftsmen, production process workers and labourers	(8) [9]	Craftsmen, production process workers and labours	(8) [8]	Workers in transport and communications occupations	(8) [8]	Transport and communication workers
(9) [6]	Protective service workers	(9) [6]	Protective service workers	(9) [9]	Craftsmen, mining, production process and construction workers and laborers	(9) [9]	Production process and related workers
(10) [5]	Service workers	(10) [5]	Service workers	(10) [10]	Workers not classifiable by occupation	(10) [10]	Workers not classifiable by occupation
(11) [10]	Unclassifiable	(11) [10]	Workers not classifiable by occupation	(11) [11]	Non-employed [c]	(11) [11]	Non-employed [c]
(12) [11]	Non-employed [c]	(11) [11]	Non-employed [c]				

[a] We consistently used occupation (major group) of the 4th revision. The number in square brackets is the classification used in ths present study.

[b] When showing geographic inequality by occupation, we summarized these 11 occupation into six groups as follows:

I. Clerical, technical and managerial occupations: (1) specialist and technical workers, (2) administrative and managerial workers, and (3) clerical workers
II. Sales and service occupations: (4) sales workers, (5) service workers, and (6) security workers
III. Agriculture, forestry and fishery occupations: (7) agriculture, forestry and fishery workers
IV. Production and transport occupations: (8) transport and communication workers and (9) production process and related workers
V. Unclassifiable occupations: (10) workers not classifiable by occupation
VI. Non-employed: (11) non-employed

[c] Non-employed refers to the sum of unemployed and non-labor force in line with the *Report of Vital Statistics: Occupational and Industrial Aspects* .

Supplementary Table 2. Description of data in 47 prefectures, Japan, 1970-2005

	Men				Women			
	No. of deaths	Total population	Mortality rate per 100,000 [a]	(SD)	No. of deaths	Total population	Mortality rate per 100,000 [a]	(SD)
Overall	984,022	251,576,351	1,569	(6,718)	532,223	259,688,353	758	(3,914)
Prefectures								
1 Hokkaido	49,247	11,489,095	1,870	(7,692)	26,436	12,394,724	886	(4,366)
2 Aomori	15,202	2,959,355	1,531	(6,760)	7,282	3,248,812	471	(2,143)
3 Iwate	13,258	2,856,175	2,187	(9,429)	6,959	3,067,651	864	(4,827)
4 Miyagi	17,042	4,448,360	1,412	(5,469)	9,137	4,625,004	728	(3,064)
5 Akita	12,371	2,512,525	1,410	(5,569)	6,168	2,740,415	561	(3,178)
6 Yamagata	10,748	2,553,156	1,863	(8,426)	5,824	2,679,130	978	(4,649)
7 Fukushima	18,520	4,200,931	1,368	(4,958)	9,601	4,341,831	454	(1,655)
8 Ibaraki	23,125	5,779,563	1,101	(3,644)	12,135	5,665,132	511	(2,853)
9 Tochigi	16,375	3,976,411	1,643	(6,942)	8,590	3,941,144	876	(3,381)
10 Gunma	15,506	4,036,944	1,704	(6,946)	8,651	4,069,213	532	(2,058)
11 Saitama	43,148	13,129,693	1,436	(5,956)	23,114	12,774,631	519	(1,419)
12 Chiba	39,273	11,279,717	1,247	(4,401)	19,925	11,073,425	652	(3,696)
13 Tokyo	91,194	25,686,395	1,374	(5,119)	49,601	25,677,746	598	(1,754)
14 Kanagawa	54,947	16,940,375	1,330	(5,569)	28,202	16,194,532	1,053	(5,584)
15 Niigata	21,083	5,083,511	1,945	(7,533)	10,861	5,245,859	714	(3,398)
16 Toyama	9,238	2,300,243	1,606	(7,190)	5,250	2,429,822	980	(5,406)
17 Ishikawa	8,670	2,301,490	1,655	(7,956)	5,013	2,447,439	953	(6,194)
18 Fukui	5,611	1,643,881	1,677	(7,209)	3,556	1,721,279	1,391	(7,473)
19 Yamanashi	7,183	1,720,587	1,436	(5,625)	3,727	1,754,097	719	(3,804)
20 Nagano	15,876	4,393,794	2,175	(8,828)	9,505	4,551,945	853	(4,017)
21 Gifu	14,957	4,139,225	1,515	(6,609)	9,222	4,333,798	913	(4,421)
22 Shizuoka	28,057	7,639,953	1,962	(8,756)	14,720	7,674,935	565	(1,736)
23 Aichi	46,925	14,066,571	1,626	(7,368)	26,699	13,817,272	764	(2,784)
24 Mie	14,118	3,624,980	1,408	(5,186)	7,828	3,794,338	583	(2,379)
25 Shiga	8,125	2,428,751	1,453	(5,976)	4,883	2,465,170	782	(3,805)
26 Kyoto	18,723	5,109,042	1,166	(3,889)	11,146	5,465,224	464	(2,094)
27 Osaka	73,055	18,232,091	1,964	(7,462)	38,671	18,808,092	1,109	(4,676)
28 Hyogo	44,110	10,970,009	1,940	(7,967)	23,963	11,550,437	798	(3,145)
29 Nara	9,755	2,621,500	1,730	(7,403)	5,598	2,813,039	971	(4,423)
30 Wakayama	10,006	2,169,994	1,276	(6,597)	5,596	2,358,333	573	(2,872)
31 Tottori	5,687	1,212,157	2,055	(8,746)	2,862	1,295,687	695	(3,717)
32 Shimane	7,103	1,546,077	2,051	(8,981)	3,829	1,651,580	891	(4,704)
33 Okayama	15,296	3,828,579	1,991	(8,329)	8,127	4,043,112	720	(3,298)
34 Hiroshima	23,074	5,750,006	1,708	(6,593)	12,338	6,008,967	852	(3,726)
35 Yamaguchi	14,671	3,127,157	2,051	(8,498)	7,883	3,435,624	582	(2,276)
36 Tokushima	7,871	1,661,674	711	(1,797)	4,406	1,786,025	454	(1,935)
37 Kagawa	8,494	2,052,654	999	(3,529)	4,743	2,182,213	551	(3,159)
38 Ehime	13,813	2,961,350	2,209	(8,794)	7,631	3,279,967	781	(3,189)
39 Kochi	8,686	1,627,246	1,004	(3,355)	4,403	1,792,884	353	(1,777)
40 Fukuoka	41,386	9,316,985	1,349	(5,374)	22,159	10,313,913	790	(3,359)
41 Saga	7,618	1,664,620	1,458	(7,446)	4,307	1,844,827	1,057	(6,718)
42 Nagasaki	14,563	2,995,173	1,398	(5,680)	8,010	3,346,375	813	(4,295)
43 Kumamoto	15,029	3,485,422	780	(2,080)	8,554	3,916,400	623	(2,600)
44 Oita	10,691	2,389,418	1,658	(6,904)	6,345	2,691,272	834	(3,893)
45 Miyazaki	10,422	2,240,503	1,866	(8,416)	5,606	2,496,028	1,239	(7,251)
46 Kagoshima	16,626	3,369,654	1,329	(5,321)	9,565	3,795,497	859	(3,649)
47 Okinawa [b]	7,544	2,053,359	1,046	(5,404)	3,592	2,083,513	722	(4,594)

SD; standard deviation

[a] Mortality rate was calculated on the basis of the means of the proportion of deaths for each prefecture across all cell types.

[b] The data for Okinawa prefecture were not available in 1970.

Supplementary Table 3. The number (percentage) of total population in each occupation, Japan, 1970-2005

	1970		1975		1980		1985		1990		1995		2000		2005	
Men																
Specialist and technical workers	1,835,895	(7.32)	2,080,025	(7.25)	2,306,830	(7.51)	3,143,412	(9.76)	3,637,515	(10.95)	3,991,077	(11.72)	4,221,683	(12.27)	3,950,815	(11.90)
Administrative and managerial workers	1,797,390	(7.17)	1,972,340	(6.88)	2,210,783	(7.19)	1,868,101	(5.80)	1,998,511	(6.01)	2,066,172	(6.07)	1,305,093	(3.79)	1,031,316	(3.11)
Clerical workers	2,914,350	(11.62)	3,674,725	(12.81)	3,637,048	(11.83)	3,857,022	(11.98)	3,895,784	(11.72)	3,906,006	(11.47)	4,077,310	(11.85)	4,093,124	(12.33)
Sales workers	2,681,490	(10.69)	3,508,340	(12.23)	4,132,015	(13.44)	4,509,884	(14.00)	4,794,455	(14.43)	5,044,836	(14.82)	5,159,661	(15.00)	4,716,064	(14.21)
Service workers	738,725	(2.95)	984,940	(3.43)	1,027,910	(3.34)	1,123,385	(3.49)	1,202,319	(3.62)	1,270,668	(3.73)	1,381,504	(4.02)	1,441,522	(4.34)
Security workers	438,955	(1.75)	520,720	(1.82)	567,438	(1.85)	615,053	(1.91)	660,161	(1.99)	706,462	(2.08)	787,325	(2.29)	832,148	(2.51)
Agriculture, forestry and fishery workers	3,531,500	(14.08)	2,849,180	(9.94)	2,379,666	(7.74)	2,112,513	(6.56)	1,615,756	(4.86)	1,199,620	(3.52)	899,881	(2.62)	823,066	(2.48)
Transport and communication workers	1,682,400	(6.71)	1,972,390	(6.88)	2,072,133	(6.74)	1,997,137	(6.2)	1,984,890	(5.97)	2,020,393	(5.93)	1,957,847	(5.69)	1,794,551	(5.41)
Production process and related workers	8,428,675	(33.61)	9,645,620	(33.63)	10,682,007	(34.76)	10,644,436	(33.05)	10,985,461	(33.06)	10,945,330	(32.15)	10,762,241	(31.28)	10,451,026	(31.48)
Workers not classifiable by occupation	6,725	(0.03)	13,870	(0.05)	22,474	(0.07)	50,391	(0.16)	115,015	(0.35)	151,362	(0.44)	294,663	(0.86)	502,667	(1.51)
Non-employed [a]	1,024,357	(4.08)	1,456,032	(5.08)	1,696,114	(5.52)	2,283,403	(7.09)	2,339,703	(7.04)	2,744,327	(8.06)	3,559,611	(10.35)	3,559,611	(10.72)
Total	25,080,462	(100.00)	28,678,182	(100.00)	30,734,418	(100.00)	32,204,737	(100.00)	33,229,570	(100.00)	34,046,253	(100.00)	34,406,819	(100.00)	33,195,910	(100.00)
Women																
Specialist and technical workers	800,245	(3.00)	1,121,045	(3.73)	1,507,610	(4.72)	1,891,400	(5.73)	2,250,231	(6.69)	2,684,971	(7.83)	3,094,599	(8.87)	3,459,894	(9.83)
Administrative and managerial workers	86,615	(0.32)	105,985	(0.35)	155,251	(0.49)	171,782	(0.52)	184,219	(0.55)	199,894	(0.58)	142,983	(0.41)	123,283	(0.35)
Clerical workers	1,694,870	(6.36)	2,753,760	(9.16)	3,369,822	(10.56)	4,248,922	(12.86)	5,155,485	(15.32)	5,748,954	(16.76)	6,289,031	(18.03)	6,422,961	(18.25)
Sales workers	1,885,440	(7.07)	2,152,320	(7.16)	2,586,857	(8.11)	2,447,212	(7.41)	2,534,197	(7.53)	2,702,863	(7.88)	2,618,387	(7.51)	2,561,132	(7.28)
Service workers	1,634,865	(6.13)	1,974,925	(6.57)	2,106,305	(6.60)	2,173,931	(6.58)	2,263,285	(6.73)	2,516,848	(7.34)	2,825,178	(8.10)	3,207,147	(9.11)
Security workers	5,830	(0.02)	8,010	(0.03)	9,876	(0.03)	12,390	(0.04)	16,562	(0.05)	24,289	(0.07)	37,414	(0.11)	43,158	(0.12)
Agriculture, forestry and fishery workers	4,558,975	(17.10)	3,154,040	(10.49)	2,471,427	(7.75)	2,029,368	(6.14)	1,478,304	(4.39)	1,055,672	(3.08)	755,524	(2.17)	600,419	(1.71)
Transport and communication workers	99,570	(0.37)	108,500	(0.36)	108,205	(0.34)	96,205	(0.29)	84,717	(0.25)	93,936	(0.27)	92,226	(0.26)	85,394	(0.24)
Production process and related workers	3,546,495	(13.30)	3,691,205	(12.28)	4,456,927	(13.97)	4,911,261	(14.87)	5,158,278	(15.33)	4,862,147	(14.17)	4,664,292	(13.37)	4,228,532	(12.01)
Workers not classifiable by occupation	5,285	(0.02)	34,995	(0.12)	24,186	(0.08)	66,917	(0.20)	89,544	(0.27)	121,135	(0.35)	223,913	(0.64)	327,266	(0.93)
Non-employed [a]	12,339,091	(46.29)	14,949,973	(49.74)	15,110,843	(47.36)	14,978,370	(45.35)	14,434,745	(42.90)	14,296,062	(41.67)	14,141,088	(40.54)	14,141,088	(40.17)
Total	26,657,281	(100.00)	30,054,758	(100.00)	31,907,309	(100.00)	33,027,758	(100.00)	33,649,567	(100.00)	34,306,771	(100.00)	34,884,635	(100.00)	35,200,274	(100.00)

[a] Non-employed is the sum of unemployed and non-labor force.

Supplementary Table 4. Description of data used for multilevel models analyzing all-cause mortality in 47 prefectures, Japan, 1970-2005

	Men					Women				
Characteristics	No. of cells [a]	No. of deaths	Total population	Mortality rate per 100,000 [b]	(SD)	No. of cells [a]	No. of deaths	Total population	Mortality rate per 100,000 [b]	(SD)
Overall	32,590	984,022	251,576,351	1,569	(6,718)	32,542	532,223	259,688,353	758	(3,914)
Level 1: cell										
Specialist and technical workers										
25-29 y	375	2,044	4,259,474	59	(38)	375	837	3,750,173	28	(32)
30-34 y	375	2,374	4,400,316	63	(39)	375	815	2,781,512	37	(37)
35-39 y	375	3,122	4,078,554	90	(51)	375	938	2,546,667	43	(43)
40-44 y	375	4,655	3,665,610	152	(69)	375	1,419	2,449,918	69	(55)
45-49 y	375	7,054	3,095,990	257	(108)	375	1,983	2,137,592	114	(82)
50-54 y	375	9,922	2,511,813	423	(144)	375	2,422	1,628,069	180	(136)
55-59 y	375	12,688	1,990,836	676	(202)	375	2,516	1,044,184	298	(216)
60-64 y	375	11,086	1,164,659	1,055	(354)	375	1,949	471,880	519	(390)
Administrative and managerial workers										
25-29 y	375	212	296,615	85	(206)	372	49	25,359	168	(751)
30-34 y	375	496	810,953	71	(124)	375	99	56,477	211	(742)
35-39 y	375	1,053	1,489,214	83	(84)	375	174	103,320	171	(587)
40-44 y	375	2,387	2,162,030	118	(71)	375	403	157,876	251	(413)
45-49 y	375	4,655	2,604,260	194	(95)	375	684	204,826	286	(326)
50-54 y	375	8,292	2,759,166	320	(119)	375	1,007	227,213	434	(529)
55-59 y	375	11,466	2,487,389	481	(151)	375	1,237	219,669	604	(646)
60-64 y	375	10,619	1,640,079	670	(235)	375	1,274	175,272	756	(966)
Clerical workers										
25-29 y	375	3,143	4,619,902	68	(41)	375	1,546	7,377,454	25	(24)
30-34 y	375	3,486	4,720,850	75	(42)	375	1,372	5,423,988	31	(33)
35-39 y	375	4,860	4,579,329	109	(61)	375	1,741	5,266,613	38	(33)
40-44 y	375	6,935	4,381,766	163	(86)	375	2,456	5,389,811	54	(48)
45-49 y	375	9,969	3,996,273	261	(127)	375	3,259	4,834,832	87	(75)
50-54 y	375	13,048	3,507,037	414	(193)	375	3,603	3,768,147	141	(121)
55-59 y	375	14,258	2,778,285	586	(292)	375	3,026	2,474,248	196	(227)
60-64 y	375	8,500	1,471,927	642	(394)	375	1,939	1,148,712	285	(359)
Sales workers										
25-29 y	375	2,773	5,895,959	55	(40)	375	684	2,326,951	32	(37)
30-34 y	375	3,330	5,923,651	67	(50)	375	910	2,218,018	40	(39)
35-39 y	375	4,582	5,414,612	106	(73)	375	1,291	2,572,122	50	(39)
40-44 y	375	6,726	4,806,468	176	(122)	375	2,131	2,931,404	74	(50)
45-49 y	375	9,791	4,194,561	299	(184)	375	3,193	3,034,544	111	(65)
50-54 y	375	12,994	3,567,706	474	(240)	375	4,432	2,762,345	174	(93)
55-59 y	375	16,386	2,882,844	727	(348)	375	4,995	2,200,556	252	(127)
60-64 y	375	16,493	1,860,944	1,025	(459)	375	4,938	1,442,468	358	(175)
Service workers										
25-29 y	375	1,612	1,659,142	112	(82)	375	762	1,935,466	45	(46)
30-34 y	375	1,667	1,453,561	127	(88)	375	856	1,964,185	44	(40)
35-39 y	375	2,258	1,284,982	209	(254)	375	1,181	2,353,506	54	(42)
40-44 y	375	3,101	1,153,463	298	(158)	375	1,890	2,741,991	75	(48)
45-49 y	375	4,630	1,041,635	475	(214)	375	2,968	2,943,583	109	(59)
50-54 y	375	6,508	956,705	729	(291)	375	3,910	2,880,236	150	(76)
55-59 y	375	8,453	888,084	1,005	(351)	375	4,557	2,432,373	218	(108)
60-64 y	375	8,185	733,401	1,261	(487)	375	3,882	1,451,144	309	(181)
Security workers										
25-29 y	375	420	826,908	56	(82)	362	40	38,591	239	(1,631)
30-34 y	375	433	746,077	66	(87)	348	41	23,805	332	(2,068)
35-39 y	375	563	694,425	86	(108)	352	58	18,416	568	(3,220)
40-44 y	375	875	692,317	126	(115)	363	87	19,017	896	(4,439)
45-49 y	375	1,380	678,802	224	(172)	360	133	18,789	869	(2,725)
50-54 y	375	1,905	621,010	340	(243)	354	151	17,878	1,208	(3,259)
55-59 y	375	2,404	517,883	492	(335)	336	189	14,007	2,138	(5,218)
60-64 y	375	2,015	350,840	636	(503)	317	137	7,026	3,053	(8,385)
Agriculture, forestry and fishery workers										
25-29 y	375	1,425	911,736	141	(121)	375	544	768,146	55	(114)
30-34 y	375	2,047	1,147,060	174	(128)	375	874	1,212,740	63	(96)
35-39 y	375	3,667	1,510,949	222	(132)	375	1,515	1,691,530	74	(100)
40-44 y	375	6,154	1,895,195	297	(142)	375	2,664	2,125,301	99	(74)
45-49 y	375	9,650	2,139,287	418	(158)	375	4,360	2,465,129	152	(96)
50-54 y	375	14,455	2,319,644	592	(176)	375	6,912	2,636,924	228	(112)
55-59 y	375	22,542	2,568,440	827	(218)	375	9,481	2,702,501	315	(151)
60-64 y	375	33,473	2,918,871	1,086	(346)	375	11,993	2,501,458	442	(241)
Transport and communication workers										
25-29 y	375	2,051	2,124,064	93	(66)	375	125	161,108	75	(249)
30-34 y	375	2,384	2,384,161	95	(58)	375	141	124,668	85	(209)
35-39 y	375	3,236	2,427,773	135	(72)	375	205	124,084	149	(274)
40-44 y	375	4,418	2,353,707	192	(147)	375	294	121,923	209	(327)
45-49 y	375	5,599	2,158,825	271	(108)	375	416	105,735	334	(486)
50-54 y	375	7,057	1,908,570	406	(187)	374	431	75,568	547	(837)
55-59 y	375	7,057	1,453,565	570	(293)	373	411	41,887	1,156	(2,098)
60-64 y	375	3,796	671,076	783	(580)	343	301	13,780	3,095	(6,452)
Production process and related workers										
25-29 y	375	7,322	12,387,917	64	(43)	375	740	2,765,852	25	(29)
30-34 y	375	8,657	12,289,511	76	(52)	375	985	3,610,544	25	(23)
35-39 y	375	12,143	11,861,114	110	(75)	375	1,748	4,939,585	34	(29)
40-44 y	375	17,256	11,459,170	164	(100)	375	2,700	5,872,068	46	(35)
45-49 y	375	23,730	10,858,257	241	(123)	375	3,933	6,045,010	68	(44)
50-54 y	375	29,381	10,014,409	339	(159)	375	4,928	5,497,531	102	(65)
55-59 y	375	33,010	8,491,654	472	(231)	375	4,742	4,297,010	135	(97)
60-64 y	375	26,151	5,182,764	608	(323)	375	3,780	2,491,537	188	(151)
Workers not classifiable by occupation										
25-29 y	345	1,513	207,647	4,422	(9,574)	354	581	150,990	1,492	(4,303)
30-34 y	346	1,796	181,239	5,530	(11,417)	361	697	122,540	1,792	(4,764)
35-39 y	336	2,399	150,763	9,618	(16,824)	355	914	111,790	2,392	(6,226)
40-44 y	323	3,544	136,098	12,160	(18,001)	351	1,360	116,798	3,402	(7,472)
45-49 y	327	5,911	128,506	16,372	(21,250)	346	2,247	116,946	4,342	(8,124)
50-54 y	310	8,721	131,754	19,824	(22,022)	347	3,360	111,753	7,301	(13,362)
55-59 y	308	10,718	125,633	23,038	(23,707)	343	3,681	96,322	8,706	(13,246)
60-64 y	295	10,281	95,527	23,592	(22,601)	331	3,800	66,102	14,147	(19,001)
Non-employed										
25-29 y	375	7,981	2,366,593	448	(245)	375	9,868	16,328,017	66	(32)
30-34 y	375	9,093	1,572,710	696	(323)	375	13,641	17,975,450	89	(39)
35-39 y	375	12,570	1,351,088	1,026	(428)	375	18,225	15,037,080	142	(61)
40-44 y	375	19,268	1,314,727	1,521	(514)	375	26,086	12,159,904	253	(92)
45-49 y	375	30,255	1,456,804	2,223	(723)	375	38,502	11,501,582	384	(118)
50-54 y	375	48,346	1,689,190	3,024	(823)	375	57,256	12,364,455	522	(161)
55-59 y	375	84,286	2,517,232	3,330	(762)	375	82,857	13,455,956	674	(210)
60-64 y	375	164,871	6,394,814	2,972	(1,194)	375	124,761	15,568,816	890	(351)

SD; standard deviation

[a] These cells are cross-clasified by sex, age (five year categories), and 11 occupations.

[b] Mortality rate was calculated on the basis of the means of the proportion of deaths for each cell type across all prefectures.

Supplementary Table 5. Age-adjusted mortality rate per 100,000 in each occupation, Japan, 1970-2005 [a]

	1970	1975	1980	1985	1990	1995	2000	2005
Men								
Specialist and technical workers	340	282	319	257	234	223	312	231
Administrative and managerial workers	233	223	192	215	193	170	248	241
Clerical workers	460	366	298	267	253	207	146	95
Sales workers	547	444	370	322	246	187	146	113
Service workers	515	389	488	426	476	442	401	348
Security workers	295	259	238	226	228	189	161	159
Agriculture, forestry and fishery workers	571	489	442	425	384	365	346	287
Transport and communication workers	449	339	328	276	253	230	200	180
Production process and related workers	415	327	250	216	181	156	105	89
Workers not classifiable by occupation	14,668	15,038	20,796	9,141	5,935	7,231	4,900	768
Non-employed [b]	2,669	2,226	1,891	1,648	1,774	1,533	1,289	1,313
Women								
Specialist and technical workers	246	181	146	126	115	90	97	66
Administrative and managerial workers	548	452	239	268	337	263	345	306
Clerical workers	234	153	105	83	68	54	39	29
Sales workers	197	164	137	135	111	81	68	55
Service workers	160	117	130	111	111	92	78	60
Security workers	1,615	1,027	822	1,335	991	508	398	390
Agriculture, forestry and fishery workers	256	224	172	148	133	114	103	85
Transport and communication workers	899	585	844	712	808	440	324	278
Production process and related workers	145	114	73	67	60	43	32	25
Workers not classifiable by occupation	4,769	1,533	6,995	3,024	2,967	3,382	2,296	325
Non-employed [b]	489	387	324	286	256	254	242	222

[a] Age-adjusted mortality rates were calculated by the direct method, using the model population of 1985 in Japan as a reference.

[b] Non-employed is the sum of unemployed and non-labor force.

Supplementary Table 6. Adjusted prefecture-level residuals for all-cause premature mortality among men, Japan, 1970-2005

	Overall			1970			1975			1980			1985			1990			1995			2000			2005		
Prefectures	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank
1 Hokkaido	1.02	(0.98 to 1.06)	31	1.02	(0.99 to 1.05)	28	1.05	(1.02 to 1.08)	37	1.05	(1.02 to 1.09)	40	1.01	(0.98 to 1.04)	26	0.97	(0.94 to 0.99)	10	1.01	(0.98 to 1.04)	26	1.05	(1.01 to 1.08)	33	1.06	(1.02 to 1.11)	36
2 Aomori	1.13	(1.09 to 1.18)	47	1.07	(1.03 to 1.12)	42	1.06	(1.01 to 1.10)	44	1.10	(1.05 to 1.15)	45	1.09	(1.05 to 1.14)	45	1.09	(1.04 to 1.14)	44	1.17	(1.11 to 1.23)	46	1.25	(1.19 to 1.31)	47	1.27	(1.20 to 1.34)	47
3 Iwate	1.07	(1.03 to 1.12)	45	1.09	(1.04 to 1.13)	44	1.04	(0.99 to 1.08)	35	1.04	(0.99 to 1.09)	37	1.02	(0.98 to 1.07)	36	1.06	(1.01 to 1.11)	43	1.05	(0.99 to 1.11)	34	1.08	(1.03 to 1.15)	40	1.22	(1.15 to 1.29)	46
4 Miyagi	0.97	(0.93 to 1.01)	14	0.94	(0.90 to 0.98)	5	0.97	(0.93 to 1.01)	11	0.96	(0.92 to 1.00)	8	0.94	(0.91 to 0.98)	4	0.98	(0.94 to 1.02)	14	0.97	(0.92 to 1.01)	14	0.99	(0.94 to 1.04)	20	1.04	(0.99 to 1.10)	31
5 Akita	1.07	(1.02 to 1.11)	44	1.12	(1.07 to 1.17)	46	1.06	(1.01 to 1.10)	43	1.04	(0.99 to 1.09)	36	1.01	(0.97 to 1.06)	29	1.01	(0.96 to 1.06)	28	1.10	(1.04 to 1.16)	44	1.09	(1.03 to 1.15)	43	1.17	(1.10 to 1.24)	45
6 Yamagata	0.99	(0.95 to 1.03)	20	1.02	(0.97 to 1.07)	27	1.00	(0.95 to 1.05)	22	1.00	(0.95 to 1.05)	20	0.94	(0.90 to 0.99)	3	0.97	(0.92 to 1.02)	13	0.97	(0.92 to 1.03)	17	1.00	(0.94 to 1.07)	23	1.06	(0.99 to 1.13)	34
7 Fukushima	1.04	(1.00 to 1.08)	37	1.02	(0.98 to 1.07)	29	1.02	(0.98 to 1.06)	31	1.00	(0.96 to 1.05)	25	1.01	(0.97 to 1.05)	31	1.01	(0.97 to 1.06)	29	1.06	(1.01 to 1.11)	37	1.09	(1.03 to 1.14)	41	1.14	(1.08 to 1.20)	44
8 Ibaraki	1.02	(0.98 to 1.07)	34	1.03	(0.99 to 1.07)	32	1.01	(0.98 to 1.05)	27	1.01	(0.97 to 1.05)	30	1.02	(0.98 to 1.06)	34	1.03	(0.99 to 1.07)	36	1.07	(1.03 to 1.12)	40	1.03	(0.99 to 1.07)	30	1.03	(0.98 to 1.08)	24
9 Tochigi	1.07	(1.03 to 1.11)	43	1.09	(1.04 to 1.14)	45	1.05	(1.01 to 1.10)	41	1.06	(1.02 to 1.11)	42	1.09	(1.05 to 1.14)	46	1.11	(1.07 to 1.16)	47	1.09	(1.04 to 1.14)	43	1.06	(1.01 to 1.11)	35	1.04	(0.98 to 1.09)	28
10 Gunma	1.01	(0.97 to 1.06)	28	1.02	(0.97 to 1.06)	26	0.97	(0.93 to 1.02)	12	0.97	(0.93 to 1.02)	11	1.04	(0.99 to 1.08)	39	1.00	(0.96 to 1.05)	24	1.06	(1.01 to 1.11)	38	1.02	(0.97 to 1.07)	26	1.04	(0.99 to 1.10)	29
11 Saitama	0.96	(0.92 to 1.00)	9	1.00	(0.97 to 1.04)	22	0.98	(0.94 to 1.01)	14	0.98	(0.94 to 1.01)	15	0.99	(0.96 to 1.02)	19	1.00	(0.97 to 1.03)	26	0.93	(0.90 to 0.97)	10	0.91	(0.88 to 0.94)	8	0.86	(0.83 to 0.90)	6
12 Chiba	0.96	(0.92 to 1.00)	8	0.98	(0.95 to 1.01)	18	0.94	(0.91 to 0.97)	5	0.95	(0.92 to 0.98)	6	0.99	(0.95 to 1.02)	17	0.99	(0.96 to 1.02)	19	0.93	(0.90 to 0.96)	7	0.91	(0.88 to 0.94)	7	0.93	(0.89 to 0.97)	12
13 Tokyo	0.99	(0.95 to 1.03)	19	0.96	(0.93 to 0.98)	16	0.97	(0.95 to 1.00)	13	1.00	(0.97 to 1.02)	21	1.01	(0.99 to 1.03)	28	1.06	(1.03 to 1.08)	41	0.93	(0.90 to 0.96)	8	0.91	(0.88 to 0.94)	6	0.97	(0.94 to 1.01)	16
14 Kanagawa	0.94	(0.90 to 0.98)	5	0.95	(0.92 to 0.98)	11	0.89	(0.86 to 0.92)	2	0.89	(0.86 to 0.91)	2	0.99	(0.96 to 1.02)	18	1.02	(0.99 to 1.05)	31	0.93	(0.90 to 0.96)	6	0.89	(0.86 to 0.92)	5	0.83	(0.80 to 0.87)	2
15 Niigata	1.02	(0.98 to 1.07)	33	1.00	(0.96 to 1.04)	21	1.01	(0.98 to 1.05)	28	1.00	(0.96 to 1.04)	22	1.02	(0.98 to 1.06)	33	0.98	(0.95 to 1.02)	16	1.07	(1.02 to 1.12)	39	1.10	(1.05 to 1.15)	45	1.06	(1.01 to 1.11)	35
16 Toyama	1.05	(1.00 to 1.09)	40	1.03	(0.98 to 1.08)	31	1.04	(0.99 to 1.09)	36	1.04	(0.98 to 1.09)	35	1.09	(1.04 to 1.15)	47	1.05	(1.00 to 1.11)	39	0.94	(0.88 to 1.00)	11	1.10	(1.03 to 1.17)	44	1.13	(1.06 to 1.21)	42
17 Ishikawa	1.00	(0.96 to 1.04)	23	0.99	(0.94 to 1.04)	19	1.01	(0.96 to 1.07)	26	1.03	(0.97 to 1.09)	34	0.97	(0.92 to 1.02)	9	0.97	(0.91 to 1.02)	11	0.94	(0.88 to 1.00)	12	1.03	(0.97 to 1.10)	31	1.10	(1.03 to 1.18)	41
18 Fukui	0.93	(0.89 to 0.98)	4	0.91	(0.86 to 0.97)	2	0.96	(0.91 to 1.02)	9	0.89	(0.84 to 0.95)	3	0.97	(0.92 to 1.03)	11	0.93	(0.87 to 0.99)	4	0.87	(0.81 to 0.94)	2	0.99	(0.92 to 1.07)	21	1.03	(0.95 to 1.12)	25
19 Yamanashi	1.07	(1.02 to 1.11)	42	1.04	(0.98 to 1.10)	34	1.00	(0.95 to 1.06)	23	1.07	(1.01 to 1.14)	43	1.06	(1.00 to 1.12)	43	1.09	(1.03 to 1.16)	45	1.11	(1.04 to 1.18)	45	1.06	(0.99 to 1.13)	36	1.09	(1.02 to 1.18)	40
20 Nagano	0.97	(0.93 to 1.01)	11	0.93	(0.90 to 0.97)	4	0.98	(0.94 to 1.02)	15	0.95	(0.90 to 0.99)	5	0.98	(0.94 to 1.02)	13	0.94	(0.89 to 0.98)	6	0.98	(0.93 to 1.03)	18	1.00	(0.95 to 1.05)	22	1.03	(0.98 to 1.09)	26
21 Gifu	1.01	(0.97 to 1.05)	26	0.89	(0.85 to 0.93)	1	1.01	(0.97 to 1.06)	25	0.97	(0.93 to 1.02)	13	1.05	(1.01 to 1.10)	42	1.02	(0.98 to 1.07)	33	1.01	(0.96 to 1.06)	27	1.07	(1.02 to 1.12)	37	1.07	(1.02 to 1.13)	37
22 Shizuoka	1.01	(0.97 to 1.05)	27	0.97	(0.94 to 1.01)	17	0.99	(0.95 to 1.02)	19	1.03	(0.99 to 1.07)	33	1.04	(1.00 to 1.08)	40	1.04	(1.00 to 1.07)	37	1.05	(1.01 to 1.09)	32	1.01	(0.97 to 1.05)	24	0.99	(0.94 to 1.03)	18
23 Aichi	0.99	(0.95 to 1.03)	18	0.95	(0.92 to 0.98)	13	0.94	(0.91 to 0.97)	4	0.95	(0.92 to 0.98)	7	0.98	(0.95 to 1.01)	15	1.00	(0.97 to 1.03)	21	1.03	(1.00 to 1.07)	31	1.02	(0.99 to 1.06)	27	1.04	(1.00 to 1.08)	30
24 Mie	0.97	(0.93 to 1.01)	15	0.94	(0.90 to 0.98)	6	0.96	(0.92 to 1.01)	7	0.96	(0.92 to 1.01)	9	0.98	(0.93 to 1.02)	12	1.00	(0.96 to 1.05)	25	1.02	(0.97 to 1.07)	29	0.99	(0.94 to 1.04)	19	0.99	(0.94 to 1.05)	19
25 Shiga	0.93	(0.89 to 0.97)	3	0.95	(0.90 to 1.01)	12	0.96	(0.91 to 1.02)	10	1.00	(0.94 to 1.06)	19	0.96	(0.91 to 1.01)	7	0.97	(0.92 to 1.02)	12	0.94	(0.88 to 1.00)	13	0.84	(0.79 to 0.90)	1	0.88	(0.82 to 0.94)	8
26 Kyoto	0.95	(0.91 to 0.99)	7	0.94	(0.91 to 0.98)	8	0.96	(0.93 to 1.00)	8	0.97	(0.93 to 1.01)	12	0.95	(0.92 to 0.99)	5	0.93	(0.90 to 0.97)	5	0.87	(0.84 to 0.91)	3	0.94	(0.90 to 0.98)	12	0.94	(0.89 to 0.99)	15
27 Osaka	1.02	(0.98 to 1.06)	32	1.04	(1.01 to 1.07)	36	1.02	(0.99 to 1.05)	30	1.05	(1.02 to 1.08)	39	1.07	(1.04 to 1.09)	44	1.09	(1.07 to 1.12)	46	1.02	(0.99 to 1.05)	28	0.97	(0.94 to 1.00)	14	0.84	(0.81 to 0.88)	4
28 Hyogo	1.00	(0.96 to 1.04)	22	1.01	(0.98 to 1.04)	24	1.02	(0.99 to 1.05)	32	1.02	(0.99 to 1.06)	32	1.01	(0.98 to 1.04)	30	1.03	(1.00 to 1.06)	35	0.99	(0.96 to 1.02)	20	0.92	(0.89 to 0.95)	11	0.90	(0.86 to 0.93)	10
29 Nara	0.94	(0.90 to 0.98)	6	0.93	(0.88 to 0.98)	3	0.98	(0.93 to 1.03)	16	0.96	(0.91 to 1.02)	10	1.00	(0.95 to 1.05)	21	1.01	(0.96 to 1.06)	27	0.91	(0.86 to 0.96)	5	0.85	(0.80 to 0.89)	2	0.81	(0.76 to 0.86)	1
30 Wakayama	0.99	(0.95 to 1.04)	21	0.95	(0.91 to 1.00)	14	0.96	(0.92 to 1.01)	6	1.01	(0.95 to 1.06)	27	0.98	(0.93 to 1.03)	14	1.00	(0.95 to 1.05)	22	0.98	(0.93 to 1.04)	19	1.01	(0.96 to 1.08)	25	1.02	(0.96 to 1.09)	22
31 Tottori	1.08	(1.03 to 1.12)	46	1.06	(0.99 to 1.12)	39	1.00	(0.94 to 1.06)	20	1.09	(1.02 to 1.16)	44	1.00	(0.95 to 1.07)	25	1.05	(0.99 to 1.12)	38	1.22	(1.13 to 1.30)	47	1.08	(1.00 to 1.16)	38	1.14	(1.05 to 1.23)	43
32 Shimane	1.05	(1.00 to 1.09)	39	1.01	(0.96 to 1.07)	23	1.05	(1.00 to 1.11)	39	1.10	(1.04 to 1.17)	46	1.00	(0.94 to 1.05)	20	1.00	(0.94 to 1.06)	23	1.08	(1.01 to 1.15)	41	1.13	(1.06 to 1.21)	46	1.03	(0.95 to 1.11)	23
33 Okayama	0.97	(0.93 to 1.01)	10	0.94	(0.90 to 0.98)	7	1.00	(0.96 to 1.04)	21	0.99	(0.94 to 1.03)	16	1.00	(0.96 to 1.04)	24	1.02	(0.98 to 1.06)	32	1.00	(0.95 to 1.04)	23	0.98	(0.93 to 1.03)	16	0.84	(0.79 to 0.89)	3
34 Hiroshima	1.00	(0.96 to 1.05)	25	1.04	(1.00 to 1.08)	35	1.05	(1.01 to 1.09)	38	1.00	(0.96 to 1.04)	24	1.05	(1.01 to 1.09)	41	1.02	(0.98 to 1.05)	30	1.05	(1.01 to 1.10)	36	0.97	(0.93 to 1.02)	15	0.87	(0.82 to 0.91)	7
35 Yamaguchi	1.06	(1.02 to 1.10)	41	1.06	(1.02 to 1.11)	40	1.05	(1.01 to 1.10)	40	1.11	(1.06 to 1.16)	47	1.03	(0.99 to 1.07)	37	1.06	(1.01 to 1.10)	40	1.09	(1.03 to 1.14)	42	1.04	(0.99 to 1.10)	32	1.05	(0.99 to 1.12)	33
36 Tokushima	0.97	(0.93 to 1.01)	12	1.03	(0.98 to 1.09)	33	1.01	(0.96 to 1.06)	24	1.01	(0.96 to 1.07)	31	0.97	(0.92 to 1.02)	10	0.92	(0.87 to 0.97)	3	0.93	(0.87 to 0.99)	9	0.89	(0.83 to 0.95)	4	0.99	(0.92 to 1.07)	20
37 Kagawa	0.98	(0.94 to 1.03)	17	1.01	(0.96 to 1.07)	25	0.98	(0.93 to 1.04)	18	0.98	(0.92 to 1.03)	14	0.96	(0.91 to 1.01)	6	0.99	(0.94 to 1.05)	20	1.00	(0.94 to 1.06)	24	0.98	(0.92 to 1.04)	17	0.99	(0.93 to 1.06)	21
38 Ehime	1.02	(0.97 to 1.06)	30	1.03	(0.98 to 1.07)	30	1.03	(0.99 to 1.08)	34	1.01	(0.96 to 1.05)	28	1.00	(0.96 to 1.04)	22	0.99	(0.94 to 1.03)	18	1.05	(0.99 to 1.10)	33	1.08	(1.03 to 1.14)	39	0.97	(0.92 to 1.03)	17
39 Kochi	1.03	(0.98 to 1.07)	35	1.07	(1.02 to 1.13)	41	1.06	(1.00 to 1.11)	46	1.05	(1.00 to 1.11)	41	0.98	(0.93 to 1.04)	16	0.94	(0.89 to 0.99)	8	0.99	(0.93 to 1.06)	22	1.03	(0.96 to 1.09)	28	1.08	(1.00 to 1.15)	39
40 Fukuoka	0.98	(0.94 to 1.02)	16	0.95	(0.92 to 0.97)	9	0.98	(0.95 to 1.01)	17	0.99	(0.96 to 1.02)	17	1.00	(0.97 to 1.03)	23	1.02	(0.99 to 1.06)	34	0.99	(0.96 to 1.03)	21	0.96	(0.92 to 0.99)	13	0.94	(0.90 to 0.98)	13
41 Saga	1.04	(1.00 to 1.09)	38	0.96	(0.90 to 1.01)	15	1.09	(1.03 to 1.15)	47	1.00	(0.95 to 1.06)	26	1.02	(0.96 to 1.08)	32	1.06	(1.00 to 1.12)	42	1.05	(0.98 to 1.12)	35	1.09	(1.02 to 1.16)	42	1.05	(0.97 to 1.13)	32
42 Nagasaki	1.01	(0.97 to 1.06)	29	1.04	(1.00 to 1.09)	37	1.02	(0.98 to 1.07)	33	0.99	(0.95 to 1.04)	18	1.02	(0.98 to 1.07)	35	0.95	(0.91 to 0.99)	9	1.02	(0.97 to 1.08)	30	0.98	(0.93 to 1.04)	18	1.07	(1.01 to 1.14)	38
43 Kumamoto	0.91	(0.87 to 0.94)	2	0.95	(0.91 to 0.99)	10	0.90	(0.86 to 0.94)	3	0.94	(0.90 to 0.98)	4	0.92	(0.88 to 0.96)	2	0.89	(0.85 to 0.93)	1	0.89	(0.85 to 0.94)	4	0.87	(0.82 to 0.91)	3	0.89	(0.84 to 0.95)	9
44 Oita	0.97	(0.93 to 1.01)	13	0.99	(0.95 to 1.04)	20	1.06	(1.01 to 1.11)	42	1.05	(1.00 to 1.10)	38	0.96	(0.92 to 1.01)	8	0.94	(0.89 to 0.98)	7	0.97	(0.91 to 1.02)	15	0.92	(0.86 to 0.97)	10	0.91	(0.85 to 0.97)	11
45 Miyazaki	1.00	(0.96 to 1.04)	24	1.05	(1.00 to 1.11)	38	1.02	(0.97 to 1.07)	29	1.00	(0.95 to 1.05)	23	1.01	(0.96 to 1.06)	27	0.99	(0.94 to 1.04)	17	0.97	(0.92 to 1.03)	16	1.03	(0.97 to 1.09)	29	0.94	(0.88 to 1.00)	14
46 Kagoshima	1.03	(0.99 to 1.08)	36	1.08	(1.04 to 1.13)	43	1.06	(1.02 to 1.10)	45	1.01	(0.97 to 1.05)	29	1.03	(0.99 to 1.08)	38	0.98	(0.94 to 1.02)	15	1.00	(0.96 to 1.05)	25	1.05	(1.00 to 1.11)	34	1.04	(0.98 to 1.10)	27
47 Okinawa	0.87	(0.83 to 0.91)	1	NA	NA	NA	0.88	(0.83 to 0.93)	1	0.82	(0.77 to 0.87)	1	0.85	(0.80 to 0.89)	1	0.91	(0.87 to 0.96)	2	0.85	(0.80 to 0.90)	1	0.91	(0.86 to 0.97)	9	0.86	(0.80 to 0.91)	5

CI; confidence interval, NA; not available, OR; odds ratio

Prefectures with a lower estimate of odds for all-cause premature mortality are ranked higher. The reference is the grand mean of all the prefectures.

Supplementary Table 7. Adjusted prefecture-level residuals for all-cause premature mortality among women, Japan, 1970-2005

		Overall			1970			1975			1980			1985			1990			1995			2000			2005		
	Prefectures	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank
1	Hokkaido	0.97	(0.93 to 1.00)	14	0.95	(0.92 to 0.99)	10	0.96	(0.92 to 1.00)	17	0.97	(0.94 to 1.01)	13	0.99	(0.95 to 1.02)	18	0.97	(0.93 to 1.01)	14	0.97	(0.93 to 1.02)	14	0.97	(0.93 to 1.01)	16	1.01	(0.96 to 1.06)	20
2	Aomori	1.04	(1.00 to 1.08)	31	0.98	(0.93 to 1.04)	15	0.99	(0.93 to 1.05)	20	1.00	(0.95 to 1.07)	23	1.05	(0.99 to 1.11)	40	1.01	(0.95 to 1.08)	23	1.07	(1.00 to 1.15)	38	1.11	(1.03 to 1.19)	42	1.13	(1.05 to 1.22)	43
3	Iwate	1.07	(1.02 to 1.11)	40	1.05	(0.99 to 1.12)	35	1.04	(0.98 to 1.10)	34	1.03	(0.97 to 1.09)	33	1.02	(0.96 to 1.09)	25	1.03	(0.97 to 1.10)	31	1.09	(1.02 to 1.17)	43	1.13	(1.05 to 1.22)	46	1.17	(1.08 to 1.27)	45
4	Miyagi	0.91	(0.88 to 0.95)	6	0.89	(0.85 to 0.94)	4	0.87	(0.82 to 0.92)	3	0.88	(0.83 to 0.93)	3	0.93	(0.88 to 0.98)	6	0.96	(0.91 to 1.02)	13	0.95	(0.90 to 1.02)	13	0.92	(0.86 to 0.98)	10	0.96	(0.90 to 1.03)	15
5	Akita	0.96	(0.92 to 1.00)	12	0.99	(0.94 to 1.05)	20	0.94	(0.89 to 1.00)	9	0.91	(0.86 to 0.97)	5	0.93	(0.88 to 1.00)	8	0.93	(0.87 to 1.00)	6	1.00	(0.93 to 1.07)	21	1.04	(0.96 to 1.13)	26	1.05	(0.96 to 1.14)	29
6	Yamagata	0.96	(0.92 to 1.00)	11	0.99	(0.93 to 1.05)	18	0.95	(0.89 to 1.01)	11	0.95	(0.89 to 1.01)	9	0.95	(0.89 to 1.01)	11	0.94	(0.88 to 1.00)	8	1.00	(0.92 to 1.08)	19	0.97	(0.89 to 1.05)	15	1.05	(0.96 to 1.14)	30
7	Fukushima	1.04	(1.00 to 1.08)	30	1.04	(0.98 to 1.09)	30	1.07	(1.01 to 1.13)	40	0.99	(0.94 to 1.05)	18	1.03	(0.98 to 1.09)	32	1.01	(0.95 to 1.06)	21	1.02	(0.95 to 1.08)	26	1.07	(1.00 to 1.14)	32	1.10	(1.02 to 1.18)	40
8	Ibaraki	1.04	(1.00 to 1.08)	33	1.08	(1.03 to 1.14)	42	1.02	(0.96 to 1.07)	28	1.01	(0.96 to 1.06)	27	1.04	(0.99 to 1.10)	36	1.06	(1.01 to 1.12)	43	1.07	(1.01 to 1.13)	37	0.99	(0.94 to 1.05)	19	1.05	(0.98 to 1.11)	31
9	Tochigi	1.09	(1.05 to 1.13)	44	1.09	(1.03 to 1.15)	43	1.05	(0.99 to 1.11)	38	1.06	(1.00 to 1.13)	40	1.13	(1.07 to 1.20)	47	1.09	(1.03 to 1.16)	46	1.04	(0.98 to 1.11)	29	1.11	(1.04 to 1.19)	43	1.09	(1.01 to 1.17)	38
10	Gunma	1.05	(1.01 to 1.09)	34	1.08	(1.02 to 1.14)	40	1.01	(0.95 to 1.07)	22	1.02	(0.96 to 1.08)	31	1.05	(0.99 to 1.11)	39	1.02	(0.97 to 1.09)	27	1.01	(0.94 to 1.08)	23	1.09	(1.02 to 1.17)	40	1.10	(1.03 to 1.18)	41
11	Saitama	0.92	(0.88 to 0.95)	7	0.94	(0.90 to 0.98)	9	0.92	(0.88 to 0.96)	6	0.91	(0.88 to 0.95)	6	0.95	(0.91 to 0.99)	10	0.96	(0.92 to 1.00)	12	0.92	(0.88 to 0.96)	9	0.89	(0.85 to 0.93)	7	0.84	(0.80 to 0.88)	4
12	Chiba	0.88	(0.85 to 0.91)	3	0.90	(0.86 to 0.95)	5	0.89	(0.85 to 0.93)	4	0.88	(0.84 to 0.92)	4	0.90	(0.86 to 0.94)	3	0.88	(0.85 to 0.92)	1	0.87	(0.83 to 0.91)	4	0.84	(0.80 to 0.88)	3	0.89	(0.85 to 0.94)	8
13	Tokyo	0.89	(0.86 to 0.92)	4	0.79	(0.76 to 0.81)	1	0.86	(0.83 to 0.89)	2	0.92	(0.89 to 0.95)	7	0.93	(0.90 to 0.96)	7	0.93	(0.90 to 0.96)	5	0.88	(0.85 to 0.91)	6	0.89	(0.86 to 0.93)	6	0.93	(0.89 to 0.97)	11
14	Kanagawa	0.84	(0.81 to 0.87)	1	0.79	(0.76 to 0.82)	2	0.82	(0.78 to 0.85)	1	0.85	(0.82 to 0.88)	1	0.87	(0.84 to 0.91)	2	0.89	(0.86 to 0.92)	3	0.86	(0.82 to 0.89)	3	0.83	(0.79 to 0.86)	2	0.80	(0.76 to 0.84)	2
15	Niigata	0.96	(0.93 to 1.00)	13	1.00	(0.96 to 1.05)	23	0.95	(0.90 to 0.99)	10	0.95	(0.90 to 1.00)	10	0.92	(0.87 to 0.97)	5	0.97	(0.92 to 1.03)	15	1.00	(0.94 to 1.06)	20	1.01	(0.95 to 1.08)	22	0.97	(0.90 to 1.04)	16
16	Toyama	1.06	(1.01 to 1.10)	38	1.08	(1.02 to 1.15)	41	1.04	(0.97 to 1.11)	35	1.02	(0.95 to 1.09)	29	1.03	(0.96 to 1.10)	29	1.01	(0.94 to 1.08)	22	1.01	(0.93 to 1.09)	24	1.15	(1.06 to 1.25)	47	1.13	(1.04 to 1.24)	44
17	Ishikawa	1.03	(0.99 to 1.07)	25	1.04	(0.97 to 1.11)	31	1.02	(0.96 to 1.10)	30	1.00	(0.93 to 1.07)	21	0.98	(0.91 to 1.05)	16	1.03	(0.96 to 1.11)	32	1.02	(0.94 to 1.11)	27	1.06	(0.98 to 1.15)	30	1.10	(1.00 to 1.20)	39
18	Fukui	1.05	(1.00 to 1.10)	35	1.07	(1.00 to 1.15)	38	1.01	(0.94 to 1.09)	25	1.06	(0.98 to 1.15)	41	1.02	(0.95 to 1.11)	27	1.04	(0.96 to 1.12)	35	0.91	(0.83 to 1.00)	8	1.07	(0.97 to 1.18)	33	1.18	(1.06 to 1.30)	46
19	Yamanashi	1.01	(0.97 to 1.06)	23	1.00	(0.93 to 1.07)	22	1.00	(0.93 to 1.08)	21	0.99	(0.92 to 1.07)	19	1.03	(0.96 to 1.12)	33	0.99	(0.91 to 1.07)	19	1.05	(0.96 to 1.15)	32	1.03	(0.94 to 1.13)	25	1.02	(0.92 to 1.13)	23
20	Nagano	1.04	(1.00 to 1.08)	32	1.05	(1.00 to 1.11)	36	1.01	(0.96 to 1.06)	24	1.05	(1.00 to 1.11)	38	1.05	(0.99 to 1.11)	41	1.06	(1.00 to 1.12)	40	1.07	(1.01 to 1.14)	39	1.01	(0.94 to 1.08)	20	1.04	(0.97 to 1.12)	28
21	Gifu	1.11	(1.07 to 1.16)	46	1.02	(0.97 to 1.08)	26	1.10	(1.04 to 1.17)	43	1.15	(1.09 to 1.22)	47	1.11	(1.05 to 1.17)	45	1.08	(1.02 to 1.15)	45	1.14	(1.08 to 1.22)	46	1.11	(1.04 to 1.18)	41	1.12	(1.04 to 1.20)	42
22	Shizuoka	1.01	(0.97 to 1.05)	22	0.94	(0.89 to 0.98)	7	0.96	(0.91 to 1.00)	15	1.00	(0.96 to 1.05)	22	1.00	(0.95 to 1.05)	21	1.06	(1.01 to 1.11)	39	1.06	(1.01 to 1.12)	35	1.05	(1.00 to 1.11)	29	1.05	(0.99 to 1.12)	33
23	Aichi	1.03	(0.99 to 1.07)	24	0.98	(0.94 to 1.02)	13	1.01	(0.97 to 1.05)	23	1.04	(1.00 to 1.08)	34	1.07	(1.03 to 1.11)	43	1.04	(1.00 to 1.08)	38	1.06	(1.02 to 1.11)	34	1.02	(0.98 to 1.07)	24	1.04	(0.99 to 1.09)	27
24	Mie	0.98	(0.94 to 1.02)	19	0.99	(0.93 to 1.04)	16	0.93	(0.88 to 0.99)	8	0.97	(0.92 to 1.03)	14	0.99	(0.93 to 1.05)	19	0.94	(0.89 to 1.00)	10	1.01	(0.95 to 1.08)	25	1.06	(0.99 to 1.14)	31	0.99	(0.92 to 1.06)	18
25	Shiga	0.98	(0.94 to 1.02)	18	1.07	(1.00 to 1.14)	37	1.02	(0.95 to 1.09)	27	1.01	(0.94 to 1.08)	28	0.94	(0.87 to 1.01)	9	0.98	(0.91 to 1.05)	17	1.01	(0.93 to 1.09)	22	0.90	(0.83 to 0.98)	8	0.90	(0.83 to 0.99)	10
26	Kyoto	0.93	(0.89 to 0.97)	9	0.89	(0.84 to 0.93)	3	0.96	(0.91 to 1.01)	16	0.99	(0.94 to 1.04)	17	0.97	(0.92 to 1.03)	15	0.94	(0.89 to 0.99)	9	0.85	(0.80 to 0.90)	2	0.88	(0.83 to 0.94)	5	0.95	(0.89 to 1.01)	13
27	Osaka	0.95	(0.91 to 0.98)	10	0.92	(0.89 to 0.95)	6	0.96	(0.92 to 0.99)	14	0.98	(0.95 to 1.02)	16	1.00	(0.97 to 1.04)	22	0.98	(0.95 to 1.02)	18	0.94	(0.91 to 0.98)	10	0.91	(0.87 to 0.95)	9	0.85	(0.81 to 0.89)	5
28	Hyogo	0.92	(0.89 to 0.96)	8	0.94	(0.90 to 0.97)	8	0.96	(0.92 to 1.00)	13	0.98	(0.94 to 1.02)	15	0.97	(0.93 to 1.01)	14	0.93	(0.89 to 0.96)	4	0.89	(0.85 to 0.93)	7	0.84	(0.80 to 0.88)	4	0.86	(0.81 to 0.90)	6
29	Nara	0.87	(0.83 to 0.90)	2	0.97	(0.91 to 1.04)	12	0.95	(0.89 to 1.02)	12	0.95	(0.88 to 1.01)	8	0.91	(0.85 to 0.97)	4	0.89	(0.83 to 0.95)	2	0.80	(0.75 to 0.86)	1	0.76	(0.71 to 0.82)	1	0.75	(0.69 to 0.82)	1
30	Wakayama	1.01	(0.96 to 1.05)	21	1.03	(0.97 to 1.09)	27	1.02	(0.95 to 1.08)	29	1.00	(0.94 to 1.07)	24	1.04	(0.98 to 1.12)	37	0.98	(0.91 to 1.05)	16	0.95	(0.87 to 1.02)	11	0.93	(0.86 to 1.02)	12	1.08	(0.99 to 1.18)	37
31	Tottori	1.07	(1.02 to 1.12)	41	1.07	(0.99 to 1.16)	39	1.04	(0.96 to 1.13)	37	1.05	(0.97 to 1.14)	37	1.04	(0.96 to 1.13)	35	1.03	(0.95 to 1.12)	33	1.08	(0.98 to 1.19)	41	1.11	(1.00 to 1.23)	44	1.01	(0.90 to 1.14)	21
32	Shimane	1.05	(1.01 to 1.10)	36	1.05	(0.98 to 1.13)	33	1.09	(1.01 to 1.17)	42	1.06	(0.98 to 1.14)	39	0.98	(0.91 to 1.06)	17	1.03	(0.95 to 1.11)	30	1.13	(1.03 to 1.23)	44	1.05	(0.95 to 1.15)	27	0.96	(0.86 to 1.07)	14
33	Okayama	0.97	(0.93 to 1.01)	16	0.98	(0.93 to 1.04)	14	0.98	(0.93 to 1.04)	18	0.97	(0.91 to 1.03)	12	1.04	(0.99 to 1.11)	38	1.03	(0.97 to 1.09)	29	0.98	(0.92 to 1.05)	17	0.92	(0.86 to 0.99)	11	0.84	(0.78 to 0.91)	3
34	Hiroshima	0.99	(0.96 to 1.03)	20	0.99	(0.94 to 1.04)	17	1.03	(0.98 to 1.08)	31	1.03	(0.98 to 1.08)	32	1.01	(0.96 to 1.06)	23	1.04	(0.99 to 1.10)	37	0.98	(0.93 to 1.04)	16	0.94	(0.88 to 0.99)	13	0.90	(0.85 to 0.96)	9
35	Yamaguchi	1.03	(0.99 to 1.07)	27	0.99	(0.94 to 1.05)	19	1.04	(0.98 to 1.10)	36	1.01	(0.95 to 1.07)	25	1.03	(0.97 to 1.09)	30	1.01	(0.96 to 1.08)	24	1.04	(0.98 to 1.12)	30	1.07	(1.00 to 1.15)	36	1.05	(0.97 to 1.13)	32
36	Tokushima	1.08	(1.04 to 1.13)	43	1.11	(1.03 to 1.18)	45	1.19	(1.11 to 1.27)	47	1.10	(1.03 to 1.18)	45	0.97	(0.90 to 1.04)	13	1.06	(0.98 to 1.14)	42	1.08	(1.00 to 1.18)	42	1.01	(0.93 to 1.11)	23	1.02	(0.92 to 1.12)	22
37	Kagawa	1.03	(0.99 to 1.08)	28	1.03	(0.96 to 1.10)	29	1.01	(0.95 to 1.09)	26	1.00	(0.93 to 1.07)	20	1.03	(0.96 to 1.11)	31	1.02	(0.95 to 1.09)	26	1.07	(0.98 to 1.16)	36	1.05	(0.96 to 1.15)	28	1.02	(0.93 to 1.12)	24
38	Ehime	1.06	(1.02 to 1.10)	37	1.02	(0.96 to 1.08)	24	1.13	(1.07 to 1.19)	44	1.02	(0.96 to 1.08)	30	1.03	(0.97 to 1.09)	28	1.08	(1.02 to 1.15)	44	1.03	(0.96 to 1.11)	28	1.07	(0.99 to 1.15)	34	1.07	(0.99 to 1.16)	35
39	Kochi	1.11	(1.06 to 1.16)	45	1.05	(0.98 to 1.13)	34	1.19	(1.11 to 1.27)	46	1.05	(0.98 to 1.13)	36	1.06	(0.99 to 1.15)	42	1.06	(0.98 to 1.14)	41	1.07	(0.99 to 1.17)	40	1.08	(0.98 to 1.18)	37	1.18	(1.07 to 1.30)	47
40	Fukuoka	0.97	(0.94 to 1.01)	17	0.96	(0.92 to 1.00)	11	0.93	(0.89 to 0.97)	7	0.97	(0.93 to 1.01)	11	1.04	(1.00 to 1.08)	34	0.99	(0.95 to 1.03)	20	0.98	(0.93 to 1.02)	15	0.97	(0.92 to 1.02)	17	0.94	(0.89 to 0.99)	12
41	Saga	1.08	(1.04 to 1.13)	42	1.03	(0.96 to 1.10)	28	1.09	(1.01 to 1.17)	41	1.09	(1.01 to 1.17)	43	0.99	(0.92 to 1.07)	20	1.10	(1.03 to 1.19)	47	1.13	(1.04 to 1.23)	45	1.11	(1.02 to 1.22)	45	1.06	(0.96 to 1.17)	34
42	Nagasaki	1.03	(0.99 to 1.07)	26	1.02	(0.97 to 1.08)	25	1.03	(0.97 to 1.09)	32	1.04	(0.98 to 1.10)	35	1.01	(0.96 to 1.08)	24	1.02	(0.96 to 1.08)	25	1.05	(0.98 to 1.12)	31	1.07	(1.00 to 1.15)	35	1.02	(0.95 to 1.11)	25
43	Kumamoto	0.97	(0.93 to 1.01)	15	1.00	(0.95 to 1.05)	21	0.98	(0.93 to 1.04)	19	1.01	(0.95 to 1.06)	26	0.96	(0.90 to 1.01)	12	0.95	(0.90 to 1.01)	11	0.95	(0.89 to 1.02)	12	0.97	(0.91 to 1.05)	18	0.99	(0.91 to 1.06)	17
44	Oita	1.03	(0.99 to 1.08)	29	1.10	(1.04 to 1.17)	44	1.03	(0.97 to 1.10)	33	1.08	(1.01 to 1.15)	42	1.08	(1.02 to 1.15)	44	1.03	(0.96 to 1.09)	28	0.99	(0.92 to 1.06)	18	1.01	(0.93 to 1.09)	21	0.89	(0.82 to 0.98)	7
45	Miyazaki	1.06	(1.02 to 1.10)	39	1.04	(0.98 to 1.11)	32	1.06	(0.99 to 1.13)	39	1.10	(1.03 to 1.17)	44	1.02	(0.95 to 1.09)	26	1.04	(0.97 to 1.11)	36	1.05	(0.97 to 1.14)	33	1.08	(1.00 to 1.17)	38	1.08	(0.99 to 1.18)	36
46	Kagoshima	1.11	(1.07 to 1.16)	47	1.14	(1.08 to 1.20)	46	1.15	(1.09 to 1.21)	45	1.13	(1.07 to 1.19)	46	1.13	(1.07 to 1.19)	46	1.04	(0.98 to 1.10)	34	1.15	(1.08 to 1.22)	47	1.09	(1.01 to 1.17)	39	1.00	(0.92 to 1.08)	19
47	Okinawa	0.89	(0.85 to 0.94)	5	NA	NA	NA	0.92	(0.85 to 0.99)	5	0.87	(0.80 to 0.93)	2	0.86	(0.80 to 0.92)	1	0.93	(0.87 to 1.00)	7	0.87	(0.80 to 0.94)	5	0.94	(0.86 to 1.02)	14	1.03	(0.95 to 1.13)	26

CI; confidence interval, NA; not available, OR; odds ratio

Prefectures with a lower estimate of odds for all-cause premature mortality are ranked higher. The reference is the grand mean of all the prefectures.

Supplementary Table 8. Variance and covariance matrices of prefecture-level variances of each occupation group, Japan, 1970-2005 [a]

	Men						Women					
	Clerical, technical and managerial occupations	Sales and service occupations	Agriculture, forestry and fishery occupations	Production and transport occupations	Unclassifiable occupations	Non-employed [b]	Clerical, technical and managerial occupations	Sales and service occupations	Agriculture, forestry and fishery occupations	Production and transport occupations	Unclassifiable occupations	Non-employed [b]
Clerical, technical and managerial occupations	0.005						0.008					
	(0.001)						(0.002)					
	1.000						*1.000*					
Sales and service occupations	0.006	0.014					0.003	0.010				
	(0.002)	(0.003)					(0.002)	(0.002)				
	0.716	*1.000*					*0.345*	*1.000*				
Agriculture, forestry and fishery occupations	0.002	0.005	0.006				0.002	0.004	0.013			
	(0.001)	(0.002)	(0.001)				(0.002)	(0.002)	(0.003)			
	0.303	*0.506*	*1.000*				*0.176*	*0.393*	*1.000*			
Production and transport occupations	0.006	0.012	0.004	0.013			0.004	0.006	0.004	0.011		
	(0.002)	(0.003)	(0.002)	(0.003)			(0.002)	(0.002)	(0.002)	(0.003)		
	0.731	*0.920*	*0.484*	*1.000*			*0.472*	*0.544*	*0.308*	*1.000*		
Unclassifiable occupations	-0.007	-0.003	0.006	-0.005	0.317		-0.022	-0.014	-0.019	-0.014	0.331	
	(0.007)	(0.010)	(0.007)	(0.010)	(0.066)		(0.009)	(0.009)	(0.011)	(0.010)	(0.070)	
	-0.168	*-0.051*	*0.139*	*-0.078*	*1.000*		*-0.440*	*-0.247*	*-0.297*	*-0.244*	*1.000*	
Non-employed [b]	-0.001	-0.003	-0.0002	-0.003	0.006	0.006	-0.002	0.005	-0.002	-0.001	0.014	0.008
	(0.001)	(0.001)	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.008)	(0.002)
	-0.226	*-0.387*	*-0.030*	*-0.358*	*0.144*	*1.000*	*-0.198*	*0.508*	*-0.203*	*-0.112*	*0.262*	*1.000*

[a] The number in parentheses is a standard error of the corresponding variances and covariances. The italicized numbers are correlation coefficients.

[b] Non-employed is the sum of unemployed and non-labor force.

Supplementary Table 9. Gini's coefficient of yearly income, average yearly income, and average savings in 47 prefectures, Japan, 1969-2004 [a]

	1969 [b c]			1974 [c]			1979			1984			1989			1994			1999			2004		
Prefectures	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings
1 Hokkaido	NA	1,154	966	NA	2,366	1,686	0.268	3,969	3,998	0.265	4,851	5,097	0.267	5,407	7,276	0.273	6,506	10,241	0.292	6,588	11,616	0.294	5,928	12,062
2 Aomori	NA	1,157	1,014	NA	2,056	1,626	0.253	3,951	3,570	0.266	4,738	4,573	0.289	5,405	6,440	0.298	5,974	7,707	0.294	6,239	9,270	0.291	5,896	11,267
3 Iwate	NA	1,012	786	NA	2,426	1,954	0.263	3,502	3,023	0.294	4,448	4,629	0.283	5,307	6,901	0.272	6,674	10,540	0.283	7,351	12,767	0.298	6,455	12,363
4 Miyagi	NA	1,105	1,021	NA	2,788	2,301	0.251	4,223	4,470	0.260	5,158	4,947	0.271	6,307	8,006	0.279	7,486	10,666	0.275	7,167	12,261	0.307	6,764	11,894
5 Akita	NA	1,336	864	NA	2,616	1,810	0.268	4,129	3,814	0.262	4,821	4,266	0.274	5,872	7,364	0.274	7,284	9,642	0.279	7,254	9,966	0.300	6,235	11,512
6 Yamagata	NA	1,053	877	NA	2,341	1,803	0.256	4,151	3,761	0.266	5,088	4,688	0.272	6,748	7,695	0.273	8,045	10,705	0.277	7,926	13,045	0.306	7,070	12,675
7 Fukushima	NA	1,027	864	NA	2,407	1,963	0.279	3,893	3,798	0.278	5,182	5,290	0.273	6,127	7,660	0.299	7,294	11,202	0.301	7,578	12,405	0.312	6,536	13,216
8 Ibaraki	NA	1,130	1,266	NA	2,573	2,376	0.264	4,369	4,751	0.278	5,437	6,813	0.272	7,140	10,569	0.276	8,516	14,506	0.295	8,261	15,136	0.295	7,339	16,224
9 Tochigi	NA	1,291	1,306	NA	2,617	2,577	0.276	4,461	4,981	0.262	5,819	6,365	0.262	6,884	11,496	0.296	8,146	16,105	0.290	7,630	15,077	0.310	7,527	15,793
10 Gunma	NA	1,203	1,135	NA	2,586	2,361	0.251	4,216	4,627	0.267	5,475	6,571	0.289	6,312	9,731	0.287	8,001	15,031	0.302	7,415	16,836	0.293	6,704	15,878
11 Saitama	NA	1,347	1,322	NA	2,758	2,462	0.244	4,473	4,314	0.253	5,803	6,431	0.268	7,322	11,731	0.274	8,565	13,811	0.281	7,994	14,871	0.295	7,165	14,919
12 Chiba	NA	1,355	1,319	NA	2,765	2,511	0.254	4,593	5,108	0.266	5,898	7,036	0.272	7,439	11,391	0.283	8,683	13,165	0.294	8,330	16,243	0.302	7,230	16,646
13 Tokyo	NA	1,572	1,700	NA	3,067	3,137	0.287	4,843	6,287	0.282	6,165	8,236	0.315	7,691	14,720	0.301	8,494	16,210	0.314	8,082	18,408	0.314	7,799	19,961
14 Kanagawa	NA	1,443	1,481	NA	2,885	2,788	0.260	4,500	4,970	0.272	6,281	7,832	0.280	7,785	13,434	0.291	8,948	16,366	0.285	8,340	17,587	0.299	7,566	17,916
15 Niigata	NA	1,227	1,259	NA	2,432	1,963	0.263	4,177	4,116	0.259	5,631	6,296	0.271	6,515	9,215	0.279	8,086	12,637	0.292	7,904	14,513	0.312	7,406	16,220
16 Toyama	NA	1,178	1,150	NA	2,815	2,506	0.268	4,460	5,176	0.259	5,959	7,286	0.259	7,481	10,780	0.294	8,947	15,490	0.276	8,915	15,676	0.303	8,001	16,814
17 Ishikawa	NA	1,235	1,384	NA	2,773	2,857	0.247	4,486	5,005	0.261	5,875	7,285	0.272	7,144	14,108	0.281	9,152	16,794	0.285	8,728	17,861	0.286	7,409	16,219
18 Fukui	NA	1,213	1,541	NA	2,735	3,181	0.286	5,025	5,759	0.269	6,089	7,819	0.316	7,823	13,122	0.273	8,639	16,529	0.291	8,841	19,639	0.304	8,297	19,330
19 Yamanashi	NA	1,114	927	NA	2,580	2,368	0.267	4,178	4,796	0.257	5,550	6,703	0.258	6,370	9,703	0.278	7,967	12,968	0.287	7,591	13,453	0.280	6,380	13,253
20 Nagano	NA	1,165	1,203	NA	2,463	2,314	0.254	4,347	4,939	0.260	5,525	6,656	0.270	6,547	10,632	0.280	8,041	13,811	0.284	7,970	15,089	0.275	6,807	15,597
21 Gifu	NA	1,160	1,272	NA	2,813	3,074	0.237	4,602	5,033	0.285	5,840	7,173	0.271	6,895	10,957	0.273	8,300	15,472	0.302	8,593	18,079	0.293	7,345	17,212
22 Shizuoka	NA	1,315	1,321	NA	2,615	2,420	0.276	4,380	5,196	0.267	5,666	7,009	0.282	7,156	10,970	0.288	8,183	13,564	0.287	8,057	16,410	0.298	7,361	17,622
23 Aichi	NA	1,279	1,540	NA	2,836	2,892	0.277	4,456	5,716	0.271	6,098	8,468	0.280	7,223	12,592	0.296	8,574	15,924	0.301	8,081	16,767	0.306	7,636	19,433
24 Mie	NA	1,269	1,597	NA	2,736	3,058	0.247	4,137	5,033	0.251	5,541	6,694	0.283	7,161	11,692	0.289	8,224	15,492	0.286	8,159	15,888	0.287	7,346	19,677
25 Shiga	NA	1,286	1,497	NA	2,930	3,361	0.232	4,753	5,470	0.262	6,027	7,817	0.266	7,407	12,852	0.266	8,745	15,929	0.286	7,994	16,220	0.280	7,231	17,098
26 Kyoto	NA	1,593	1,646	NA	3,004	3,105	0.260	4,439	5,632	0.270	5,485	8,077	0.272	6,678	11,127	0.294	7,458	13,633	0.303	7,434	16,289	0.295	6,565	16,383
27 Osaka	NA	1,481	1,736	NA	2,844	2,975	0.276	4,275	5,378	0.271	5,304	7,208	0.291	6,725	12,716	0.308	7,742	14,578	0.296	7,223	15,175	0.323	6,443	15,079
28 Hyogo	NA	1,367	1,779	NA	2,746	2,827	0.272	4,384	5,839	0.281	5,771	7,835	0.293	6,709	13,310	0.287	7,955	15,221	0.296	7,552	15,521	0.314	6,857	16,826
29 Nara	NA	1,220	1,733	NA	2,639	2,927	0.248	4,659	6,405	0.255	5,664	7,923	0.252	6,882	12,601	0.292	8,066	15,819	0.292	8,019	16,010	0.290	7,019	19,270
30 Wakayama	NA	1,180	1,693	NA	2,574	3,311	0.255	4,038	5,210	0.303	5,511	8,111	0.303	5,916	10,795	0.309	7,009	12,886	0.295	6,959	14,747	0.304	6,209	16,929
31 Tottori	NA	1,112	1,134	NA	2,574	2,223	0.259	4,100	4,752	0.278	5,208	6,922	0.276	6,599	9,898	0.289	7,698	13,798	0.296	7,400	14,908	0.297	6,875	16,442
32 Shimane	NA	999	777	NA	2,343	1,890	0.269	4,021	4,191	0.284	5,444	5,958	0.271	6,032	9,969	0.292	7,395	12,366	0.322	7,707	13,343	0.298	6,789	15,128
33 Okayama	NA	1,164	1,330	NA	2,594	2,696	0.267	4,478	5,659	0.280	5,329	7,799	0.292	6,162	11,342	0.282	7,206	14,636	0.291	7,756	16,356	0.303	6,493	17,909
34 Hiroshima	NA	1,187	1,326	NA	2,641	2,444	0.264	4,136	4,935	0.276	5,351	6,620	0.275	6,225	10,185	0.286	7,659	13,471	0.311	7,240	15,763	0.301	6,778	15,478
35 Yamaguchi	NA	1,069	1,168	NA	2,639	2,391	0.252	4,122	5,025	0.267	4,990	6,585	0.283	6,135	10,064	0.282	7,410	13,813	0.294	6,530	13,216	0.293	6,388	14,772
36 Tokushima	NA	1,101	1,292	NA	2,330	2,156	0.298	4,128	5,444	0.287	5,384	6,979	0.284	6,065	9,934	0.294	7,235	13,253	0.321	7,361	15,291	0.345	6,607	16,186
37 Kagawa	NA	1,165	1,259	NA	2,762	2,886	0.266	4,429	5,768	0.288	5,257	7,573	0.266	6,347	13,286	0.294	7,438	15,379	0.285	7,530	17,431	0.292	6,805	18,858
38 Ehime	NA	1,144	1,084	NA	2,272	2,126	0.265	3,876	4,516	0.291	4,834	6,734	0.299	5,627	10,117	0.300	6,833	12,740	0.288	6,355	12,883	0.295	6,157	15,770
39 Kochi	NA	1,074	1,058	NA	2,496	2,325	0.271	3,749	4,267	0.310	4,613	5,482	0.299	5,613	9,695	0.330	6,612	12,490	0.326	6,726	13,279	0.313	6,331	16,847
40 Fukuoka	NA	1,175	1,079	NA	2,404	1,788	0.267	4,008	4,112	0.296	5,024	5,324	0.290	5,579	8,374	0.311	7,159	11,540	0.317	6,797	11,946	0.302	6,464	13,414
41 Saga	NA	1,073	1,064	NA	2,293	2,065	0.261	3,799	3,610	0.286	4,923	5,248	0.301	6,147	8,612	0.296	7,159	11,607	0.284	7,440	12,538	0.296	6,832	13,363
42 Nagasaki	NA	1,113	942	NA	2,184	1,473	0.249	3,659	3,511	0.287	4,273	5,116	0.259	5,249	6,941	0.289	6,129	8,777	0.301	6,646	10,999	0.309	5,855	11,355
43 Kumamoto	NA	1,116	804	NA	2,233	1,750	0.276	3,713	3,716	0.286	4,791	5,155	0.308	5,721	7,603	0.313	6,874	10,354	0.310	6,640	10,824	0.316	6,388	11,657
44 Oita	NA	1,178	1,072	NA	2,281	1,969	0.275	3,666	3,944	0.274	4,470	4,539	0.299	5,560	7,827	0.291	6,406	10,268	0.283	6,764	12,249	0.299	5,811	12,271
45 Miyazaki	NA	1,037	906	NA	2,408	1,677	0.301	3,520	3,125	0.319	4,104	3,876	0.298	4,781	6,044	0.294	5,797	8,779	0.312	6,216	10,263	0.311	5,934	10,030
46 Kagoshima	NA	887	644	NA	2,037	1,423	0.272	3,236	2,854	0.291	3,730	4,031	0.310	4,583	6,318	0.302	5,831	8,461	0.282	5,885	10,217	0.293	5,827	10,410
47 Okinawa	NA	NA	NA	NA	2,128	990	0.299	3,261	2,345	0.337	3,648	2,656	0.332	4,505	4,728	0.380	5,491	5,238	0.353	5,298	5,918	0.344	4,516	5,484
Mean	NA	1,197	1,220	NA	2,562	2,357	0.265	4,170	4,637	0.276	5,278	6,335	0.282	6,368	10,054	0.291	7,575	12,971	0.296	7,457	14,261	0.302	6,753	15,120
Standard deviation	NA	144	293	NA	248	557	0.015	391	919	0.018	617	1,375	0.017	833	2,386	0.018	915	2,680	0.015	792	2,754	0.013	688	3,007
Lowest	NA	887	644	NA	2,037	990	0.232	3,236	2,345	0.251	3,648	2,656	0.252	4,505	4,728	0.266	5,491	5,238	0.275	5,298	5,918	0.275	4,516	5,484
Highest	NA	1,593	1,779	NA	3,067	3,361	0.301	5,025	6,405	0.337	6,281	8,468	0.332	7,823	14,720	0.380	9,152	16,794	0.353	8,915	19,639	0.345	8,297	19,961

NA; not available

[a] These data were obtained from the *National Survey of Family Income and Expenditure* . All variables were calculated among two-or-more-person households. Average yearly income and average savings are shown in thousand yen.

[b] The data for Okinawa prefecture were not available in 1969.

[c] Gini's coefficients of yearly income were not available in these years, and we imputed the values of 1979 forwardly in the analysis.

Supplementary Table 10. Odds ratios for all-cause premature mortality of prefecture-level socioeconomic status variables, Japan, 1970-2005 [a]

	Overall		1970 [b]		1975 [b]		1980		1985		1990		1995		2000		2005	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Men																		
Gini's coefficient of yearly income [c]																		
Low	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.01	(0.99 to 1.03)	1.03	(0.98 to 1.07)	1.03	(0.99 to 1.07)	1.01	(0.97 to 1.06)	1.00	(0.97 to 1.04)	1.03	(0.99 to 1.07)	0.99	(0.93 to 1.04)	1.02	(0.96 to 1.08)	0.99	(0.92 to 1.07)
High	1.01	(0.98 to 1.03)	1.03	(0.99 to 1.07)	1.01	(0.97 to 1.05)	0.99	(0.95 to 1.04)	0.98	(0.94 to 1.01)	0.99	(0.95 to 1.03)	1.00	(0.94 to 1.06)	0.98	(0.93 to 1.05)	0.98	(0.91 to 1.06)
Average yearly income [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	0.99	(0.97 to 1.02)	0.99	(0.95 to 1.03)	1.04	(1.00 to 1.08)	1.05	(1.00 to 1.09)	0.99	(0.95 to 1.03)	1.00	(0.96 to 1.04)	1.05	(0.99 to 1.11)	1.07	(1.01 to 1.13)	0.99	(0.91 to 1.07)
Low	0.99	(0.96 to 1.02)	1.04	(1.00 to 1.08)	1.05	(1.01 to 1.08)	1.04	(0.99 to 1.09)	0.98	(0.94 to 1.02)	0.96	(0.92 to 1.00)	1.01	(0.96 to 1.07)	1.04	(0.98 to 1.10)	1.03	(0.96 to 1.11)
Average savings [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.00	(0.97 to 1.02)	1.04	(1.00 to 1.08)	1.04	(1.00 to 1.08)	1.02	(0.97 to 1.07)	1.02	(0.98 to 1.06)	0.99	(0.95 to 1.03)	1.05	(0.99 to 1.11)	1.07	(1.01 to 1.13)	1.03	(0.95 to 1.11)
Low	1.01	(0.98 to 1.05)	1.07	(1.03 to 1.12)	1.05	(1.01 to 1.09)	1.02	(0.98 to 1.07)	0.99	(0.95 to 1.03)	0.97	(0.93 to 1.01)	1.04	(0.98 to 1.10)	1.07	(1.01 to 1.14)	1.08	(1.00 to 1.16)
Women																		
Gini's coefficient of yearly income [c]																		
Low	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.00	(0.97 to 1.02)	0.98	(0.93 to 1.05)	1.01	(0.95 to 1.08)	1.00	(0.95 to 1.05)	1.04	(0.99 to 1.09)	1.02	(0.97 to 1.07)	0.97	(0.90 to 1.03)	0.96	(0.89 to 1.03)	0.99	(0.91 to 1.07)
High	1.01	(0.98 to 1.04)	1.01	(0.95 to 1.07)	1.04	(0.98 to 1.11)	1.04	(0.98 to 1.10)	1.05	(1.00 to 1.10)	1.02	(0.97 to 1.07)	0.99	(0.93 to 1.06)	0.99	(0.92 to 1.07)	1.00	(0.93 to 1.09)
Average yearly income [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.01	(0.98 to 1.04)	1.09	(1.03 to 1.15)	1.07	(1.01 to 1.13)	1.01	(0.96 to 1.06)	1.04	(0.99 to 1.10)	1.01	(0.97 to 1.07)	1.00	(0.94 to 1.07)	1.06	(0.99 to 1.14)	0.96	(0.89 to 1.04)
Low	1.02	(0.99 to 1.06)	1.10	(1.05 to 1.16)	1.09	(1.04 to 1.16)	1.05	(0.99 to 1.11)	1.04	(0.98 to 1.09)	1.02	(0.97 to 1.08)	1.04	(0.98 to 1.12)	1.04	(0.97 to 1.12)	1.04	(0.96 to 1.13)
Average savings [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.00	(0.97 to 1.03)	1.09	(1.03 to 1.15)	1.05	(0.99 to 1.12)	1.01	(0.96 to 1.07)	1.02	(0.96 to 1.07)	1.08	(1.03 to 1.13)	1.03	(0.96 to 1.10)	1.05	(0.98 to 1.13)	1.01	(0.93 to 1.09)
Low	1.02	(0.98 to 1.06)	1.08	(1.02 to 1.14)	1.04	(0.98 to 1.11)	1.02	(0.96 to 1.07)	1.01	(0.96 to 1.07)	1.03	(0.98 to 1.07)	1.06	(0.99 to 1.13)	1.08	(1.00 to 1.16)	1.05	(0.97 to 1.14)

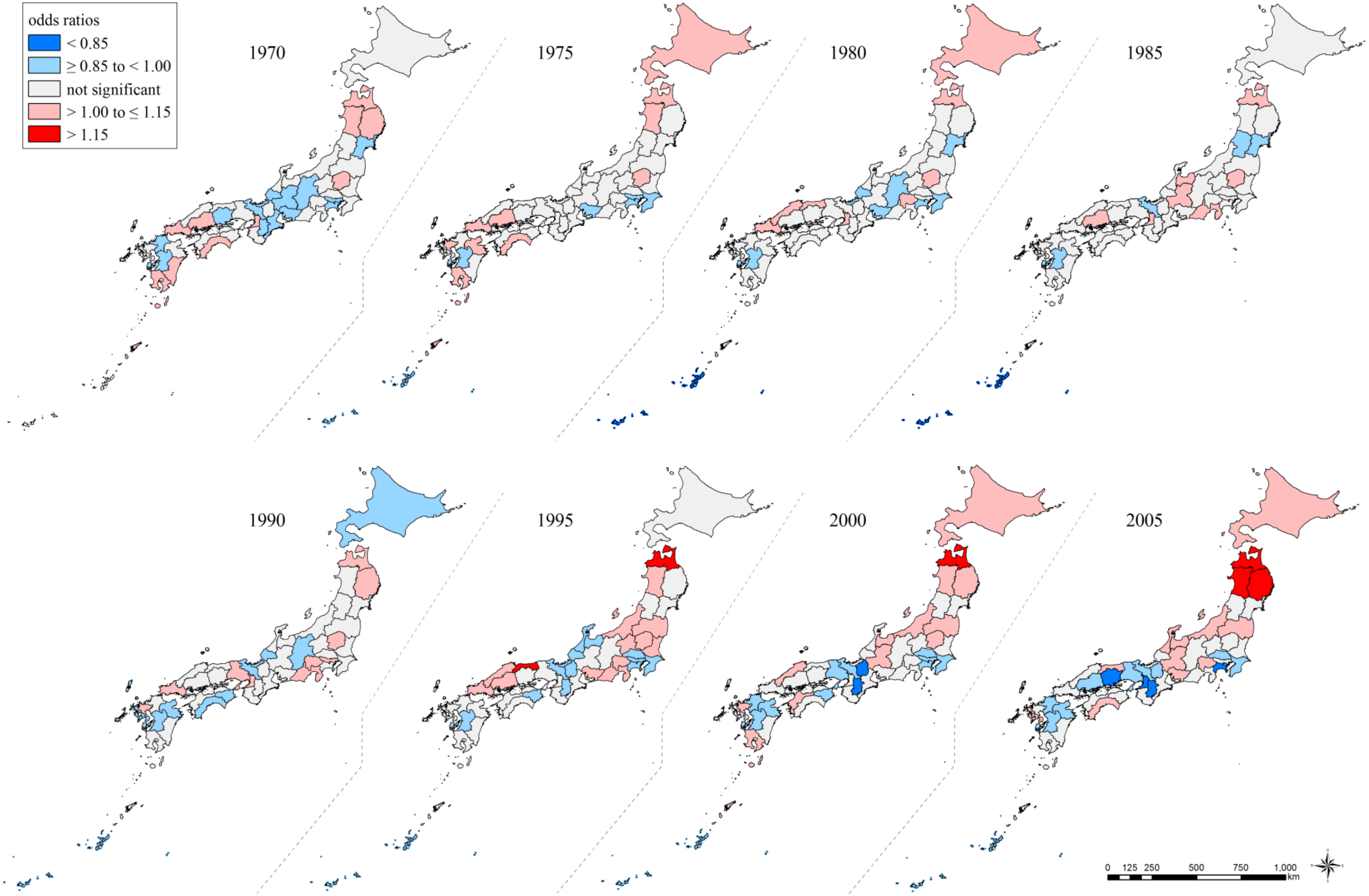
CI; confidence interval, OR; odds ratio

[a] These odds ratios were adjusted for age, occupations, and year (only in the overall model). Prefecture-level variables were adjusted for separately.

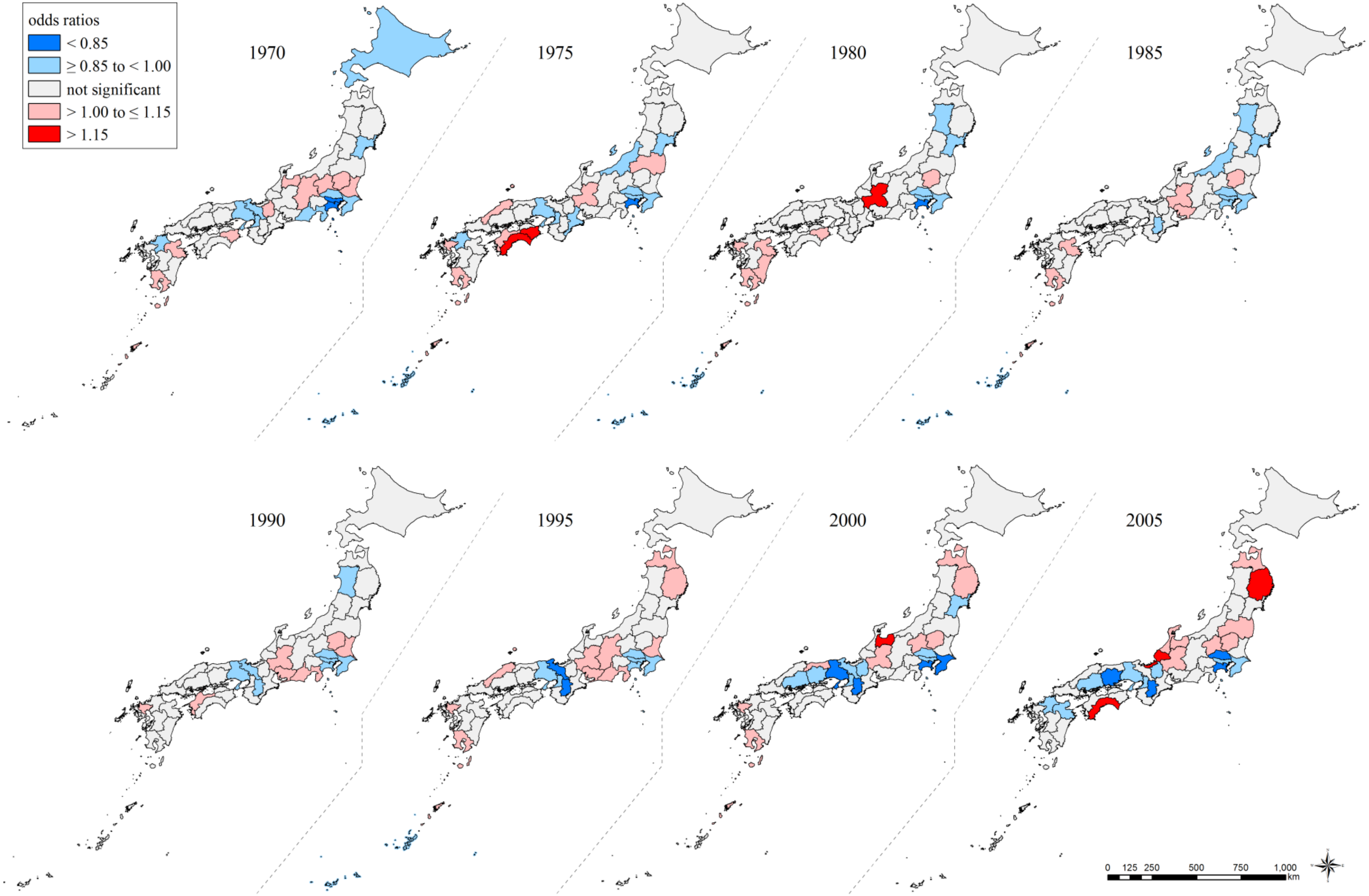
[b] Gini's coefficients of yearly income were not available in these models, and we imputed the vlaues of the 1980 model to them.

[c] These variables were calculated among two-or-more-person households.

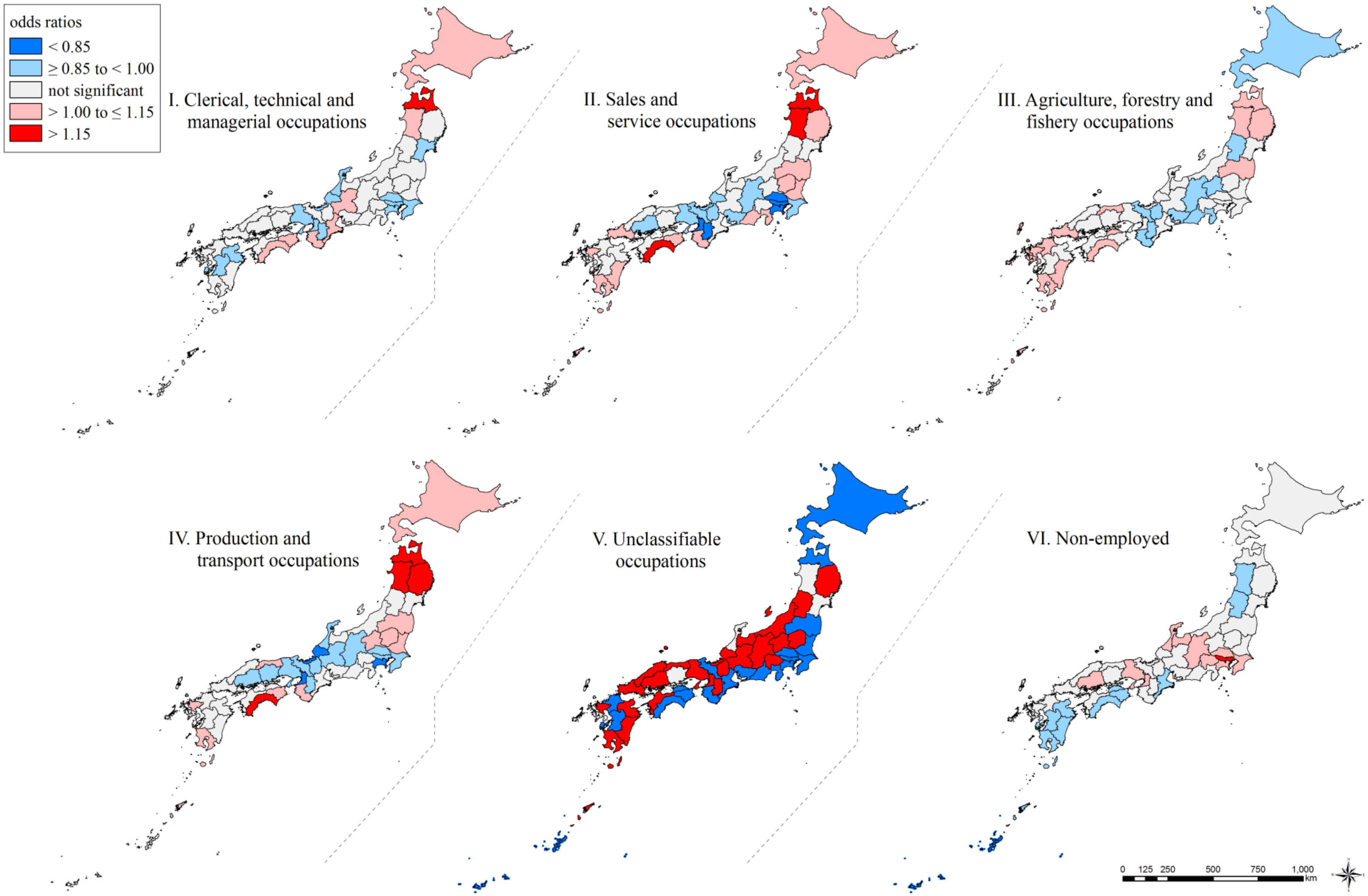
Supplementary Figure 1. A blank map of Japan.



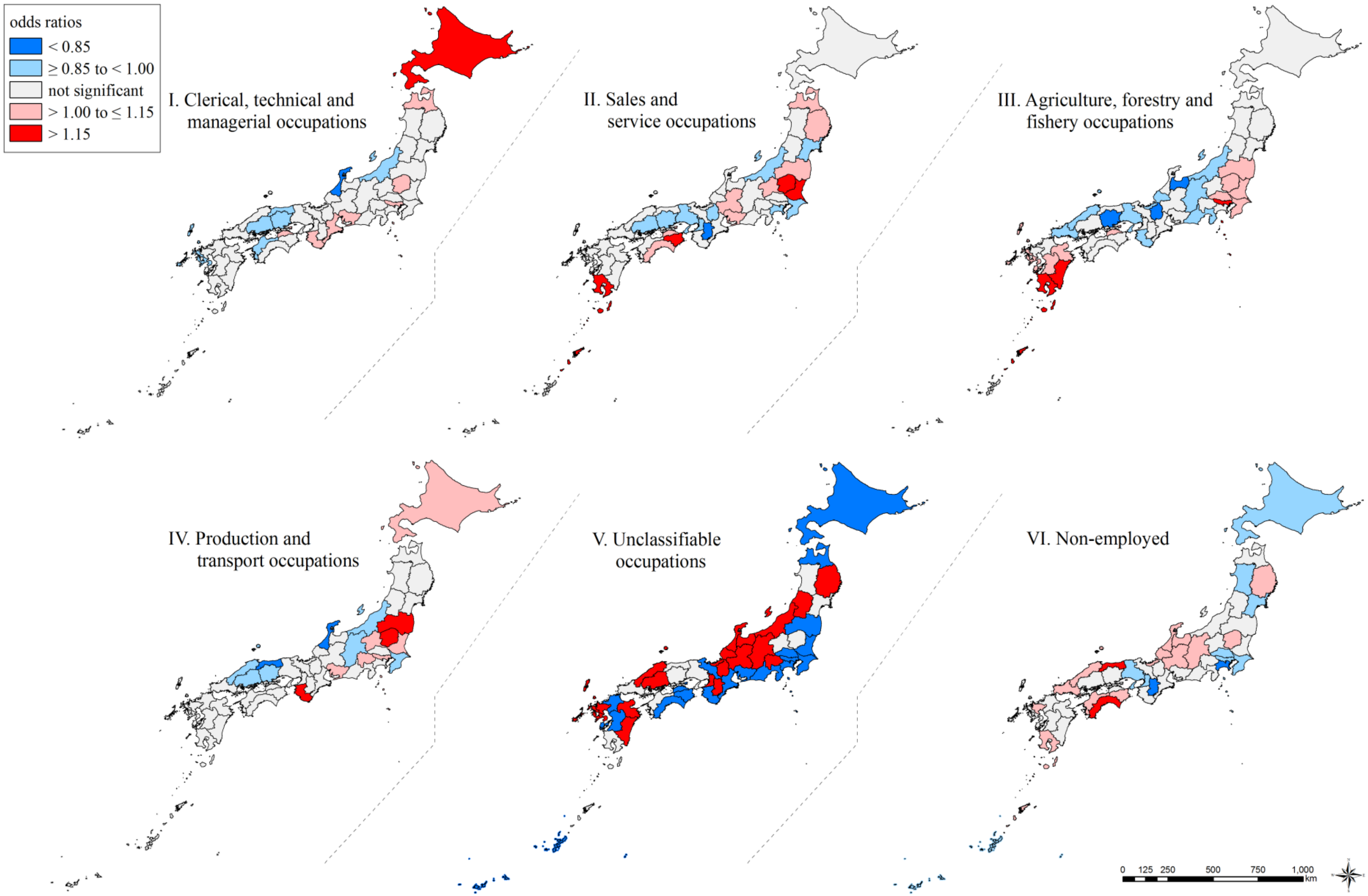
Supplementary Figure 2. Geographic and temporal variation in all-cause premature mortality among men, Japan.



Supplementary Figure 3. Geographic and temporal variation in all-cause premature mortality among women, Japan.



Supplementary Figure 4. Geographic inequality of all-cause premature mortality by occupational groups among men, Japan, 1970-2005.



Supplementary Figure 5. Geographic inequality of all-cause premature mortality by occupational groups among women, Japan, 1970-2005.

Legends of Supplementary Figures

Supplementary Figure 1. A blank map of Japan.

We show the locations of 47 prefectures in Japan.

Supplementary Figure 2. Geographic and temporal variation in all-cause premature mortality among men, Japan.

We show year-specific geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age and occupation. (The data for Okinawa prefecture were not available in 1970.) Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Supplementary Figure 3. Geographic and temporal variation in all-cause premature mortality among women, Japan.

We show year-specific geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age and occupation. (The data for Okinawa prefecture were not available in 1970.) Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Supplementary Figure 4. Geographic inequality of all-cause premature mortality by occupational groups among men, Japan, 1970-2005.

We show the geographic inequality of all-cause mortality across 47 prefectures for the six collapsed occupational groups, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Supplementary Figure 5. Geographic inequality of all-cause premature mortality by occupational groups among women, Japan, 1970-2005.

We show the geographic inequality of all-cause mortality across 47 prefectures for the six collapsed occupational groups, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes
Methods			
Study design	4	Present key elements of study design early in the paper	Yes
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Yes
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	Yes
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes
		(*b*) Describe any methods used to examine subgroups and interactions	Yes
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	Yes
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which	Yes

		confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Yes
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Yes
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Social and geographic inequalities in premature adult mortality in Japan: an observational study from 1970 to 2005

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1970-2005_adj_animation.gif

Social and geographic inequalities in premature adult mortality in Japan: an observational study from 1970 to 2005

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Abstract

Objectives: To examine trends in social and geographic inequalities in all-cause premature adult mortality in Japan.

Design: Observational study of the Vital Statistics and the Census data.

Setting: Japan.

Participants: Entire population aged 25 or older and less than 65 in 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. The total number of decedents was 984,022 and 532,223 in men and women, respectively.

Main outcome measures: For each sex, odds ratios (ORs) and 95% confidence intervals (CIs) for mortality were estimated by using multilevel logistic regression models with "cells" (cross-tabulated by age and occupation) at level 1, eight years at level 2, and 47 prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality.

Results: Adjusting for age and time-trends, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (2.19 to 2.24) among service workers in men. By contrast, in women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (11.40 to

13.10) among security workers. The degree of occupational inequality increased in both sexes. Higher occupational groups did not experience reductions in mortality throughout the period and was overtaken by lower occupational groups in the early 1990s, among men. Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small in both sexes; the ORs ranged from 0.87 (Okinawa) to 1.13 (Aomori) for men and from 0.84 (Kanagawa) to 1.11 (Kagoshima) for women, even though there is a suggestion of increasing inequalities across prefectures since 1995 in both sexes.

Conclusions: The present findings suggest that both social and geographic inequalities in all-cause mortality have increased in Japan during the last three decades.

Article summary

Article focus:

While Japan enjoys the highest average life expectancy in the world, less has been documented on the trends and patterns of health inequalities within the nation.

We examined trends in social and geographic inequalities in all-cause premature adult mortality from 1970 through 2005.

Key messages:

This is the first study that simultaneously examines time trends in premature mortality by occupational class as well as geographic locality, and the results of our study indicate that health disparities have widened during the decades following the collapse of the asset bubble in the early 1990s.

Given the multiple challenges that threaten to further dampen economic activity of the nation, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

Strengths and limitations of this study:

The data are census based and cover the whole of Japan from 1970 through 2005.

This study uses multilevel methods to properly adjust for micro- and macro-level bias simultaneously.

We lacked information on whether the individuals were in standard jobs or precarious jobs, and a possibility of measurement error in occupation at the time of death cannot be ruled out.

INTRODUCTION

The postwar Constitution (1946) of Japan made equality a primary objective of the health system, and by 1961, the country achieved universal and compulsory health insurance coverage.[1] Although Japanese longevity was well below that of most European countries in 1960, subsequent health gains enabled the country to overtake other nations to the point where Japan reached the top of the national life expectancy rankings by 1985.[1 2] During the period of rapid economic growth (mid-1960s to 1989), Japan's social and economic policies helped to create a broad middle class with secure (often life-long) employment and comparatively egalitarian growth in living standards across the income spectrum.[1 3] Following the collapse of the asset bubble in the early 1990s, however, Japan's economy has been characterized by persistently low growth accompanied by a marked increase in the number of precarious workers (i.e., non-standard jobs such as part-time and contingent workers), from 1 in 5 employees in the 1990s to 1 in 3 employees by 2005.[4] The period since the collapse of the asset bubble – now referred to as the "Lost Two Decades" – has been characterized by a widening of income disparities and the emergence of a new class of "working poor" hitherto unrecognized in Japanese society.[5] In retrospect, the post-War period of comparatively egalitarian economic growth appears to have lasted about forty years,

and today, Japan ranks closer to countries such as the United States and the UK in terms of indicators of relative poverty, such as poverty rate and poverty gap.[6]

While there are considerable studies documenting social and geographic inequalities in mortality in other industrialized countries,[7-12] we are not aware of a similar comprehensive assessment of the trends in health inequalities in Japan that may have accompanied the major macroeconomic changes.[13] In this study, by using occupations as an indicator of socioeconomic position,[14] we examine the trends in occupational and geographic inequalities of all-cause premature adult mortality from 1970 through 2005. Since premature adult mortality focuses on death occurring at younger ages, they constitute a useful measure in public health as well as preventive medicine.[15]

METHODS

Data

Data on deaths were obtained from the *Report of Vital Statistics: Occupational and Industrial Aspects*,[16] which has been conducted by the Ministry of Health, Labour and Welfare every five years since 1970, coinciding with the years of the Population Census. The latest year for which data are available is 2005. In the notification of deaths, the respondents are asked to fill in the occupation of decedent at the time of death,[17] and one of the following persons is obliged to submit the notification: (1) relatives who live together with decedents, (2) other housemates, (3) landlord, estate owner, land/house agent, or (4) relatives who do not live together with decedents. The occupation at the time of death is recorded for each decedent following the Japan Standard Occupational Classification.[18] During the follow-up period, the occupational classification scheme underwent four revisions (Supplementary Table 1).[18] In this study, we used the fourth revision of the Occupational Classification, which includes the following 11 groups[18]: (1) specialist and technical workers, (2) administrative and managerial workers, (3) clerical workers, (4) sales workers, (5) service workers, (6) security workers, (7) agriculture, forestry and fishery workers, (8) transport and communication workers, (9) production process and related workers, (10) workers not classifiable by occupation, and (11) non-employed. (The full description of each occupational group is available on-line in English.[18]) Note that the group "production process and related workers" includes mining workers. Note also that the group "non-employed" includes the unemployed as well as non-labor force (e.g., home-makers, students, and the retired). Although the Census distinguishes the unemployed from home-makers, the vital records combine these categories as "non-employed." We restricted the analysis to those who are aged 25 or older and less than 65 to exclude students as well as the retired. The total number of decedents was 984,022 and 532,223 in men and women, respectively (Supplementary Figure 1 and Supplementary Table 2).

Denominator data for the calculation of mortality rates were obtained from the Population Census which has been conducted by the Ministry of Internal Affairs and Communications every five years since 1920.[19] In the questionnaire for the Census, the occupation was assessed by asking a following question[19]: "Description of work – Describe in detail the duties you are assigned to perform." The questionnaires are delivered to each household, and someone in each household answers the question. We used "production process and related workers" as the referent category since they were the largest occupational category in a majority of the time periods (Supplementary Table 3).

Analysis

The data had a three-level multilevel structure of 32,590 cells for men and 32,542 cells for women at level 1, nested within eight years at level 2, nested within 47 prefectures at level 3. The eight years comprised of 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Each year had a maximum 88 cells (eight age groups times 11 occupational groups) (Supplementary Table 4). Note that the numbers of deaths for each cell are recorded during one fiscal year. For the descriptive purpose, we first calculated age-adjusted mortality rates by occupational class by year and sex (Supplementary Table 5). We used the direct method, using the model population of 1985 as a reference.[20] The model population of 1985 is based on the Japanese population under census of 1985 and it is created on the basis of 1,000 persons as 1 unit, after adjusting radical increase or decrease such as baby boom.[21] We then employed multilevel statistical procedures because of their ability to model complex variance structures at multiple levels.[22] In the present analysis, they allow estimation of the relationship between mortality and occupation, conditional on individual age variation ("fixed parameters") and year- and prefecture-level variations ("random parameters"). They also enable an estimation of the extent to which the relationship between mortality and occupation varies across years and prefectures (random parameters) and the degree to which prefecture-level socioeconomic status explains this variation (fixed parameters). The unit of analysis was "cells," and our models were structurally identical to models with individuals at level 1.[23]

The response variable, proportion of deaths in each cell, was modeled with allowances made for the varying denominator in each cell. The fixed and random parameter estimates (along with their standard errors) for the multilevel binomial logit link model were calibrated using predictive/penalized quasi-likelihood procedures with second order Taylor series expansion, as implemented within the MLwiN 2.22.[24] Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). A *p* value of less than 0.05 (two-sided test) was considered statistically significant.

First, we conducted three-level analysis as an overall model, with cells at level 1, years at level 2, and prefectures at level 3. The prefecture-level variance was used as an estimate of geographic inequalities of mortality. Prefectures were ranked by ORs having the whole country of Japan as reference (value = 1), and uncertainty was estimated by 95% CIs. Further, to examine the temporal patterns of occupational and geographic inequality of mortality across years, we also conducted two-level analysis, with cells at level 1 and prefectures at level 2 separately for each year.

Then, to explore the temporal change of occupational inequality, we ran a three-level multilevel model including a fixed cross-level interaction effect between the 11 occupations (at level 1) and year (at level 2). In this analysis, we modeled the year as a continuous variable, and we calculated mean predicted probabilities for mortality among those aged 25 to 29 (referent category).

To present the results of geographic inequality in all-cause mortality, we created maps showing prefecture-level residuals by using the ArcGIS (ESRI Japan Inc., version 9.3).

RESULTS

Social inequality of mortality

Table 1 shows the results of social inequality of all-cause premature mortality in terms of occupation from overall model as well as year-specific models in multilevel analyses. Excluding workers not classifiable by occupation and non-employed, there were substantial health disparities by occupations in both sexes. Adjusting for age and time-trends in the overall model, compared with production process and related workers, ORs ranged from 0.97 (95% CI 0.96 to 0.98) among administrative and managerial workers to 2.22 (95% CI 2.19 to 2.24) among service workers in men. Among women, the lowest odds for mortality was observed among production process and related workers (reference) while the highest OR was 12.22 (95% CI 11.40 to 13.10) among security workers.

The degree of occupational inequality increased in both sexes. Among men, in 1970, the lowest OR was 0.54 (95% CI 0.53 to 0.56) among administrative and managerial workers while the highest OR was 1.34 (95% CI 1.32 to 1.37) among agriculture, forestry and fishery workers. In 2005, however, the lowest odds for mortality was observed among production process and related workers (reference) whereas the highest OR was 3.97 (95% CI 3.84 to 4.11) among service workers. Among women, the lowest odds for mortality was observed among production process and related workers (reference) throughout the follow-up period, and the highest ORs in 1970 and 2005 were 11.43 (95% CI 9.14 to 14.29) and 16.25 (95% CI 13.65 to 19.34), respectively, among security workers.

The widening social inequalities can be more clearly seen in Figures 1 and 2, which show the temporal pattern of these occupational inequalities across years. We excluded workers not classifiable by occupation and non-employed from these Figures to enhance readability although they were included in the analysis. Among men, the mortality risk among three occupations (specialist and technical workers, administrative and managerial workers, and service workers) remained unchanged, whereas those of other occupational groups declined more or less. Especially, in addition to the workers not classifiable by occupation, three occupations (clerical workers, sales workers, and product process and related workers) experienced a considerable decline in mortality risk between 1970 and 2005.

By contrast, trends in mortality by occupational groups were more stable for women. Most occupations experienced the comparable trajectories during the period although administrative and managerial workers experienced relatively small declines in mortality risk. Specialist and technical workers and service workers also experienced declines in mortality risk among women although they remained on a plateau among men.

Geographic inequality of mortality

Conditional on individual age and occupation, overall geographic inequality of mortality were relatively small across prefectures in both sexes, with slightly larger geographic inequality among women than men (Table 2). Note that Tables 1 and 2 are based on the same multilevel models, showing the results of fixed and random parts, respectively. Prefecture-specific ORs ranged from 0.87 (Okinawa prefecture) to 1.13 (Aomori prefecture) for men and from 0.84 (Kanagawa prefecture) to 1.11 (Kagoshima prefecture) for women (Supplementary Tables 6 and 7). Figure 3 shows the results of geographic inequalities in mortality. We observed similar patterns in both sexes although they led to opposite results between the sexes in Akita and Fukui prefectures; in Akita, the mortality risk was higher in men whereas it was lower in women. In Fukui, however, the pattern was reversed.

Although overall geographic inequalities of mortality were relatively small, they appear to have increased over time (Table 2). In men, although prefecture-level variance was less pronounced until 1990 (around 0.003 on logit scale), it began to increase since 1995 steadily to 0.011 in 2005. By contrast, in women the prefecture-level variance (on logit scale) was 0.007 in 1970s, and it declined to 0.004 in 1990, and then increased up to 0.012 in 2005. The adjusted ORs and 95% CIs for mortality in each prefecture across years are shown in Supplementary Tables 6 and 7. In 1970, ORs ranged from 0.89 (Gifu prefecture) to 1.12 (Akita prefecture) for men and from 0.79 (Tokyo) to 1.14 (Kagoshima prefecture) for women. In 2005, the ranges were widened, and ORs ranged from 0.81 (Nara prefecture) to 1.27 (Aomori prefecture) for men and from 0.75 (Nara prefecture) to 1.18 (Kochi prefecture) for women. We show geographic and temporal variation in mortality, suggesting an increase in geographic inequalities across prefectures since 1995 in both sexes (Supplementary Figures 2 and 3 and Video).

Supplementary analyses

We examined two additional issues to further explore the occupational and geographic inequalities in premature mortality; (i) the patterns of geographic inequalities in mortality by occupations, and (ii) the presence of contextual effects of prefecture-level socioeconomic status on mortality risk (Supplementary Text, Supplementary Figures 4 and 5, Supplementary Tables 8 to 10).

DISCUSSION

Summary of findings

The findings of the present study suggest that the economic trends during the past 35 years have been accompanied by a widening of health inequalities between occupational classes as well as geographic areas of the country. The post-bubble economy has been characterized by lackluster growth combined with a dramatic shift in the work-force away from life-long employment towards more precarious employment.[4] This economic restructuring has increased pressure on workers in managerial and professional workers (primarily men) who are being squeezed to raise their productivity. The changing pattern of health inequalities across occupational groups is consistent with this interpretation, i.e., the stalled decline in premature mortality among white collar workers relative to other occupational classes.

Comparison with other studies

The present findings suggest that the health effects of the changing economic conditions depend on individual's socioeconomic circumstances. A previous study in Japan demonstrated that, although self-rated health improved for both sexes throughout the economic crisis of the 1990s, health disparities in relation to occupations widened, especially among men.[25] They also reported that middle-class male workers and female homemakers seemed to be particularly adversely affected by the crisis.[25] The present study, however, provides a different pattern of widening health disparities in both sexes. For men, absolute health status improvement was observed only among some lower occupational groups (e.g., production process and related workers, sales workers, and clerical workers), whereas higher occupational classes (e.g., specialist and technical workers and administrative and managerial workers) apparently obtained no benefit throughout the period. Indeed, although they were advantaged with regard to mortality risk in 1970s and 1980s, they were overtaken in the 1990s by those in lower occupational classes who benefited more during the same period. Of note, this "cross-over" almost coincided with the collapse of the economic bubble in the early 1990s. We note at the same time that neither male service workers nor agricultural, forestry and fishery workers experienced improvements in premature mortality throughout the period.

By contrast, for women, we observe that absolute health status improved roughly to the same extent across occupational groups, and that changes in ranking were less pronounced in women compared to men. We should note that relatively few women were represented in the three occupational groups with higher risk of mortality (i.e., administrative and managerial workers, security workers, and transport and communication workers). Even excluding these occupational groups, however, health inequalities appeared to have increased in women. These findings may be explained by differences between men and women according to the type of work and industrial sector of employment. Men are more likely to be engaged in work in the private sector as well as in parts of the economy that are more vulnerable to economic downturns (such as finance and business services, manufacturing, construction).[26]

Potential mechanisms of social inequalities in mortality

The present findings provide a marked contrast to the evolution of health inequalities described in other industrialized countries. In industrialized western European and north American countries, health status typically follows a hierarchical pattern: i.e., the lower the socioeconomic position, the worse the health status.[5 8 10 11] We show that this "typical" pattern of health inequalities does not necessarily apply to Japan. In contrast to Western countries, previous studies in Japan have yielded inconsistent results with regard to the relationship between socioeconomic status and health outcomes, and lower non-manual or manual workers do not necessarily exhibit less healthy behaviors compared with those in higher occupational classes.[27-32] Nevertheless, a recent study of a nationally representative sample in 2001 showed that men in lower occupational classes, such as service work, transportation, and labor work, were significantly more likely to engage in health risk behaviors compared with professional workers.[33] They also showed that there is a cumulation of risky behaviors in lower female occupational classes.[33] Further, another cross-sectional study in Japan demonstrated that occupation was not significantly associated with psychological distress among men or women by using a nationally representative sample in 2007.[34] Thus, the pattern of health inequalities in the present analysis is not consistent with occupational class differences in health behaviors or psychosocial stress.

As a possible explanation for the present findings, we note that occupation-based socioeconomic position may reflect social networks,[14] which enables its members to access a wide variety of resources. In this respect, recent research from Japan has emphasized the evaluation of social capital as well as social networks in the workplace to explain variations in workers' health.[35-37] We thus hypothesized a posteriori that, following the collapse of the economic bubble, workers of higher occupational classes were more likely to experience a breakdown of social cohesion within companies, which could cancel out the potential positive benefits among them. We also note that there is a possibility that the "compositions" of each occupational group went through a (substantial) change throughout the study period, which might have led to different patterns of occupational hazards, especially among lower occupational groups. In other words, there is a possibility that work environment have improved markedly among them throughout the study period, which now requires less labor load. Finally, a possibility of healthy worker effect cannot be ruled out among some lower occupational groups. This could be induced by the following two processes; (i) healthy people might have selectively entered these occupations, and (ii) unhealthy workers might have selectively exited these occupations. Further studies are warranted to examine these possible explanations of the present findings.[38]

It is worth mentioning that typical occupational hierarchy does not necessarily apply to the occupation (major group) of the Japan Standard Occupational Classification. Indeed, there is inherently more ambiguity in the ranking of occupations, compared with education and income.[39] In addition, as noted by Galobardes et al.,[14] the decrease in manual occupations with concomitant increase in low-level service occupations has altered the stratification that occupation generates in terms of socioeconomic position, and so classification such as manual and non-manual worker may lose some of their meaning in economies which include a large number of low-paid, non-manual service jobs. Importantly, the occupational classification in the present study yields reasonably consistent occupational grouping throughout the study period, and each group has a reasonably large data. We therefore examined the time trend of social inequalities by using the finest occupational classification available in the Census. By using a fairly detailed occupational classification, it is likely that we could adjust for other omitted compositional variables (e.g., education), to the extent that the cross-tabulation of age and occupation correlate with them.

Geographic and temporal variation in mortality

By applying the novel multilevel methods, the present study shows that geographic inequalities in premature mortality have also widened since 1995. In an ecological study, Fukuda et al.[40] assessed the time trend of geographic health inequality in Japan, by examining the association of life expectancy and age-adjusted mortality with per capita income of prefectures and municipalities. While excluding Okinawa prefecture from the analyses, they found a possible increase in geographic health inequalities from 1995 to 2000, following a decrease from 1955 to 1995.[40] Note that the present study examined geographic inequalities, conditional on individual age and occupation. The present findings thus provide suggestive evidence of "common ecologic effects" of place where people live,[41] although we should note that the seemingly ecologic effects might be due to an omitted compositional effect (e.g., income). Broadly speaking, since 1995, higher mortality risk has been consistently observed in the northeastern region in the main island (Tohoku region) for both sexes. Overall, the economic conditions of the predominantly rural areas in the region may be characterized by population decline, population aging, and lower per capita income.[19] [42] Notably, however, not all rural prefectures have undergone the same transition; indeed some rural prefectures (such as Nara and Okayama) had moved up through the ranks as having significantly lower mortality for both sexes in 2005. In the supplementary analysis, no clear associations were found with prefecture-level socioeconomic variables, and it remains unknown what contributed to these distinct patterns. These patterns deserve further attention in future studies.

Limitations of the study

There are some limitations of our analysis. First, although we were able to conduct a fairly detailed analysis of trends by using occupations to measure certain aspects of socioeconomic position, neither the status in employment nor the predominant type of employment contract was available, and in particular, we lacked information on whether the individuals were in standard jobs or precarious jobs. Given the conspicuous increase in the proportion of the labor force engaged in non-standard work,[4] as well as mounting evidence that precarious work is associated with worse health,[43] future work needs to examine whether the changing character of the workforce in Japan is contributing to widening health inequalities. The use of more detailed indicators of socioeconomic position would provide further insight into the social inequalities of health. Indeed, greater attention to the theoretical as well as empirical aspects of measurement of socioeconomic position will likely enhance the rigor of research on occupational health inequalities, which would increase the possibility for meaningfully comparing results across studies.[44]

Second, occupation at the time of death was used in our numerator data, which may not necessarily reflect the individual's life-course socioeconomic position.[44 45] If unhealthy workers selectively exited some occupations, this would have led to an under-estimation of mortality in those sectors. The proportion of agricultural workers significantly decreased during the study period for both sexes, as well as that of administrative and managerial workers (for men). However, this may reflect real trends in the work-force.

Third, considering the possible discrepancies of the respondents on the two occasions (i.e., the notification of deaths and the census), we should note the potential for numerator denominator bias between the two sources of information. In particular, the possibility of measurement error in occupation at the time of death cannot be ruled out – the person recording the notification of deaths may either promotes the deceased to a higher status job or demotes them because the respondents did not know the details of the deceased's job. Indeed, rapid changes in the occupational structure of Japan could give plausibility to the extremely large odds ratios resulting from the potential for numerator denominator bias.

Fourth, the smallest geographic unit available was the prefecture (of which there are 47), and we could not explore geographic inequalities in finer detail. However, the prefecture may be a useful and valid unit of analysis since it is the unit that has direct administrative authority in the economic, education, and health sectors.[1] Furthermore, the prefecture has specific jurisdiction over health centers, which is the locus of preventive health care activity in Japan.[1] Note also that the boundaries between prefectures have not changed since the Meiji Restoration (1867), enabling long-term analysis.[1] Since previous studies demonstrated that the choice of geographic units as well as area-based measures is critical in the investigation of geographic inequalities,[46 47] these issues warrant further examination.

Conclusions

Despite several limitations associated with the use of secondary data, the present findings indicate that both social and geographic inequalities in premature adult mortality have increased during Japan's "Lost Two Decades" following the collapse of the asset bubble. As a nation, Japan must grapple with the triple demographic trends of declining fertility, population aging, and overall population decline. These trends threaten to further dampen economic activity, escalating the load on the social security system. In addition, Japan now faces multiple challenges in the wake of the earthquake and tsunami on March 11, 2011, and this may further place downward momentum on the nation's struggling economy. Given these momentous challenges, it is imperative to continue to monitor future trends in health inequalities in order to avert the potential impacts on Japan's health security.

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Figure legends

Figure 1. Predicted mortality by occupations in men, Japan, 1970-2005.

We show mean predicted probabilities for all-cause premature mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed from the Figure.

Figure 2. Predicted mortality by occupations in women, Japan, 1970-2005.

We show mean predicted probabilities for all-cause premature mortality by nine occupational groups among those aged 25 to 29 (referent category). We excluded workers not classifiable by occupation and non-employed from the Figure.

Figure 3. Geographic inequality of all-cause premature mortality, Japan, 1970-2005.

We show the overall geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Table 1. Odds ratios for all-cause premature mortality in each occupation, Japan, 1970-2005 [a]

	Overall		1970		1975		1980	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Men								
Specialist and technical workers	1.31	(1.30 to 1.33)	0.74	(0.72 to 0.77)	0.80	(0.77 to 0.82)	1.18	(1.14 to 1.21)
Administrative and managerial workers	0.97	(0.96 to 0.98)	0.54	(0.53 to 0.56)	0.66	(0.64 to 0.68)	0.76	(0.74 to 0.78)
Clerical workers	1.20	(1.19 to 1.21)	1.05	(1.03 to 1.08)	1.09	(1.06 to 1.12)	1.18	(1.15 to 1.21)
Sales workers	1.26	(1.25 to 1.27)	1.25	(1.23 to 1.28)	1.26	(1.24 to 1.29)	1.38	(1.35 to 1.41)
Service workers	2.22	(2.19 to 2.24)	1.22	(1.18 to 1.27)	1.20	(1.16 to 1.25)	1.93	(1.86 to 1.99)
Security workers	1.05	(1.03 to 1.08)	0.67	(0.63 to 0.72)	0.76	(0.72 to 0.81)	0.94	(0.88 to 1.00)
Agriculture, forestry and fishery workers	1.89	(1.87 to 1.91)	1.34	(1.32 to 1.37)	1.48	(1.45 to 1.51)	1.74	(1.71 to 1.78)
Transport and communication workers	1.29	(1.28 to 1.31)	1.06	(1.02 to 1.09)	0.98	(0.95 to 1.02)	1.17	(1.13 to 1.21)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	29.61	(29.28 to 29.94)	41.44	(37.93 to 45.28)	59.25	(56.07 to 62.61)	115.11	(110.66 to 119.75)
Non-employed	7.78	(7.73 to 7.82)	5.83	(5.73 to 5.93)	6.18	(6.07 to 6.28)	6.68	(6.56 to 6.80)
Women								
Specialist and technical workers	1.85	(1.81 to 1.89)	1.64	(1.54 to 1.74)	1.54	(1.44 to 1.63)	1.88	(1.77 to 2.00)
Administrative and managerial workers	4.91	(4.76 to 5.06)	3.57	(3.26 to 3.91)	3.54	(3.23 to 3.87)	3.17	(2.88 to 3.50)
Clerical workers	1.23	(1.20 to 1.25)	1.63	(1.55 to 1.72)	1.35	(1.28 to 1.42)	1.45	(1.38 to 1.53)
Sales workers	1.80	(1.77 to 1.83)	1.35	(1.29 to 1.41)	1.45	(1.38 to 1.52)	1.87	(1.78 to 1.97)
Service workers	1.65	(1.62 to 1.68)	1.11	(1.06 to 1.17)	1.04	(0.99 to 1.10)	1.77	(1.68 to 1.86)
Security workers	12.22	(11.40 to 13.10)	11.43	(9.14 to 14.29)	9.24	(7.30 to 11.69)	11.57	(9.07 to 14.76)
Agriculture, forestry and fishery workers	2.25	(2.22 to 2.29)	1.65	(1.60 to 1.71)	1.88	(1.80 to 1.95)	2.18	(2.09 to 2.28)
Transport and communication workers	6.88	(6.59 to 7.18)	4.01	(3.53 to 4.55)	3.89	(3.42 to 4.43)	7.07	(6.31 to 7.91)
Production process and related workers	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Workers not classifiable by occupation	42.07	(41.22 to 42.93)	41.07	(35.48 to 47.54)	14.58	(13.19 to 16.12)	110.06	(103.28 to 117.29)
Non-employed	4.81	(4.75 to 4.88)	3.39	(3.29 to 3.50)	3.45	(3.34 to 3.56)	4.48	(4.32 to 4.65)

CI; confidence interval, OR; odds ratio

[a] We adjusted for age (five year categories) and year in the overall model. We adjusted for only age (five year categories) in other models.

Table 1. Odds ratios for all-cause premature mortality in each occupation, Japan, 1970-2005 (cont.)

1985		1990		1995		2000		2005	
OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
1.14	(1.10 to 1.17)	1.25	(1.21 to 1.28)	1.35	(1.32 to 1.39)	2.83	(2.75 to 2.90)	2.50	(2.43 to 2.57)
1.01	(0.98 to 1.04)	1.04	(1.01 to 1.07)	1.08	(1.05 to 1.11)	2.26	(2.19 to 2.34)	2.50	(2.41 to 2.60)
1.25	(1.22 to 1.28)	1.40	(1.37 to 1.44)	1.34	(1.31 to 1.38)	1.42	(1.37 to 1.46)	1.07	(1.03 to 1.11)
1.38	(1.35 to 1.41)	1.26	(1.23 to 1.29)	1.15	(1.12 to 1.18)	1.37	(1.33 to 1.41)	1.27	(1.23 to 1.31)
1.97	(1.91 to 2.04)	2.64	(2.56 to 2.72)	2.90	(2.81 to 2.99)	3.93	(3.81 to 4.06)	3.97	(3.84 to 4.11)
1.05	(0.99 to 1.11)	1.28	(1.21 to 1.36)	1.21	(1.15 to 1.29)	1.53	(1.45 to 1.62)	1.77	(1.68 to 1.87)
1.97	(1.92 to 2.01)	2.21	(2.16 to 2.27)	2.37	(2.30 to 2.44)	3.32	(3.21 to 3.43)	3.12	(3.00 to 3.24)
1.20	(1.17 to 1.24)	1.33	(1.29 to 1.37)	1.43	(1.39 to 1.48)	1.88	(1.82 to 1.94)	1.92	(1.85 to 2.00)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
49.01	(47.39 to 50.69)	34.66	(33.64 to 35.72)	54.18	(52.82 to 55.58)	52.73	(51.40 to 54.08)	9.13	(8.80 to 9.48)
6.94	(6.82 to 7.06)	8.15	(8.01 to 8.30)	8.59	(8.44 to 8.74)	11.16	(10.93 to 11.39)	14.21	(13.90 to 14.52)
1.82	(1.71 to 1.93)	1.85	(1.74 to 1.96)	2.02	(1.89 to 2.15)	2.83	(2.65 to 3.01)	2.63	(2.45 to 2.82)
3.68	(3.37 to 4.02)	5.16	(4.77 to 5.58)	6.08	(5.60 to 6.61)	10.16	(9.31 to 11.09)	12.21	(11.07 to 13.47)
1.26	(1.20 to 1.33)	1.17	(1.11 to 1.23)	1.32	(1.25 to 1.40)	1.31	(1.23 to 1.39)	1.26	(1.17 to 1.35)
2.03	(1.93 to 2.13)	1.89	(1.80 to 1.98)	1.94	(1.83 to 2.05)	2.20	(2.06 to 2.34)	2.32	(2.16 to 2.50)
1.67	(1.58 to 1.76)	1.86	(1.77 to 1.95)	2.21	(2.09 to 2.33)	2.42	(2.28 to 2.57)	2.49	(2.33 to 2.67)
19.51	(16.24 to 23.43)	17.07	(14.34 to 20.33)	13.22	(10.88 to 16.05)	12.49	(10.34 to 15.09)	16.25	(13.65 to 19.34)
2.08	(1.98 to 2.18)	2.10	(2.00 to 2.20)	2.63	(2.47 to 2.79)	3.15	(2.93 to 3.39)	3.42	(3.14 to 3.73)
7.52	(6.73 to 8.40)	9.54	(8.59 to 10.61)	8.17	(7.20 to 9.28)	9.65	(8.45 to 11.01)	11.54	(10.06 to 13.24)
1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
48.48	(45.76 to 51.37)	51.39	(48.69 to 54.24)	90.68	(86.15 to 95.46)	80.79	(76.53 to 85.29)	14.45	(13.33 to 15.67)
4.38	(4.23 to 4.54)	4.46	(4.30 to 4.62)	6.29	(6.04 to 6.55)	7.91	(7.55 to 8.29)	9.62	(9.10 to 10.16)

1 Table 2. Adjusted prefecture-level variance for all-cause premature mortality, Japan, 1970-2005 [a]

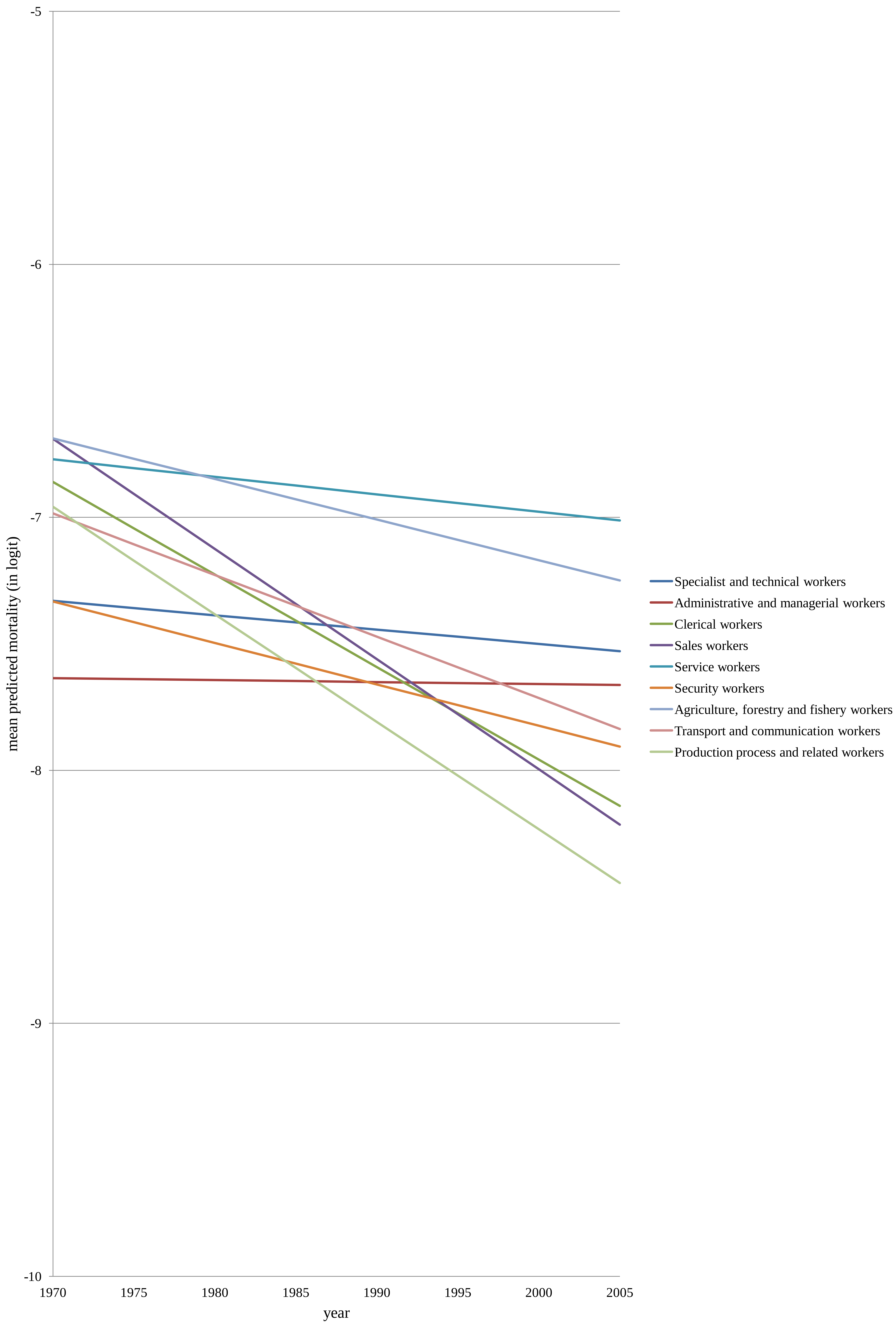
	Men			Women		
	Variance (on logit scale)			Variance (on logit scale)		
	Estimate	(95% CI)	Range of OR [b]	Estimate	(95% CI)	Range of OR [b]
Overall	0.003	(0.001 to 0.004)	0.87 to 1.13	0.005	(0.003 to 0.007)	0.84 to 1.11
1970 [c]	0.003	(0.002 to 0.005)	0.89 to 1.12	0.007	(0.004 to 0.010)	0.79 to 1.14
1975	0.003	(0.001 to 0.004)	0.88 to 1.09	0.007	(0.004 to 0.010)	0.82 to 1.19
1980	0.004	(0.002 to 0.005)	0.82 to 1.11	0.005	(0.003 to 0.008)	0.85 to 1.15
1985	0.003	(0.001 to 0.004)	0.85 to 1.09	0.005	(0.002 to 0.007)	0.86 to 1.13
1990	0.003	(0.002 to 0.004)	0.89 to 1.11	0.004	(0.002 to 0.006)	0.88 to 1.10
1995	0.006	(0.003 to 0.009)	0.85 to 1.22	0.008	(0.004 to 0.012)	0.80 to 1.15
2000	0.007	(0.004 to 0.010)	0.84 to 1.25	0.010	(0.005 to 0.015)	0.76 to 1.15
2005	0.011	(0.007 to 0.016)	0.81 to 1.27	0.012	(0.007 to 0.017)	0.75 to 1.18

2 CI; confidence interval, OR; odds ratio

3 [a] We adjusted for age (five year categories) and occupations. We further adjusted for year in the overall model.

4 [b] The range of adjusted odds ratios for mortality in each prefecture is shown. The reference is the grand mean of all the prefectures.

5 [c] The variance between 46 prefectures is shown because the data for Okinawa prefecture were not available in 1970.


-5
-6
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1970
1975
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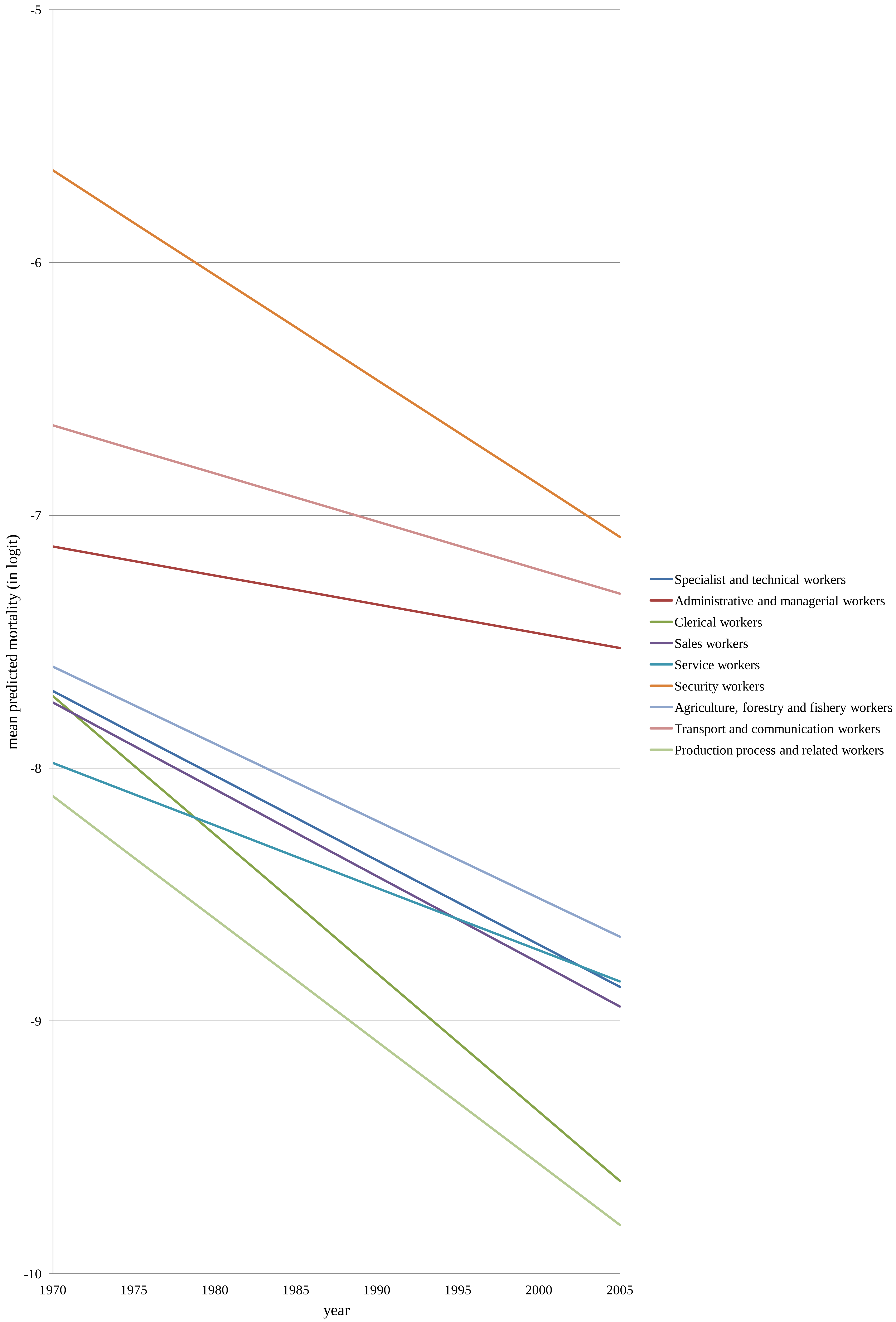
1995
2000
2005
year
mean predicted mortality (in logit)
Specialist and technical workers
Administrative and managerial workers
Clerical workers
Sales workers
Service workers
Security workers
Agriculture, forestry and fishery workers
Transport and communication workers
Production process and related workers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Specialist and technical workers
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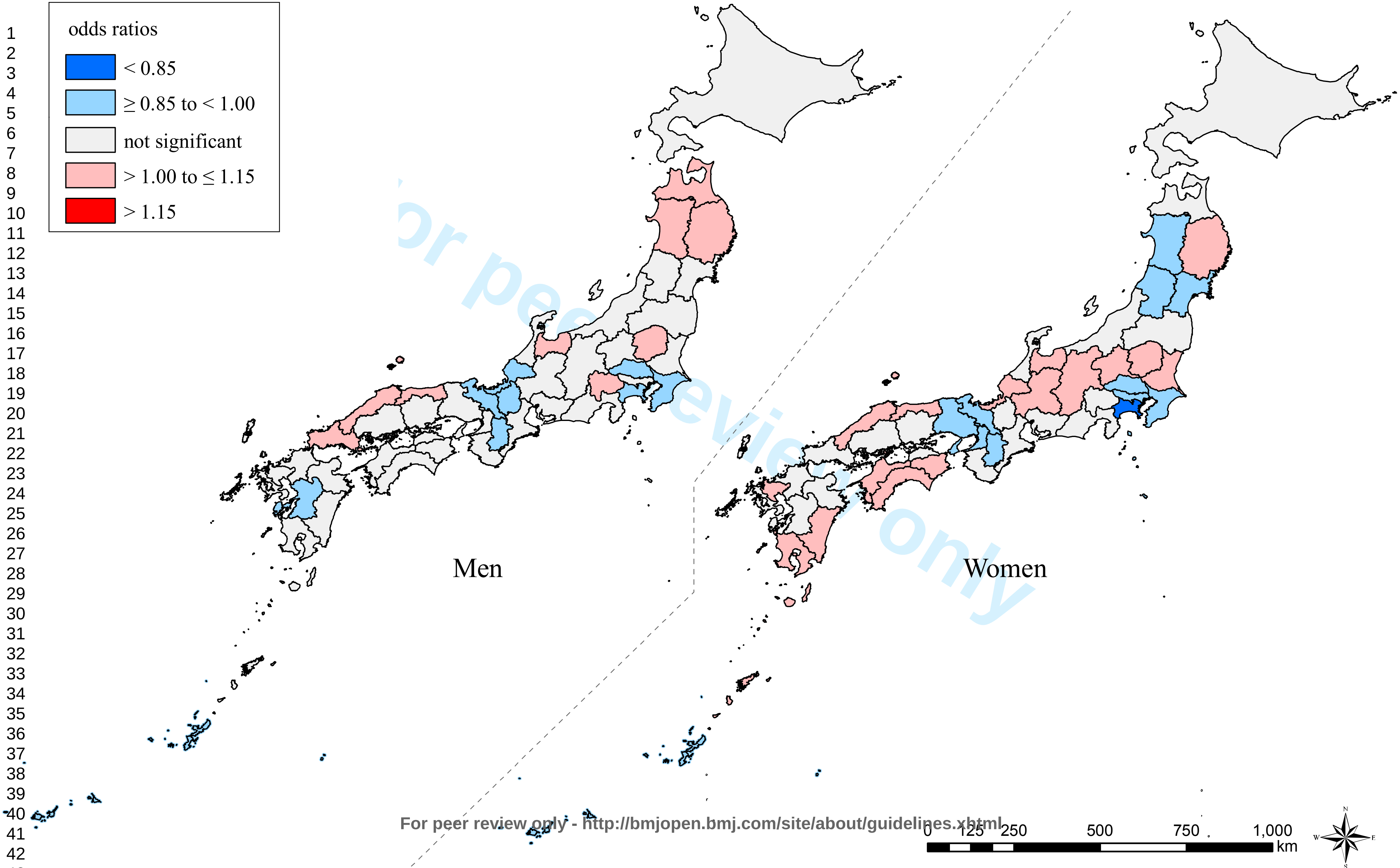
Clerical workers
Sales workers
Service workers
Security workers
Agriculture, forestry and fishery workers
Transport and communication workers
Production process and related workers


odds ratios
< 0.85
≥ 0.85 to < 1.00
not significant
> 1.00 to ≤ 1.15
> 1.15
Men
Women
0 125 250 500 750 1,000
km
N
E
S
W

Supplementary Text

Overview of supplementary analyses

As supplementary analyses, we examined two additional issues to further explore the social and geographic inequalities in premature mortality; (i) the patterns of geographic inequalities in mortality by occupations, and (ii) the presence of contextual effects of prefecture-level socioeconomic status on mortality risk.

Geographic inequalities in all-cause premature mortality by occupations

Background and aims

Although we examined the patterns of geographic inequalities in premature mortality for all occupations in the main analysis, the patterns may vary (substantially) according to occupations. Therefore, we examined the occupation-specific geographic inequality in premature mortality for the overall study period. This analysis may further facilitate understanding of the possible pathways of emerging geographic inequalities in Japan.

Methods

Following the previous report of the Population Census,[1] we summarized the 11 occupations into six groups to increase the statistical power as follows: I. clerical, technical and managerial occupations (i.e., (1) specialist and technical workers, (2) administrative and managerial workers, and (3) clerical workers), II. sales and service occupations (i.e., (4) sales workers, (5) service workers, and (6) security workers), III. agriculture, forestry and fishery occupations (i.e., (7) agriculture, forestry and fishery workers), IV. production and transport occupations (i.e., (8) transport and communication workers and (9) production process and related workers), V. unclassifiable occupations (i.e., (10) workers not classifiable by occupation), and VI. non-employed (i.e., (11) non-employed) (Supplementary Table 1).

In this supplementary analysis, we specified six prefecture-level error terms (at level 3) corresponding to the six occupational groups, conditional on individual age, 11 occupations, and years as fixed terms. We calculated the variance and covariance of these error terms, and we also derived their correlation coefficients to explore the possible differential geographic patterns of mortality by the six occupational groups. Finally, we created maps showing prefecture-level residuals in the same methods as the main analysis.

Results

We show the results of variance and covariance of prefecture-level residuals among the six occupational groups (Supplementary Table 8). Men and women revealed a similar pattern except for the covariance between sales and service occupations and non-employed (-0.003 and 0.005 in men and women, respectively) and the covariance between agriculture, forestry and fishery occupations and unclassifiable occupations (0.006 and -0.019 in men and women, respectively). In both sexes, the variances among unclassifiable occupations were much higher than those of other occupational groups (0.317 and 0.331 in men and women, respectively). Further, excluding unclassifiable occupations and non-employed, the signs of correlation coefficients were all positive, indicating that the patterns of geographic inequalities were similar across the remaining four occupational groups. We show these geographic patterns in both sexes (Supplementary Figures 4 and 5).

Contextual effect of prefecture-level socioeconomic status

Background and aims

Previous studies in Japan have examined possible contextual effects of area-level socioeconomic status (e.g., income inequality, per-capita income) on self-rated health and health-related behaviors by using multilevel analysis.[2-4] The relationship between area-level socioeconomic status and mortality has been also investigated in ecological studies,[5-12] most of which indicated higher mortality in areas of lower socioeconomic position. Indeed, recent international comparative studies have confirmed an association between income inequality and health, which included Japan.[13-15] However, no studies have examined the association between area-level socioeconomic status and premature adult mortality in Japan, by considering both individual- and area-level socioeconomic indicators. Further, we note the possibility that contextual effects by area-level disadvantage may have changed after the collapse of asset bubble in the early 1990s. Therefore, we examined the trends of contextual effects of prefecture-level socioeconomic status on premature adult mortality.

Methods

We derived prefecture-level socioeconomic status variables from the *National Survey of Family Income and Expenditure*,[16] which has been implemented every five years since the first survey in 1959. We derived the following three variables for each prefecture and divided them into tertiles; Gini's coefficient of yearly income, average yearly income, and average savings (Supplementary Table 9). These variables were calculated among two-or-more-person households. Gini's coefficient of yearly income was available since 1979, and we imputed the values of 1979 forwardly to 1969 and 1974. Although household income and savings may follow the skewed distributions, median income or savings were not available throughout the study period. Note that a previous review article suggested that the studies in income inequality are more supportive in large areas, e.g., states, regions, and metropolitan areas, because in that context income inequality serves as a measure of the scale of social stratification.[17] As Shibuya et al.[2] noted, a prefecture is similar to a state in the United States in terms of its population size and variations in income inequality.

We linked the data set of prefecture-level variables to the data set of the Population Census and the Vital Statistics one year out, e.g., National Survey of Family Income and Expenditure in 2004 was linked with the Population Census in 2005 and the Vital Statistics in 2005 fiscal year.

In the analysis, we conducted three-level analyses as an overall model, with cells at level 1, years at level 2, and prefectures at level 3. The prefecture-level socioeconomic status variable was entered into the model as a level-2 variable separately. Furthermore, to examine the joint effects of income inequality and average income/savings, we also entered Gini's coefficient and average yearly income/savings into the model simultaneously. In like manner, to examine the temporal patterns of contextual effects, we also conducted two-level analysis, with cells at level 1 and prefectures at level 2 separately for each year.

Results

Overall, we found little evidence of the association between prefecture-level socioeconomic status and the risk of mortality in both sexes, conditional on individual age and occupation (Supplementary Table 10). Likewise, in year-specific analyses, no clear associations were found although lower average savings were associated with higher risk of mortality in some years. When we examined the joint effects of income inequality and average income/savings, no substantial differences were observed (data not shown).

Conclusions of supplementary analyses

Excluding unclassifiable occupations and non-employed, the patterns of geographic inequalities were similar across occupational groups. We found no clear associations between prefecture-level socioeconomic status and premature mortality risk throughout the period although there is suggestion of inverse association between average savings and mortality in some years.

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Supplementary Table 1. The history of the Japan Standard Occupational Classification [a]

1st revision, 1970		2nd revision, 1979		3rd revision, 1986		4th revision, 1997	
No.	Occupation (major group)	No.	Occupation (major group)	No.	Occupation (major group)	No.	Occupation (major group) [b]
(1) [1]	Professional and technical workers	(1) [1]	Professional and technical workers	(1) [1]	Professional and technical workers	(1) [1]	Specialist and technical workers
(2) [2]	Managers and officials	(2) [2]	Managers and officials	(2) [2]	Managers and officials	(2) [2]	Administrative and managerial workers
(3) [3]	Clerical and related workers	(3) [3]	Clerical and related workers	(3) [3]	Clerical and related workers	(3) [3]	Clerical workers
(4) [4]	Sales workers	(4) [4]	Sales workers	(4) [4]	Sales workers	(4) [4]	Sales workers
(5) [7]	Farmers, Lumbermen and fishermen	(5) [7]	Agricultural, forestry and fisheries workers	(5) [5]	Service workers	(5) [5]	Service workers
(6) [9]	Workers in mining and quarrying occupations	(6) [9]	Mining workers	(6) [6]	Protective service workers	(6) [6]	Security workers
(7) [8]	Workers in transport and communications occupations	(7) [8]	Workers in transport and communications occupations	(7) [7]	Agricultural, forestry and fisheries workers	(7) [7]	Agriculture, forestry and fishery workers
(8) [9]	Craftsmen, production process workers and labourers	(8) [9]	Craftsmen, production process workers and labours	(8) [8]	Workers in transport and communications occupations	(8) [8]	Transport and communication workers
(9) [6]	Protective service workers	(9) [6]	Protective service workers	(9) [9]	Craftsmen, mining, production process and construction workers and laborers	(9) [9]	Production process and related workers
(10) [5]	Service workers	(10) [5]	Service workers	(10) [10]	Workers not classifiable by occupation	(10) [10]	Workers not classifiable by occupation
(11) [10]	Unclassifiable	(11) [10]	Workers not classifiable by occupation	(11) [11]	Non-employed [c]	(11) [11]	Non-employed [c]
(12) [11]	Non-employed [c]	(11) [11]	Non-employed [c]				

[a] We consistently used occupation (major group) of the 4th revision. The number in square brackets is the classification used in ths present study.

[b] When showing geographic inequality by occupation, we summarized these 11 occupation into six groups as follows:

I. Clerical, technical and managerial occupations: (1) specialist and technical workers, (2) administrative and managerial workers, and (3) clerical workers
II. Sales and service occupations: (4) sales workers, (5) service workers, and (6) security workers
III. Agriculture, forestry and fishery occupations: (7) agriculture, forestry and fishery workers
IV. Production and transport occupations: (8) transport and communication workers and (9) production process and related workers
V. Unclassifiable occupations: (10) workers not classifiable by occupation
VI. Non-employed: (11) non-employed

[c] Non-employed refers to the sum of unemployed and non-labor force in line with the *Report of Vital Statistics: Occupational and Industrial Aspects* .

Supplementary Table 2. Description of data in 47 prefectures, Japan, 1970-2005

	Men				Women			
	No. of deaths	Total population	Mortality rate per 100,000 [a]	(SD)	No. of deaths	Total population	Mortality rate per 100,000 [a]	(SD)
Overall	984,022	251,576,351	1,569	(6,718)	532,223	259,688,353	758	(3,914)
Prefectures								
1 Hokkaido	49,247	11,489,095	1,870	(7,692)	26,436	12,394,724	886	(4,366)
2 Aomori	15,202	2,959,355	1,531	(6,760)	7,282	3,248,812	471	(2,143)
3 Iwate	13,258	2,856,175	2,187	(9,429)	6,959	3,067,651	864	(4,827)
4 Miyagi	17,042	4,448,360	1,412	(5,469)	9,137	4,625,004	728	(3,064)
5 Akita	12,371	2,512,525	1,410	(5,569)	6,168	2,740,415	561	(3,178)
6 Yamagata	10,748	2,553,156	1,863	(8,426)	5,824	2,679,130	978	(4,649)
7 Fukushima	18,520	4,200,931	1,368	(4,958)	9,601	4,341,831	454	(1,655)
8 Ibaraki	23,125	5,779,563	1,101	(3,644)	12,135	5,665,132	511	(2,853)
9 Tochigi	16,375	3,976,411	1,643	(6,942)	8,590	3,941,144	876	(3,381)
10 Gunma	15,506	4,036,944	1,704	(6,946)	8,651	4,069,213	532	(2,058)
11 Saitama	43,148	13,129,693	1,436	(5,956)	23,114	12,774,631	519	(1,419)
12 Chiba	39,273	11,279,717	1,247	(4,401)	19,925	11,073,425	652	(3,696)
13 Tokyo	91,194	25,686,395	1,374	(5,119)	49,601	25,677,746	598	(1,754)
14 Kanagawa	54,947	16,940,375	1,330	(5,569)	28,202	16,194,532	1,053	(5,584)
15 Niigata	21,083	5,083,511	1,945	(7,533)	10,861	5,245,859	714	(3,398)
16 Toyama	9,238	2,300,243	1,606	(7,190)	5,250	2,429,822	980	(5,406)
17 Ishikawa	8,670	2,301,490	1,655	(7,956)	5,013	2,447,439	953	(6,194)
18 Fukui	5,611	1,643,881	1,677	(7,209)	3,556	1,721,279	1,391	(7,473)
19 Yamanashi	7,183	1,720,587	1,436	(5,625)	3,727	1,754,097	719	(3,804)
20 Nagano	15,876	4,393,794	2,175	(8,828)	9,505	4,551,945	853	(4,017)
21 Gifu	14,957	4,139,225	1,515	(6,609)	9,222	4,333,798	913	(4,421)
22 Shizuoka	28,057	7,639,953	1,962	(8,756)	14,720	7,674,935	565	(1,736)
23 Aichi	46,925	14,066,571	1,626	(7,368)	26,699	13,817,272	764	(2,784)
24 Mie	14,118	3,624,980	1,408	(5,186)	7,828	3,794,338	583	(2,379)
25 Shiga	8,125	2,428,751	1,453	(5,976)	4,883	2,465,170	782	(3,805)
26 Kyoto	18,723	5,109,042	1,166	(3,889)	11,146	5,465,224	464	(2,094)
27 Osaka	73,055	18,232,091	1,964	(7,462)	38,671	18,808,092	1,109	(4,676)
28 Hyogo	44,110	10,970,009	1,940	(7,967)	23,963	11,550,437	798	(3,145)
29 Nara	9,755	2,621,500	1,730	(7,403)	5,598	2,813,039	971	(4,423)
30 Wakayama	10,006	2,169,994	1,276	(6,597)	5,596	2,358,333	573	(2,872)
31 Tottori	5,687	1,212,157	2,055	(8,746)	2,862	1,295,687	695	(3,717)
32 Shimane	7,103	1,546,077	2,051	(8,981)	3,829	1,651,580	891	(4,704)
33 Okayama	15,296	3,828,579	1,991	(8,329)	8,127	4,043,112	720	(3,298)
34 Hiroshima	23,074	5,750,006	1,708	(6,593)	12,338	6,008,967	852	(3,726)
35 Yamaguchi	14,671	3,127,157	2,051	(8,498)	7,883	3,435,624	582	(2,276)
36 Tokushima	7,871	1,661,674	711	(1,797)	4,406	1,786,025	454	(1,935)
37 Kagawa	8,494	2,052,654	999	(3,529)	4,743	2,182,213	551	(3,159)
38 Ehime	13,813	2,961,350	2,209	(8,794)	7,631	3,279,967	781	(3,189)
39 Kochi	8,686	1,627,246	1,004	(3,355)	4,403	1,792,884	353	(1,777)
40 Fukuoka	41,386	9,316,985	1,349	(5,374)	22,159	10,313,913	790	(3,359)
41 Saga	7,618	1,664,620	1,458	(7,446)	4,307	1,844,827	1,057	(6,718)
42 Nagasaki	14,563	2,995,173	1,398	(5,680)	8,010	3,346,375	813	(4,295)
43 Kumamoto	15,029	3,485,422	780	(2,080)	8,554	3,916,400	623	(2,600)
44 Oita	10,691	2,389,418	1,658	(6,904)	6,345	2,691,272	834	(3,893)
45 Miyazaki	10,422	2,240,503	1,866	(8,416)	5,606	2,496,028	1,239	(7,251)
46 Kagoshima	16,626	3,369,654	1,329	(5,321)	9,565	3,795,497	859	(3,649)
47 Okinawa [b]	7,544	2,053,359	1,046	(5,404)	3,592	2,083,513	722	(4,594)

SD; standard deviation

[a] Mortality rate was calculated on the basis of the means of the proportion of deaths for each prefecture across all cell types.

[b] The data for Okinawa prefecture were not available in 1970.

Supplementary Table 3. The number (percentage) of total population in each occupation, Japan, 1970-2005

	1970		1975		1980		1985		1990		1995		2000		2005	
Men																
Specialist and technical workers	1,835,895	(7.32)	2,080,025	(7.25)	2,306,830	(7.51)	3,143,412	(9.76)	3,637,515	(10.95)	3,991,077	(11.72)	4,221,683	(12.27)	3,950,815	(11.90)
Administrative and managerial workers	1,797,390	(7.17)	1,972,340	(6.88)	2,210,783	(7.19)	1,868,101	(5.80)	1,998,511	(6.01)	2,066,172	(6.07)	1,305,093	(3.79)	1,031,316	(3.11)
Clerical workers	2,914,350	(11.62)	3,674,725	(12.81)	3,637,048	(11.83)	3,857,022	(11.98)	3,895,784	(11.72)	3,906,006	(11.47)	4,077,310	(11.85)	4,093,124	(12.33)
Sales workers	2,681,490	(10.69)	3,508,340	(12.23)	4,132,015	(13.44)	4,509,884	(14.00)	4,794,455	(14.43)	5,044,836	(14.82)	5,159,661	(15.00)	4,716,064	(14.21)
Service workers	738,725	(2.95)	984,940	(3.43)	1,027,910	(3.34)	1,123,385	(3.49)	1,202,319	(3.62)	1,270,668	(3.73)	1,381,504	(4.02)	1,441,522	(4.34)
Security workers	438,955	(1.75)	520,720	(1.82)	567,438	(1.85)	615,053	(1.91)	660,161	(1.99)	706,462	(2.08)	787,325	(2.29)	832,148	(2.51)
Agriculture, forestry and fishery workers	3,531,500	(14.08)	2,849,180	(9.94)	2,379,666	(7.74)	2,112,513	(6.56)	1,615,756	(4.86)	1,199,620	(3.52)	899,881	(2.62)	823,066	(2.48)
Transport and communication workers	1,682,400	(6.71)	1,972,390	(6.88)	2,072,133	(6.74)	1,997,137	(6.2)	1,984,890	(5.97)	2,020,393	(5.93)	1,957,847	(5.69)	1,794,551	(5.41)
Production process and related workers	8,428,675	(33.61)	9,645,620	(33.63)	10,682,007	(34.76)	10,644,436	(33.05)	10,985,461	(33.06)	10,945,330	(32.15)	10,762,241	(31.28)	10,451,026	(31.48)
Workers not classifiable by occupation	6,725	(0.03)	13,870	(0.05)	22,474	(0.07)	50,391	(0.16)	115,015	(0.35)	151,362	(0.44)	294,663	(0.86)	502,667	(1.51)
Non-employed [a]	1,024,357	(4.08)	1,456,032	(5.08)	1,696,114	(5.52)	2,283,403	(7.09)	2,339,703	(7.04)	2,744,327	(8.06)	3,559,611	(10.35)	3,559,611	(10.72)
Total	25,080,462	(100.00)	28,678,182	(100.00)	30,734,418	(100.00)	32,204,737	(100.00)	33,229,570	(100.00)	34,046,253	(100.00)	34,406,819	(100.00)	33,195,910	(100.00)
Women																
Specialist and technical workers	800,245	(3.00)	1,121,045	(3.73)	1,507,610	(4.72)	1,891,400	(5.73)	2,250,231	(6.69)	2,684,971	(7.83)	3,094,599	(8.87)	3,459,894	(9.83)
Administrative and managerial workers	86,615	(0.32)	105,985	(0.35)	155,251	(0.49)	171,782	(0.52)	184,219	(0.55)	199,894	(0.58)	142,983	(0.41)	123,283	(0.35)
Clerical workers	1,694,870	(6.36)	2,753,760	(9.16)	3,369,822	(10.56)	4,248,922	(12.86)	5,155,485	(15.32)	5,748,954	(16.76)	6,289,031	(18.03)	6,422,961	(18.25)
Sales workers	1,885,440	(7.07)	2,152,320	(7.16)	2,586,857	(8.11)	2,447,212	(7.41)	2,534,197	(7.53)	2,702,863	(7.88)	2,618,387	(7.51)	2,561,132	(7.28)
Service workers	1,634,865	(6.13)	1,974,925	(6.57)	2,106,305	(6.60)	2,173,931	(6.58)	2,263,285	(6.73)	2,516,848	(7.34)	2,825,178	(8.10)	3,207,147	(9.11)
Security workers	5,830	(0.02)	8,010	(0.03)	9,876	(0.03)	12,390	(0.04)	16,562	(0.05)	24,289	(0.07)	37,414	(0.11)	43,158	(0.12)
Agriculture, forestry and fishery workers	4,558,975	(17.10)	3,154,040	(10.49)	2,471,427	(7.75)	2,029,368	(6.14)	1,478,304	(4.39)	1,055,672	(3.08)	755,524	(2.17)	600,419	(1.71)
Transport and communication workers	99,570	(0.37)	108,500	(0.36)	108,205	(0.34)	96,205	(0.29)	84,717	(0.25)	93,936	(0.27)	92,226	(0.26)	85,394	(0.24)
Production process and related workers	3,546,495	(13.30)	3,691,205	(12.28)	4,456,927	(13.97)	4,911,261	(14.87)	5,158,278	(15.33)	4,862,147	(14.17)	4,664,292	(13.37)	4,228,532	(12.01)
Workers not classifiable by occupation	5,285	(0.02)	34,995	(0.12)	24,186	(0.08)	66,917	(0.20)	89,544	(0.27)	121,135	(0.35)	223,913	(0.64)	327,266	(0.93)
Non-employed [a]	12,339,091	(46.29)	14,949,973	(49.74)	15,110,843	(47.36)	14,978,370	(45.35)	14,434,745	(42.90)	14,296,062	(41.67)	14,141,088	(40.54)	14,141,088	(40.17)
Total	26,657,281	(100.00)	30,054,758	(100.00)	31,907,309	(100.00)	33,027,758	(100.00)	33,649,567	(100.00)	34,306,771	(100.00)	34,884,635	(100.00)	35,200,274	(100.00)

[a] Non-employed is the sum of unemployed and non-labor force.

Supplementary Table 4. Description of data used for multilevel models analyzing all-cause mortality in 47 prefectures, Japan, 1970-2005

Characteristics	Men					Women				
	No. of cells [a]	No. of deaths	Total population	Mortality rate per 100,000 [b]	(SD)	No. of cells [a]	No. of deaths	Total population	Mortality rate per 100,000 [b]	(SD)
Overall	32,590	984,022	251,576,351	1,569	(6,718)	32,542	532,223	259,688,353	758	(3,914)
Level 1: cell										
Specialist and technical workers										
25-29 y	375	2,044	4,259,474	59	(38)	375	837	3,750,173	28	(32)
30-34 y	375	2,374	4,400,316	63	(39)	375	815	2,781,512	37	(37)
35-39 y	375	3,122	4,078,554	90	(51)	375	938	2,546,667	43	(43)
40-44 y	375	4,655	3,665,610	152	(69)	375	1,419	2,449,918	69	(55)
45-49 y	375	7,054	3,095,990	257	(108)	375	1,983	2,137,592	114	(82)
50-54 y	375	9,922	2,511,813	423	(144)	375	2,422	1,628,069	180	(136)
55-59 y	375	12,688	1,990,836	676	(202)	375	2,516	1,044,184	298	(216)
60-64 y	375	11,086	1,164,659	1,055	(354)	375	1,949	471,880	519	(390)
Administrative and managerial workers										
25-29 y	375	212	296,615	85	(206)	372	49	25,359	168	(751)
30-34 y	375	496	810,953	71	(124)	375	99	56,477	211	(742)
35-39 y	375	1,053	1,489,214	83	(84)	375	174	103,320	171	(587)
40-44 y	375	2,387	2,162,030	118	(71)	375	403	157,876	251	(413)
45-49 y	375	4,655	2,604,260	194	(95)	375	684	204,826	286	(326)
50-54 y	375	8,292	2,759,166	320	(119)	375	1,007	227,213	434	(529)
55-59 y	375	11,466	2,487,389	481	(151)	375	1,237	219,669	604	(646)
60-64 y	375	10,619	1,640,079	670	(235)	375	1,274	175,272	756	(966)
Clerical workers										
25-29 y	375	3,143	4,619,902	68	(41)	375	1,546	7,377,454	25	(24)
30-34 y	375	3,486	4,720,850	75	(42)	375	1,372	5,423,988	31	(33)
35-39 y	375	4,860	4,579,329	109	(61)	375	1,741	5,266,613	38	(33)
40-44 y	375	6,935	4,381,766	163	(86)	375	2,456	5,389,811	54	(48)
45-49 y	375	9,969	3,996,273	261	(127)	375	3,259	4,834,832	87	(75)
50-54 y	375	13,048	3,507,037	414	(193)	375	3,603	3,768,147	141	(121)
55-59 y	375	14,258	2,778,285	586	(292)	375	3,026	2,474,248	196	(227)
60-64 y	375	8,500	1,471,927	642	(394)	375	1,939	1,148,712	285	(359)
Sales workers										
25-29 y	375	2,773	5,895,959	55	(40)	375	684	2,326,951	32	(37)
30-34 y	375	3,330	5,923,651	67	(50)	375	910	2,218,018	40	(39)
35-39 y	375	4,582	5,414,612	106	(73)	375	1,291	2,572,122	50	(39)
40-44 y	375	6,726	4,806,468	176	(122)	375	2,131	2,931,404	74	(50)
45-49 y	375	9,791	4,194,561	299	(184)	375	3,193	3,034,544	111	(65)
50-54 y	375	12,994	3,567,706	474	(240)	375	4,432	2,762,345	174	(93)
55-59 y	375	16,386	2,882,844	727	(348)	375	4,995	2,200,556	252	(127)
60-64 y	375	16,493	1,860,944	1,025	(459)	375	4,938	1,442,468	358	(175)
Service workers										
25-29 y	375	1,612	1,659,142	112	(82)	375	762	1,935,466	45	(46)
30-34 y	375	1,667	1,453,561	127	(88)	375	856	1,964,185	44	(40)
35-39 y	375	2,258	1,284,982	209	(254)	375	1,181	2,353,506	54	(42)
40-44 y	375	3,101	1,153,463	298	(158)	375	1,890	2,741,991	75	(48)
45-49 y	375	4,630	1,041,635	475	(214)	375	2,968	2,943,583	109	(59)
50-54 y	375	6,508	956,705	729	(291)	375	3,910	2,880,236	150	(76)
55-59 y	375	8,453	888,084	1,005	(351)	375	4,557	2,432,373	218	(108)
60-64 y	375	8,185	733,401	1,261	(487)	375	3,882	1,451,144	309	(181)
Security workers										
25-29 y	375	420	826,908	56	(82)	362	40	38,591	239	(1,631)
30-34 y	375	433	746,077	66	(87)	348	41	23,805	332	(2,068)
35-39 y	375	563	694,425	86	(108)	352	58	18,416	568	(3,220)
40-44 y	375	875	692,317	126	(115)	363	87	19,017	896	(4,439)
45-49 y	375	1,380	678,802	224	(172)	360	133	18,789	869	(2,725)
50-54 y	375	1,905	621,010	340	(243)	354	151	17,878	1,208	(3,259)
55-59 y	375	2,404	517,883	492	(335)	336	189	14,007	2,138	(5,218)
60-64 y	375	2,015	350,840	636	(503)	317	137	7,026	3,053	(8,385)
Agriculture, forestry and fishery workers										
25-29 y	375	1,425	911,736	141	(121)	375	544	768,146	55	(114)
30-34 y	375	2,047	1,147,060	174	(128)	375	874	1,212,740	63	(96)
35-39 y	375	3,667	1,510,949	222	(132)	375	1,515	1,691,530	74	(100)
40-44 y	375	6,154	1,895,195	297	(142)	375	2,664	2,125,301	99	(74)
45-49 y	375	9,650	2,139,287	418	(158)	375	4,360	2,465,129	152	(96)
50-54 y	375	14,455	2,319,644	592	(176)	375	6,912	2,636,924	228	(112)
55-59 y	375	22,542	2,568,440	827	(218)	375	9,481	2,702,501	315	(151)
60-64 y	375	33,473	2,918,871	1,086	(346)	375	11,993	2,501,458	442	(241)
Transport and communication workers										
25-29 y	375	2,051	2,124,064	93	(66)	375	125	161,108	75	(249)
30-34 y	375	2,384	2,384,161	95	(58)	375	141	124,668	85	(209)
35-39 y	375	3,236	2,427,773	135	(72)	375	205	124,084	149	(274)
40-44 y	375	4,418	2,353,707	192	(147)	375	294	121,923	209	(327)
45-49 y	375	5,599	2,158,825	271	(108)	375	416	105,735	334	(486)
50-54 y	375	7,057	1,908,570	406	(187)	374	431	75,568	547	(837)
55-59 y	375	7,057	1,453,565	570	(293)	373	411	41,887	1,156	(2,098)
60-64 y	375	3,796	671,076	783	(580)	343	301	13,780	3,095	(6,452)
Production process and related workers										
25-29 y	375	7,322	12,387,917	64	(43)	375	740	2,765,852	25	(29)
30-34 y	375	8,657	12,289,511	76	(52)	375	985	3,610,544	25	(23)
35-39 y	375	12,143	11,861,114	110	(75)	375	1,748	4,939,585	34	(29)
40-44 y	375	17,256	11,459,170	164	(100)	375	2,700	5,872,068	46	(35)
45-49 y	375	23,730	10,858,257	241	(123)	375	3,933	6,045,010	68	(44)
50-54 y	375	29,381	10,014,409	339	(159)	375	4,928	5,497,531	102	(65)
55-59 y	375	33,010	8,491,654	472	(231)	375	4,742	4,297,010	135	(97)
60-64 y	375	26,151	5,182,764	608	(323)	375	3,780	2,491,537	188	(151)
Workers not classifiable by occupation										
25-29 y	345	1,513	207,647	4,422	(9,574)	354	581	150,990	1,492	(4,303)
30-34 y	346	1,796	181,239	5,530	(11,417)	361	697	122,540	1,792	(4,764)
35-39 y	336	2,399	150,763	9,618	(16,824)	355	914	111,790	2,392	(6,226)
40-44 y	323	3,544	136,098	12,160	(18,001)	351	1,360	116,798	3,402	(7,472)
45-49 y	327	5,911	128,506	16,372	(21,250)	346	2,247	116,946	4,342	(8,124)
50-54 y	310	8,721	131,754	19,824	(22,022)	347	3,360	111,753	7,301	(13,362)
55-59 y	308	10,718	125,633	23,038	(23,707)	343	3,681	96,322	8,706	(13,246)
60-64 y	295	10,281	95,527	23,592	(22,601)	331	3,800	66,102	14,147	(19,001)
Non-employed										
25-29 y	375	7,981	2,366,593	448	(245)	375	9,868	16,328,017	66	(32)
30-34 y	375	9,093	1,572,710	696	(323)	375	13,641	17,975,450	89	(39)
35-39 y	375	12,570	1,351,088	1,026	(428)	375	18,225	15,037,080	142	(61)
40-44 y	375	19,268	1,314,727	1,521	(514)	375	26,086	12,159,904	253	(92)
45-49 y	375	30,255	1,456,804	2,223	(723)	375	38,502	11,501,582	384	(118)
50-54 y	375	48,346	1,689,190	3,024	(823)	375	57,256	12,364,455	522	(161)
55-59 y	375	84,286	2,517,232	3,330	(762)	375	82,857	13,455,956	674	(210)
60-64 y	375	164,871	6,394,814	2,972	(1,194)	375	124,761	15,568,816	890	(351)

SD; standard deviation

[a] These cells are cross-clasified by sex, age (five year categories), and 11 occupations.

[b] Mortality rate was calculated on the basis of the means of the proportion of deaths for each cell type across all prefectures.

Supplementary Table 5. Age-adjusted mortality rate per 100,000 in each occupation, Japan, 1970-2005 [a]

	1970	1975	1980	1985	1990	1995	2000	2005
Men								
Specialist and technical workers	340	282	319	257	234	223	312	231
Administrative and managerial workers	233	223	192	215	193	170	248	241
Clerical workers	460	366	298	267	253	207	146	95
Sales workers	547	444	370	322	246	187	146	113
Service workers	515	389	488	426	476	442	401	348
Security workers	295	259	238	226	228	189	161	159
Agriculture, forestry and fishery workers	571	489	442	425	384	365	346	287
Transport and communication workers	449	339	328	276	253	230	200	180
Production process and related workers	415	327	250	216	181	156	105	89
Workers not classifiable by occupation	14,668	15,038	20,796	9,141	5,935	7,231	4,900	768
Non-employed [b]	2,669	2,226	1,891	1,648	1,774	1,533	1,289	1,313
Women								
Specialist and technical workers	246	181	146	126	115	90	97	66
Administrative and managerial workers	548	452	239	268	337	263	345	306
Clerical workers	234	153	105	83	68	54	39	29
Sales workers	197	164	137	135	111	81	68	55
Service workers	160	117	130	111	111	92	78	60
Security workers	1,615	1,027	822	1,335	991	508	398	390
Agriculture, forestry and fishery workers	256	224	172	148	133	114	103	85
Transport and communication workers	899	585	844	712	808	440	324	278
Production process and related workers	145	114	73	67	60	43	32	25
Workers not classifiable by occupation	4,769	1,533	6,995	3,024	2,967	3,382	2,296	325
Non-employed [b]	489	387	324	286	256	254	242	222

[a] Age-adjusted mortality rates were calculated by the direct method, using the model population of 1985 in Japan as a reference.

[b] Non-employed is the sum of unemployed and non-labor force.

Supplementary Table 6. Adjusted prefecture-level residuals for all-cause premature mortality among men, Japan, 1970-2005

		Overall			1970			1975			1980			1985			1990			1995			2000			2005		
	Prefectures	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank
1	Hokkaido	1.02	(0.98 to 1.06)	31	1.02	(0.99 to 1.05)	28	1.05	(1.02 to 1.08)	37	1.05	(1.02 to 1.09)	40	1.01	(0.98 to 1.04)	26	0.97	(0.94 to 0.99)	10	1.01	(0.98 to 1.04)	26	1.05	(1.01 to 1.08)	33	1.06	(1.02 to 1.11)	36
2	Aomori	1.13	(1.09 to 1.18)	47	1.07	(1.03 to 1.12)	42	1.06	(1.01 to 1.10)	44	1.10	(1.05 to 1.15)	45	1.09	(1.05 to 1.14)	45	1.09	(1.04 to 1.14)	44	1.17	(1.11 to 1.23)	46	1.25	(1.19 to 1.31)	47	1.27	(1.20 to 1.34)	47
3	Iwate	1.07	(1.03 to 1.12)	45	1.09	(1.04 to 1.13)	44	1.04	(0.99 to 1.08)	35	1.04	(0.99 to 1.09)	37	1.02	(0.98 to 1.07)	36	1.06	(1.01 to 1.11)	43	1.05	(0.99 to 1.11)	34	1.08	(1.03 to 1.15)	40	1.22	(1.15 to 1.29)	46
4	Miyagi	0.97	(0.93 to 1.01)	14	0.94	(0.90 to 0.98)	5	0.97	(0.93 to 1.01)	11	0.96	(0.92 to 1.00)	8	0.94	(0.91 to 0.98)	4	0.98	(0.94 to 1.02)	14	0.97	(0.92 to 1.01)	14	0.99	(0.94 to 1.04)	20	1.04	(0.99 to 1.10)	31
5	Akita	1.07	(1.02 to 1.11)	44	1.12	(1.07 to 1.17)	46	1.06	(1.01 to 1.10)	43	1.04	(0.99 to 1.09)	36	1.01	(0.97 to 1.06)	29	1.01	(0.96 to 1.06)	28	1.10	(1.04 to 1.16)	44	1.09	(1.03 to 1.15)	43	1.17	(1.10 to 1.24)	45
6	Yamagata	0.99	(0.95 to 1.03)	20	1.02	(0.97 to 1.07)	27	1.00	(0.95 to 1.05)	22	1.00	(0.95 to 1.05)	20	0.94	(0.90 to 0.99)	3	0.97	(0.92 to 1.02)	13	0.97	(0.92 to 1.03)	17	1.00	(0.94 to 1.07)	23	1.06	(0.99 to 1.13)	34
7	Fukushima	1.04	(1.00 to 1.08)	37	1.02	(0.98 to 1.07)	29	1.02	(0.98 to 1.06)	31	1.00	(0.96 to 1.05)	25	1.01	(0.97 to 1.05)	31	1.01	(0.97 to 1.06)	29	1.06	(1.01 to 1.11)	37	1.09	(1.03 to 1.14)	41	1.14	(1.08 to 1.20)	44
8	Ibaraki	1.02	(0.98 to 1.07)	34	1.03	(0.99 to 1.07)	32	1.01	(0.98 to 1.05)	27	1.01	(0.97 to 1.05)	30	1.02	(0.98 to 1.06)	34	1.03	(0.99 to 1.07)	36	1.07	(1.03 to 1.12)	40	1.03	(0.99 to 1.07)	30	1.03	(0.98 to 1.08)	24
9	Tochigi	1.07	(1.03 to 1.11)	43	1.09	(1.04 to 1.14)	45	1.05	(1.01 to 1.10)	41	1.06	(1.02 to 1.11)	42	1.09	(1.05 to 1.14)	46	1.11	(1.07 to 1.16)	47	1.09	(1.04 to 1.14)	43	1.06	(1.01 to 1.11)	35	1.04	(0.98 to 1.09)	28
10	Gunma	1.01	(0.97 to 1.06)	28	1.02	(0.97 to 1.06)	26	0.97	(0.93 to 1.02)	12	0.97	(0.93 to 1.02)	11	1.04	(0.99 to 1.08)	39	1.00	(0.96 to 1.05)	24	1.06	(1.01 to 1.11)	38	1.02	(0.97 to 1.07)	26	1.04	(0.99 to 1.10)	29
11	Saitama	0.96	(0.92 to 1.00)	9	1.00	(0.97 to 1.04)	22	0.98	(0.94 to 1.01)	14	0.98	(0.94 to 1.01)	15	0.99	(0.96 to 1.02)	19	1.00	(0.97 to 1.03)	26	0.93	(0.90 to 0.97)	10	0.91	(0.88 to 0.94)	8	0.86	(0.83 to 0.90)	6
12	Chiba	0.96	(0.92 to 1.00)	8	0.98	(0.95 to 1.01)	18	0.94	(0.91 to 0.97)	5	0.95	(0.92 to 0.98)	6	0.99	(0.95 to 1.02)	17	0.99	(0.96 to 1.02)	19	0.93	(0.90 to 0.96)	7	0.91	(0.88 to 0.94)	7	0.93	(0.89 to 0.97)	12
13	Tokyo	0.99	(0.95 to 1.03)	19	0.96	(0.93 to 0.98)	16	0.97	(0.95 to 1.00)	13	1.00	(0.97 to 1.02)	21	1.01	(0.99 to 1.03)	28	1.06	(1.03 to 1.08)	41	0.93	(0.90 to 0.96)	8	0.91	(0.88 to 0.94)	6	0.97	(0.94 to 1.01)	16
14	Kanagawa	0.94	(0.90 to 0.98)	5	0.95	(0.92 to 0.98)	11	0.89	(0.86 to 0.92)	2	0.89	(0.86 to 0.91)	2	0.99	(0.96 to 1.02)	18	1.02	(0.99 to 1.05)	31	0.93	(0.90 to 0.96)	6	0.89	(0.86 to 0.92)	5	0.83	(0.80 to 0.87)	2
15	Niigata	1.02	(0.98 to 1.07)	33	1.00	(0.96 to 1.04)	21	1.01	(0.98 to 1.05)	28	1.00	(0.96 to 1.04)	22	1.02	(0.98 to 1.06)	33	0.98	(0.95 to 1.02)	16	1.07	(1.02 to 1.12)	39	1.10	(1.05 to 1.15)	45	1.06	(1.01 to 1.11)	35
16	Toyama	1.05	(1.00 to 1.09)	40	1.03	(0.98 to 1.08)	31	1.04	(0.99 to 1.09)	36	1.04	(0.98 to 1.09)	35	1.09	(1.04 to 1.15)	47	1.05	(1.00 to 1.11)	39	0.94	(0.88 to 1.00)	11	1.10	(1.03 to 1.17)	44	1.13	(1.06 to 1.21)	42
17	Ishikawa	1.00	(0.96 to 1.04)	23	0.99	(0.94 to 1.04)	19	1.01	(0.96 to 1.07)	26	1.03	(0.97 to 1.09)	34	0.97	(0.92 to 1.02)	9	0.97	(0.91 to 1.02)	11	0.94	(0.88 to 1.00)	12	1.03	(0.97 to 1.10)	31	1.10	(1.03 to 1.18)	41
18	Fukui	0.93	(0.89 to 0.98)	4	0.91	(0.86 to 0.97)	2	0.96	(0.91 to 1.02)	9	0.89	(0.84 to 0.95)	3	0.97	(0.92 to 1.03)	11	0.93	(0.87 to 0.99)	4	0.87	(0.81 to 0.94)	2	0.99	(0.92 to 1.07)	21	1.03	(0.95 to 1.12)	25
19	Yamanashi	1.07	(1.02 to 1.11)	42	1.04	(0.98 to 1.10)	34	1.00	(0.95 to 1.06)	23	1.07	(1.01 to 1.14)	43	1.06	(1.00 to 1.12)	43	1.09	(1.03 to 1.16)	45	1.11	(1.04 to 1.18)	45	1.06	(0.99 to 1.13)	36	1.09	(1.02 to 1.18)	40
20	Nagano	0.97	(0.93 to 1.01)	11	0.93	(0.90 to 0.97)	4	0.98	(0.94 to 1.02)	15	0.95	(0.90 to 0.99)	5	0.98	(0.94 to 1.02)	13	0.94	(0.89 to 0.98)	6	0.98	(0.93 to 1.03)	18	1.00	(0.95 to 1.05)	22	1.03	(0.98 to 1.09)	26
21	Gifu	1.01	(0.97 to 1.05)	26	0.89	(0.85 to 0.93)	1	1.01	(0.97 to 1.06)	25	0.97	(0.93 to 1.02)	13	1.05	(1.01 to 1.10)	42	1.02	(0.98 to 1.07)	33	1.01	(0.96 to 1.06)	27	1.07	(1.02 to 1.12)	37	1.07	(1.02 to 1.13)	37
22	Shizuoka	1.01	(0.97 to 1.05)	27	0.97	(0.94 to 1.01)	17	0.99	(0.95 to 1.02)	19	1.03	(0.99 to 1.07)	33	1.04	(1.00 to 1.08)	40	1.04	(1.00 to 1.07)	37	1.05	(1.01 to 1.09)	32	1.01	(0.97 to 1.05)	24	0.99	(0.94 to 1.03)	18
23	Aichi	0.99	(0.95 to 1.03)	18	0.95	(0.92 to 0.98)	13	0.94	(0.91 to 0.97)	4	0.95	(0.92 to 0.98)	7	0.98	(0.95 to 1.01)	15	1.00	(0.97 to 1.03)	21	1.03	(1.00 to 1.07)	31	1.02	(0.99 to 1.06)	27	1.04	(1.00 to 1.08)	30
24	Mie	0.97	(0.93 to 1.01)	15	0.94	(0.90 to 0.98)	6	0.96	(0.92 to 1.01)	7	0.96	(0.92 to 1.01)	9	0.98	(0.93 to 1.02)	12	1.00	(0.96 to 1.05)	25	1.02	(0.97 to 1.07)	29	0.99	(0.94 to 1.04)	19	0.99	(0.94 to 1.05)	19
25	Shiga	0.93	(0.89 to 0.97)	3	0.95	(0.90 to 1.01)	12	0.96	(0.91 to 1.02)	10	1.00	(0.94 to 1.06)	19	0.96	(0.91 to 1.01)	7	0.97	(0.92 to 1.02)	12	0.94	(0.88 to 1.00)	13	0.84	(0.79 to 0.90)	1	0.88	(0.82 to 0.94)	8
26	Kyoto	0.95	(0.91 to 0.99)	7	0.94	(0.91 to 0.98)	8	0.96	(0.93 to 1.00)	8	0.97	(0.93 to 1.01)	12	0.95	(0.92 to 0.99)	5	0.93	(0.90 to 0.97)	5	0.87	(0.84 to 0.91)	3	0.94	(0.90 to 0.98)	12	0.94	(0.89 to 0.99)	15
27	Osaka	1.02	(0.98 to 1.06)	32	1.04	(1.01 to 1.07)	36	1.02	(0.99 to 1.05)	30	1.05	(1.02 to 1.08)	39	1.07	(1.04 to 1.09)	44	1.09	(1.07 to 1.12)	46	1.02	(0.99 to 1.05)	28	0.97	(0.94 to 1.00)	14	0.84	(0.81 to 0.88)	4
28	Hyogo	1.00	(0.96 to 1.04)	22	1.01	(0.98 to 1.04)	24	1.02	(0.99 to 1.05)	32	1.02	(0.99 to 1.06)	32	1.01	(0.98 to 1.04)	30	1.03	(1.00 to 1.06)	35	0.99	(0.96 to 1.02)	20	0.92	(0.89 to 0.95)	11	0.90	(0.86 to 0.93)	10
29	Nara	0.94	(0.90 to 0.98)	6	0.93	(0.88 to 0.98)	3	0.98	(0.93 to 1.03)	16	0.96	(0.91 to 1.02)	10	1.00	(0.95 to 1.05)	21	1.01	(0.96 to 1.06)	27	0.91	(0.86 to 0.96)	5	0.85	(0.80 to 0.89)	2	0.81	(0.76 to 0.86)	1
30	Wakayama	0.99	(0.95 to 1.04)	21	0.95	(0.91 to 1.00)	14	0.96	(0.92 to 1.01)	6	1.01	(0.95 to 1.06)	27	0.98	(0.93 to 1.03)	14	1.00	(0.95 to 1.05)	22	0.98	(0.93 to 1.04)	19	1.01	(0.96 to 1.08)	25	1.02	(0.96 to 1.09)	22
31	Tottori	1.08	(1.03 to 1.12)	46	1.06	(0.99 to 1.12)	39	1.00	(0.94 to 1.06)	20	1.09	(1.02 to 1.16)	44	1.00	(0.95 to 1.07)	25	1.05	(0.99 to 1.12)	38	1.22	(1.13 to 1.30)	47	1.08	(1.00 to 1.16)	38	1.14	(1.05 to 1.23)	43
32	Shimane	1.05	(1.00 to 1.09)	39	1.01	(0.96 to 1.07)	23	1.05	(1.00 to 1.11)	39	1.10	(1.04 to 1.17)	46	1.00	(0.94 to 1.05)	20	1.00	(0.94 to 1.06)	23	1.08	(1.01 to 1.15)	41	1.13	(1.06 to 1.21)	46	1.03	(0.95 to 1.11)	23
33	Okayama	0.97	(0.93 to 1.01)	10	0.94	(0.90 to 0.98)	7	1.00	(0.96 to 1.04)	21	0.99	(0.94 to 1.03)	16	1.00	(0.96 to 1.04)	24	1.02	(0.98 to 1.06)	32	1.00	(0.95 to 1.04)	23	0.98	(0.93 to 1.03)	16	0.84	(0.79 to 0.89)	3
34	Hiroshima	1.00	(0.96 to 1.05)	25	1.04	(1.00 to 1.08)	35	1.05	(1.01 to 1.09)	38	1.00	(0.96 to 1.04)	24	1.05	(1.01 to 1.09)	41	1.02	(0.98 to 1.05)	30	1.05	(1.01 to 1.10)	36	0.97	(0.93 to 1.02)	15	0.87	(0.82 to 0.91)	7
35	Yamaguchi	1.06	(1.02 to 1.10)	41	1.06	(1.02 to 1.11)	40	1.05	(1.01 to 1.10)	40	1.11	(1.06 to 1.16)	47	1.03	(0.99 to 1.07)	37	1.06	(1.01 to 1.10)	40	1.09	(1.03 to 1.14)	42	1.04	(0.99 to 1.10)	32	1.05	(0.99 to 1.12)	33
36	Tokushima	0.97	(0.93 to 1.01)	12	1.03	(0.98 to 1.09)	33	1.01	(0.96 to 1.06)	24	1.01	(0.96 to 1.07)	31	0.97	(0.92 to 1.02)	10	0.92	(0.87 to 0.97)	3	0.93	(0.87 to 0.99)	9	0.89	(0.83 to 0.95)	4	0.99	(0.92 to 1.07)	20
37	Kagawa	0.98	(0.94 to 1.03)	17	1.01	(0.96 to 1.07)	25	0.98	(0.93 to 1.04)	18	0.98	(0.92 to 1.03)	14	0.96	(0.91 to 1.01)	6	0.99	(0.94 to 1.05)	20	1.00	(0.94 to 1.06)	24	0.98	(0.92 to 1.04)	17	0.99	(0.93 to 1.06)	21
38	Ehime	1.02	(0.97 to 1.06)	30	1.03	(0.98 to 1.07)	30	1.03	(0.99 to 1.08)	34	1.01	(0.96 to 1.05)	28	1.00	(0.96 to 1.04)	22	0.99	(0.94 to 1.03)	18	1.05	(0.99 to 1.10)	33	1.08	(1.03 to 1.14)	39	0.97	(0.92 to 1.03)	17
39	Kochi	1.03	(0.98 to 1.07)	35	1.07	(1.02 to 1.13)	41	1.06	(1.00 to 1.11)	46	1.05	(1.00 to 1.11)	41	0.98	(0.93 to 1.04)	16	0.94	(0.89 to 0.99)	8	0.99	(0.93 to 1.06)	22	1.03	(0.96 to 1.09)	28	1.08	(1.00 to 1.15)	39
40	Fukuoka	0.98	(0.94 to 1.02)	16	0.95	(0.92 to 0.97)	9	0.98	(0.95 to 1.01)	17	0.99	(0.96 to 1.02)	17	1.00	(0.97 to 1.03)	23	1.02	(0.99 to 1.06)	34	0.99	(0.96 to 1.03)	21	0.96	(0.92 to 0.99)	13	0.94	(0.90 to 0.98)	13
41	Saga	1.04	(1.00 to 1.09)	38	0.96	(0.90 to 1.01)	15	1.09	(1.03 to 1.15)	47	1.00	(0.95 to 1.06)	26	1.02	(0.96 to 1.08)	32	1.06	(1.00 to 1.12)	42	1.05	(0.98 to 1.12)	35	1.09	(1.02 to 1.16)	42	1.05	(0.97 to 1.13)	32
42	Nagasaki	1.01	(0.97 to 1.06)	29	1.04	(1.00 to 1.09)	37	1.02	(0.98 to 1.07)	33	0.99	(0.95 to 1.04)	18	1.02	(0.98 to 1.07)	35	0.95	(0.91 to 0.99)	9	1.02	(0.97 to 1.08)	30	0.98	(0.93 to 1.04)	18	1.07	(1.01 to 1.14)	38
43	Kumamoto	0.91	(0.87 to 0.94)	2	0.95	(0.91 to 0.99)	10	0.90	(0.86 to 0.94)	3	0.94	(0.90 to 0.98)	4	0.92	(0.88 to 0.96)	2	0.89	(0.85 to 0.93)	1	0.89	(0.85 to 0.94)	4	0.87	(0.82 to 0.91)	3	0.89	(0.84 to 0.95)	9
44	Oita	0.97	(0.93 to 1.01)	13	0.99	(0.95 to 1.04)	20	1.06	(1.01 to 1.11)	42	1.05	(1.00 to 1.10)	38	0.96	(0.92 to 1.01)	8	0.94	(0.89 to 0.98)	7	0.97	(0.91 to 1.02)	15	0.92	(0.86 to 0.97)	10	0.91	(0.85 to 0.97)	11
45	Miyazaki	1.00	(0.96 to 1.04)	24	1.05	(1.00 to 1.11)	38	1.02	(0.97 to 1.07)	29	1.00	(0.95 to 1.05)	23	1.01	(0.96 to 1.06)	27	0.99	(0.94 to 1.04)	17	0.97	(0.92 to 1.03)	16	1.03	(0.97 to 1.09)	29	0.94	(0.88 to 1.00)	14
46	Kagoshima	1.03	(0.99 to 1.08)	36	1.08	(1.04 to 1.13)	43	1.06	(1.02 to 1.10)	45	1.01	(0.97 to 1.05)	29	1.03	(0.99 to 1.08)	38	0.98	(0.94 to 1.02)	15	1.00	(0.96 to 1.05)	25	1.05	(1.00 to 1.11)	34	1.04	(0.98 to 1.10)	27
47	Okinawa	0.87	(0.83 to 0.91)	1	NA	NA	NA	0.88	(0.83 to 0.93)	1	0.82	(0.77 to 0.87)	1	0.85	(0.80 to 0.89)	1	0.91	(0.87 to 0.96)	2	0.85	(0.80 to 0.90)	1	0.91	(0.86 to 0.97)	9	0.86	(0.80 to 0.91)	5

CI; confidence interval, NA; not available, OR; odds ratio

Prefectures with a lower estimate of odds for all-cause premature mortality are ranked higher. The reference is the grand mean of all the prefectures.

Supplementary Table 7. Adjusted prefecture-level residuals for all-cause premature mortality among women, Japan, 1970-2005

Prefectures	Overall			1970			1975			1980			1985			1990			1995			2000			2005		
	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank	OR	(95% CI)	Rank
1 Hokkaido	0.97	(0.93 to 1.00)	14	0.95	(0.92 to 0.99)	10	0.96	(0.92 to 1.00)	17	0.97	(0.94 to 1.01)	13	0.99	(0.95 to 1.02)	18	0.97	(0.93 to 1.01)	14	0.97	(0.93 to 1.02)	14	0.97	(0.93 to 1.01)	16	1.01	(0.96 to 1.06)	20
2 Aomori	1.04	(1.00 to 1.08)	31	0.98	(0.93 to 1.04)	15	0.99	(0.93 to 1.05)	20	1.00	(0.95 to 1.07)	23	1.05	(0.99 to 1.11)	40	1.01	(0.95 to 1.08)	23	1.07	(1.00 to 1.15)	38	1.11	(1.03 to 1.19)	42	1.13	(1.05 to 1.22)	43
3 Iwate	1.07	(1.02 to 1.11)	40	1.05	(0.99 to 1.12)	35	1.04	(0.98 to 1.10)	34	1.03	(0.97 to 1.09)	33	1.02	(0.96 to 1.09)	25	1.03	(0.97 to 1.10)	31	1.09	(1.02 to 1.17)	43	1.13	(1.05 to 1.22)	46	1.17	(1.08 to 1.27)	45
4 Miyagi	0.91	(0.88 to 0.95)	6	0.89	(0.85 to 0.94)	4	0.87	(0.82 to 0.92)	3	0.88	(0.83 to 0.93)	3	0.93	(0.88 to 0.98)	6	0.96	(0.91 to 1.02)	13	0.95	(0.90 to 1.02)	13	0.92	(0.86 to 0.98)	10	0.96	(0.90 to 1.03)	15
5 Akita	0.96	(0.92 to 1.00)	12	0.99	(0.94 to 1.05)	20	0.94	(0.89 to 1.00)	9	0.91	(0.86 to 0.97)	5	0.93	(0.88 to 1.00)	8	0.93	(0.87 to 1.00)	6	1.00	(0.93 to 1.07)	21	1.04	(0.96 to 1.13)	26	1.05	(0.96 to 1.14)	29
6 Yamagata	0.96	(0.92 to 1.00)	11	0.99	(0.93 to 1.05)	18	0.95	(0.89 to 1.01)	11	0.95	(0.89 to 1.01)	9	0.95	(0.89 to 1.01)	11	0.94	(0.88 to 1.00)	8	1.00	(0.92 to 1.08)	19	0.97	(0.89 to 1.05)	15	1.05	(0.96 to 1.14)	30
7 Fukushima	1.04	(1.00 to 1.08)	30	1.04	(0.98 to 1.09)	30	1.07	(1.01 to 1.13)	40	0.99	(0.94 to 1.05)	18	1.03	(0.98 to 1.09)	32	1.01	(0.95 to 1.06)	21	1.02	(0.95 to 1.08)	26	1.07	(1.00 to 1.14)	32	1.10	(1.02 to 1.18)	40
8 Ibaraki	1.04	(1.00 to 1.08)	33	1.08	(1.03 to 1.14)	42	1.02	(0.96 to 1.07)	28	1.01	(0.96 to 1.06)	27	1.04	(0.99 to 1.10)	36	1.06	(1.01 to 1.12)	43	1.07	(1.01 to 1.13)	37	0.99	(0.94 to 1.05)	19	1.05	(0.98 to 1.11)	31
9 Tochigi	1.09	(1.05 to 1.13)	44	1.09	(1.03 to 1.15)	43	1.05	(0.99 to 1.11)	38	1.06	(1.00 to 1.13)	40	1.13	(1.07 to 1.20)	47	1.09	(1.03 to 1.16)	46	1.04	(0.98 to 1.11)	29	1.11	(1.04 to 1.19)	43	1.09	(1.01 to 1.17)	38
10 Gunma	1.05	(1.01 to 1.09)	34	1.08	(1.02 to 1.14)	40	1.01	(0.95 to 1.07)	22	1.02	(0.96 to 1.08)	31	1.05	(0.99 to 1.11)	39	1.02	(0.97 to 1.09)	27	1.01	(0.94 to 1.08)	23	1.09	(1.02 to 1.17)	40	1.10	(1.03 to 1.18)	41
11 Saitama	0.92	(0.88 to 0.95)	7	0.94	(0.90 to 0.98)	9	0.92	(0.88 to 0.96)	6	0.91	(0.88 to 0.95)	6	0.95	(0.91 to 0.99)	10	0.96	(0.92 to 1.00)	12	0.92	(0.88 to 0.96)	9	0.89	(0.85 to 0.93)	7	0.84	(0.80 to 0.88)	4
12 Chiba	0.88	(0.85 to 0.91)	3	0.90	(0.86 to 0.95)	5	0.89	(0.85 to 0.93)	4	0.88	(0.84 to 0.92)	4	0.90	(0.86 to 0.94)	3	0.88	(0.85 to 0.92)	1	0.87	(0.83 to 0.91)	4	0.84	(0.80 to 0.88)	3	0.89	(0.85 to 0.94)	8
13 Tokyo	0.89	(0.86 to 0.92)	4	0.79	(0.76 to 0.81)	1	0.86	(0.83 to 0.89)	2	0.92	(0.89 to 0.95)	7	0.93	(0.90 to 0.96)	7	0.93	(0.90 to 0.96)	5	0.88	(0.85 to 0.91)	6	0.89	(0.86 to 0.93)	6	0.93	(0.89 to 0.97)	11
14 Kanagawa	0.84	(0.81 to 0.87)	1	0.79	(0.76 to 0.82)	2	0.82	(0.78 to 0.85)	1	0.85	(0.82 to 0.88)	1	0.87	(0.84 to 0.91)	2	0.89	(0.86 to 0.92)	3	0.86	(0.82 to 0.89)	3	0.83	(0.79 to 0.86)	2	0.80	(0.76 to 0.84)	2
15 Niigata	0.96	(0.93 to 1.00)	13	1.00	(0.96 to 1.05)	23	0.95	(0.90 to 0.99)	10	0.95	(0.90 to 1.00)	10	0.92	(0.87 to 0.97)	5	0.97	(0.92 to 1.03)	15	1.00	(0.94 to 1.06)	20	1.01	(0.95 to 1.08)	22	0.97	(0.90 to 1.04)	16
16 Toyama	1.06	(1.01 to 1.10)	38	1.08	(1.02 to 1.15)	41	1.04	(0.97 to 1.11)	35	1.02	(0.95 to 1.09)	29	1.03	(0.96 to 1.10)	29	1.01	(0.94 to 1.08)	22	1.01	(0.93 to 1.09)	24	1.15	(1.06 to 1.25)	47	1.13	(1.04 to 1.24)	44
17 Ishikawa	1.03	(0.99 to 1.07)	25	1.04	(0.97 to 1.11)	31	1.02	(0.96 to 1.10)	30	1.00	(0.93 to 1.07)	21	0.98	(0.91 to 1.05)	16	1.03	(0.96 to 1.11)	32	1.02	(0.94 to 1.11)	27	1.06	(0.98 to 1.15)	30	1.10	(1.00 to 1.20)	39
18 Fukui	1.05	(1.00 to 1.10)	35	1.07	(1.00 to 1.15)	38	1.01	(0.94 to 1.09)	25	1.06	(0.98 to 1.15)	41	1.02	(0.95 to 1.11)	27	1.04	(0.96 to 1.12)	35	0.91	(0.83 to 1.00)	8	1.07	(0.97 to 1.18)	33	1.18	(1.06 to 1.30)	46
19 Yamanashi	1.01	(0.97 to 1.06)	23	1.00	(0.93 to 1.07)	22	1.00	(0.93 to 1.08)	21	0.99	(0.92 to 1.07)	19	1.03	(0.96 to 1.12)	33	0.99	(0.91 to 1.07)	19	1.05	(0.96 to 1.15)	32	1.03	(0.94 to 1.13)	25	1.02	(0.92 to 1.13)	23
20 Nagano	1.04	(1.00 to 1.08)	32	1.05	(1.00 to 1.11)	36	1.01	(0.96 to 1.06)	24	1.05	(1.00 to 1.11)	38	1.05	(0.99 to 1.11)	41	1.06	(1.00 to 1.12)	40	1.07	(1.01 to 1.14)	39	1.01	(0.94 to 1.08)	20	1.04	(0.97 to 1.12)	28
21 Gifu	1.11	(1.07 to 1.16)	46	1.02	(0.97 to 1.08)	26	1.10	(1.04 to 1.17)	43	1.15	(1.09 to 1.22)	47	1.11	(1.05 to 1.17)	45	1.08	(1.02 to 1.15)	45	1.14	(1.08 to 1.22)	46	1.11	(1.04 to 1.18)	41	1.12	(1.04 to 1.20)	42
22 Shizuoka	1.01	(0.97 to 1.05)	22	0.94	(0.89 to 0.98)	7	0.96	(0.91 to 1.00)	15	1.00	(0.96 to 1.05)	22	1.00	(0.95 to 1.05)	21	1.06	(1.01 to 1.11)	39	1.06	(1.01 to 1.12)	35	1.05	(1.00 to 1.11)	29	1.05	(0.99 to 1.12)	33
23 Aichi	1.03	(0.99 to 1.07)	24	0.98	(0.94 to 1.02)	13	1.01	(0.97 to 1.05)	23	1.04	(1.00 to 1.08)	34	1.07	(1.03 to 1.11)	43	1.04	(1.00 to 1.08)	38	1.06	(1.02 to 1.11)	34	1.02	(0.98 to 1.07)	24	1.04	(0.99 to 1.09)	27
24 Mie	0.98	(0.94 to 1.02)	19	0.99	(0.93 to 1.04)	16	0.93	(0.88 to 0.99)	8	0.97	(0.92 to 1.03)	14	0.99	(0.93 to 1.05)	19	0.94	(0.89 to 1.00)	10	1.01	(0.95 to 1.08)	25	1.06	(0.99 to 1.14)	31	0.99	(0.92 to 1.06)	18
25 Shiga	0.98	(0.94 to 1.02)	18	1.07	(1.00 to 1.14)	37	1.02	(0.95 to 1.09)	27	1.01	(0.94 to 1.08)	28	0.94	(0.87 to 1.01)	9	0.98	(0.91 to 1.05)	17	1.01	(0.93 to 1.09)	22	0.90	(0.83 to 0.98)	8	0.90	(0.83 to 0.99)	10
26 Kyoto	0.93	(0.89 to 0.97)	9	0.89	(0.84 to 0.93)	3	0.96	(0.91 to 1.01)	16	0.99	(0.94 to 1.04)	17	0.97	(0.92 to 1.03)	15	0.94	(0.89 to 0.99)	9	0.85	(0.80 to 0.90)	2	0.88	(0.83 to 0.94)	5	0.95	(0.89 to 1.01)	13
27 Osaka	0.95	(0.91 to 0.98)	10	0.92	(0.89 to 0.95)	6	0.96	(0.92 to 0.99)	14	0.98	(0.95 to 1.02)	16	1.00	(0.97 to 1.04)	22	0.98	(0.95 to 1.02)	18	0.94	(0.91 to 0.98)	10	0.91	(0.87 to 0.95)	9	0.85	(0.81 to 0.89)	5
28 Hyogo	0.92	(0.89 to 0.96)	8	0.94	(0.90 to 0.97)	8	0.96	(0.92 to 1.00)	13	0.98	(0.94 to 1.02)	15	0.97	(0.93 to 1.01)	14	0.93	(0.89 to 0.96)	4	0.89	(0.85 to 0.93)	7	0.84	(0.80 to 0.88)	4	0.86	(0.81 to 0.90)	6
29 Nara	0.87	(0.83 to 0.90)	2	0.97	(0.91 to 1.04)	12	0.95	(0.89 to 1.02)	12	0.95	(0.88 to 1.01)	8	0.91	(0.85 to 0.97)	4	0.89	(0.83 to 0.95)	2	0.80	(0.75 to 0.86)	1	0.76	(0.71 to 0.82)	1	0.75	(0.69 to 0.82)	1
30 Wakayama	1.01	(0.96 to 1.05)	21	1.03	(0.97 to 1.09)	27	1.02	(0.95 to 1.08)	29	1.00	(0.94 to 1.07)	24	1.04	(0.98 to 1.12)	37	0.98	(0.91 to 1.05)	16	0.95	(0.87 to 1.02)	11	0.93	(0.86 to 1.02)	12	1.08	(0.99 to 1.18)	37
31 Tottori	1.07	(1.02 to 1.12)	41	1.07	(0.99 to 1.16)	39	1.04	(0.96 to 1.13)	37	1.05	(0.97 to 1.14)	37	1.04	(0.96 to 1.13)	35	1.03	(0.95 to 1.12)	33	1.08	(0.98 to 1.19)	41	1.11	(1.00 to 1.23)	44	1.01	(0.90 to 1.14)	21
32 Shimane	1.05	(1.01 to 1.10)	36	1.05	(0.98 to 1.13)	33	1.09	(1.01 to 1.17)	42	1.06	(0.98 to 1.14)	39	0.98	(0.91 to 1.06)	17	1.03	(0.95 to 1.11)	30	1.13	(1.03 to 1.23)	44	1.05	(0.95 to 1.15)	27	0.96	(0.86 to 1.07)	14
33 Okayama	0.97	(0.93 to 1.01)	16	0.98	(0.93 to 1.04)	14	0.98	(0.93 to 1.04)	18	0.97	(0.91 to 1.03)	12	1.04	(0.99 to 1.11)	38	1.03	(0.97 to 1.09)	29	0.98	(0.92 to 1.05)	17	0.92	(0.86 to 0.99)	11	0.84	(0.78 to 0.91)	3
34 Hiroshima	0.99	(0.96 to 1.03)	20	0.99	(0.94 to 1.04)	17	1.03	(0.98 to 1.08)	31	1.03	(0.98 to 1.08)	32	1.01	(0.96 to 1.06)	23	1.04	(0.99 to 1.10)	37	0.98	(0.93 to 1.04)	16	0.94	(0.88 to 0.99)	13	0.90	(0.85 to 0.96)	9
35 Yamaguchi	1.03	(0.99 to 1.07)	27	0.99	(0.94 to 1.05)	19	1.04	(0.98 to 1.10)	36	1.01	(0.95 to 1.07)	25	1.03	(0.97 to 1.09)	30	1.01	(0.96 to 1.08)	24	1.04	(0.98 to 1.12)	30	1.07	(1.00 to 1.15)	36	1.05	(0.97 to 1.13)	32
36 Tokushima	1.08	(1.04 to 1.13)	43	1.11	(1.03 to 1.18)	45	1.19	(1.11 to 1.27)	47	1.10	(1.03 to 1.18)	45	0.97	(0.90 to 1.04)	13	1.06	(0.98 to 1.14)	42	1.08	(1.00 to 1.18)	42	1.01	(0.93 to 1.11)	23	1.02	(0.92 to 1.12)	22
37 Kagawa	1.03	(0.99 to 1.08)	28	1.03	(0.96 to 1.10)	29	1.01	(0.95 to 1.09)	26	1.00	(0.93 to 1.07)	20	1.03	(0.96 to 1.11)	31	1.02	(0.95 to 1.09)	26	1.07	(0.98 to 1.16)	36	1.05	(0.96 to 1.15)	28	1.02	(0.93 to 1.12)	24
38 Ehime	1.06	(1.02 to 1.10)	37	1.02	(0.96 to 1.08)	24	1.13	(1.07 to 1.19)	44	1.02	(0.96 to 1.08)	30	1.03	(0.97 to 1.09)	28	1.08	(1.02 to 1.15)	44	1.03	(0.96 to 1.11)	28	1.07	(0.99 to 1.15)	34	1.07	(0.99 to 1.16)	35
39 Kochi	1.11	(1.06 to 1.16)	45	1.05	(0.98 to 1.13)	34	1.19	(1.11 to 1.27)	46	1.05	(0.98 to 1.13)	36	1.06	(0.99 to 1.15)	42	1.06	(0.98 to 1.14)	41	1.07	(0.99 to 1.17)	40	1.08	(0.98 to 1.18)	37	1.18	(1.07 to 1.30)	47
40 Fukuoka	0.97	(0.94 to 1.01)	17	0.96	(0.92 to 1.00)	11	0.93	(0.89 to 0.97)	7	0.97	(0.93 to 1.01)	11	1.04	(1.00 to 1.08)	34	0.99	(0.95 to 1.03)	20	0.98	(0.93 to 1.02)	15	0.97	(0.92 to 1.02)	17	0.94	(0.89 to 0.99)	12
41 Saga	1.08	(1.04 to 1.13)	42	1.03	(0.96 to 1.10)	28	1.09	(1.01 to 1.17)	41	1.09	(1.01 to 1.17)	43	0.99	(0.92 to 1.07)	20	1.10	(1.03 to 1.19)	47	1.13	(1.04 to 1.23)	45	1.11	(1.02 to 1.22)	45	1.06	(0.96 to 1.17)	34
42 Nagasaki	1.03	(0.99 to 1.07)	26	1.02	(0.97 to 1.08)	25	1.03	(0.97 to 1.09)	32	1.04	(0.98 to 1.10)	35	1.01	(0.96 to 1.08)	24	1.02	(0.96 to 1.08)	25	1.05	(0.98 to 1.12)	31	1.07	(1.00 to 1.15)	35	1.02	(0.95 to 1.11)	25
43 Kumamoto	0.97	(0.93 to 1.01)	15	1.00	(0.95 to 1.05)	21	0.98	(0.93 to 1.04)	19	1.01	(0.95 to 1.06)	26	0.96	(0.90 to 1.01)	12	0.95	(0.90 to 1.01)	11	0.95	(0.89 to 1.02)	12	0.97	(0.91 to 1.05)	18	0.99	(0.91 to 1.06)	17
44 Oita	1.03	(0.99 to 1.08)	29	1.10	(1.04 to 1.17)	44	1.03	(0.97 to 1.10)	33	1.08	(1.01 to 1.15)	42	1.08	(1.02 to 1.15)	44	1.03	(0.96 to 1.09)	28	0.99	(0.92 to 1.06)	18	1.01	(0.93 to 1.09)	21	0.89	(0.82 to 0.98)	7
45 Miyazaki	1.06	(1.02 to 1.10)	39	1.04	(0.98 to 1.11)	32	1.06	(0.99 to 1.13)	39	1.10	(1.03 to 1.17)	44	1.02	(0.95 to 1.09)	26	1.04	(0.97 to 1.11)	36	1.05	(0.97 to 1.14)	33	1.08	(1.00 to 1.17)	38	1.08	(0.99 to 1.18)	36
46 Kagoshima	1.11	(1.07 to 1.16)	47	1.14	(1.08 to 1.20)	46	1.15	(1.09 to 1.21)	45	1.13	(1.07 to 1.19)	46	1.13	(1.07 to 1.19)	46	1.04	(0.98 to 1.10)	34	1.15	(1.08 to 1.22)	47	1.09	(1.01 to 1.17)	39	1.00	(0.92 to 1.08)	19
47 Okinawa	0.89	(0.85 to 0.94)	5	NA	NA	NA	0.92	(0.85 to 0.99)	5	0.87	(0.80 to 0.93)	2	0.86	(0.80 to 0.92)	1	0.93	(0.87 to 1.00)	7	0.87	(0.80 to 0.94)	5	0.94	(0.86 to 1.02)	14	1.03	(0.95 to 1.13)	26

CI; confidence interval, NA; not available, OR; odds ratio

Prefectures with a lower estimate of odds for all-cause premature mortality are ranked higher. The reference is the grand mean of all the prefectures.

Supplementary Table 8. Variance and covariance matrices of prefecture-level variances of each occupation group, Japan, 1970-2005 [a]

	Men						Women					
	Clerical, technical and managerial occupations	Sales and service occupations	Agriculture, forestry and fishery occupations	Production and transport occupations	Unclassifiable occupations	Non-employed [b]	Clerical, technical and managerial occupations	Sales and service occupations	Agriculture, forestry and fishery occupations	Production and transport occupations	Unclassifiable occupations	Non-employed [b]
Clerical, technical and managerial occupations	0.005						0.008					
	(0.001)						(0.002)					
	1.000						*1.000*					
Sales and service occupations	0.006	0.014					0.003	0.010				
	(0.002)	(0.003)					(0.002)	(0.002)				
	0.716	*1.000*					*0.345*	*1.000*				
Agriculture, forestry and fishery occupations	0.002	0.005	0.006				0.002	0.004	0.013			
	(0.001)	(0.002)	(0.001)				(0.002)	(0.002)	(0.003)			
	0.303	*0.506*	*1.000*				*0.176*	*0.393*	*1.000*			
Production and transport occupations	0.006	0.012	0.004	0.013			0.004	0.006	0.004	0.011		
	(0.002)	(0.003)	(0.002)	(0.003)			(0.002)	(0.002)	(0.002)	(0.003)		
	0.731	*0.920*	*0.484*	*1.000*			*0.472*	*0.544*	*0.308*	*1.000*		
Unclassifiable occupations	-0.007	-0.003	0.006	-0.005	0.317		-0.022	-0.014	-0.019	-0.014	0.331	
	(0.007)	(0.010)	(0.007)	(0.010)	(0.066)		(0.009)	(0.009)	(0.011)	(0.010)	(0.070)	
	-0.168	*-0.051*	*0.139*	*-0.078*	*1.000*		*-0.440*	*-0.247*	*-0.297*	*-0.244*	*1.000*	
Non-employed [b]	-0.001	-0.003	-0.0002	-0.003	0.006	0.006	-0.002	0.005	-0.002	-0.001	0.014	0.008
	(0.001)	(0.001)	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.008)	(0.002)
	-0.226	*-0.387*	*-0.030*	*-0.358*	*0.144*	*1.000*	*-0.198*	*0.508*	*-0.203*	*-0.112*	*0.262*	*1.000*

[a] The number in parentheses is a standard error of the corresponding variances and covariances. The italicized numbers are correlation coefficients.

[b] Non-employed is the sum of unemployed and non-labor force.

Supplementary Table 9. Gini's coefficient of yearly income, average yearly income, and average savings in 47 prefectures, Japan, 1969-2004 [a]

	1969 [b c]			1974 [c]			1979			1984			1989			1994			1999			2004		
Prefectures	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings	Gini	Income	Savings
1 Hokkaido	NA	1,154	966	NA	2,366	1,686	0.268	3,969	3,998	0.265	4,851	5,097	0.267	5,407	7,276	0.273	6,506	10,241	0.292	6,588	11,616	0.294	5,928	12,062
2 Aomori	NA	1,157	1,014	NA	2,056	1,626	0.253	3,951	3,570	0.266	4,738	4,573	0.289	5,405	6,440	0.298	5,974	7,707	0.294	6,239	9,270	0.291	5,896	11,267
3 Iwate	NA	1,012	786	NA	2,426	1,954	0.263	3,502	3,023	0.294	4,448	4,629	0.283	5,307	6,901	0.272	6,674	10,540	0.283	7,351	12,767	0.298	6,455	12,363
4 Miyagi	NA	1,105	1,021	NA	2,788	2,301	0.251	4,223	4,470	0.260	5,158	4,947	0.271	6,307	8,006	0.279	7,486	10,666	0.275	7,167	12,261	0.307	6,764	11,894
5 Akita	NA	1,336	864	NA	2,616	1,810	0.268	4,129	3,814	0.262	4,821	4,266	0.274	5,872	7,364	0.274	7,284	9,642	0.279	7,254	9,966	0.300	6,235	11,512
6 Yamagata	NA	1,053	877	NA	2,341	1,803	0.256	4,151	3,761	0.266	5,088	4,688	0.272	6,748	7,695	0.273	8,045	10,705	0.277	7,926	13,045	0.306	7,070	12,675
7 Fukushima	NA	1,027	864	NA	2,407	1,963	0.279	3,893	3,798	0.278	5,182	5,290	0.273	6,127	7,660	0.299	7,294	11,202	0.301	7,578	12,405	0.312	6,536	13,216
8 Ibaraki	NA	1,130	1,266	NA	2,573	2,376	0.264	4,369	4,751	0.278	5,437	6,813	0.272	7,140	10,569	0.276	8,516	14,506	0.295	8,261	15,136	0.295	7,339	16,224
9 Tochigi	NA	1,291	1,306	NA	2,617	2,577	0.276	4,461	4,981	0.262	5,819	6,365	0.262	6,884	11,496	0.296	8,146	16,105	0.290	7,630	15,077	0.310	7,527	15,793
10 Gunma	NA	1,203	1,135	NA	2,586	2,361	0.251	4,216	4,627	0.267	5,475	6,571	0.289	6,312	9,731	0.287	8,001	15,031	0.302	7,415	16,836	0.293	6,704	15,878
11 Saitama	NA	1,347	1,322	NA	2,758	2,462	0.244	4,473	4,314	0.253	5,803	6,431	0.268	7,322	11,731	0.274	8,565	13,811	0.281	7,994	14,871	0.295	7,165	14,919
12 Chiba	NA	1,355	1,319	NA	2,765	2,511	0.254	4,593	5,108	0.266	5,898	7,036	0.272	7,439	11,391	0.283	8,683	13,165	0.294	8,330	16,243	0.302	7,230	16,646
13 Tokyo	NA	1,572	1,700	NA	3,067	3,137	0.287	4,843	6,287	0.282	6,165	8,236	0.315	7,691	14,720	0.301	8,494	16,210	0.314	8,082	18,408	0.314	7,799	19,961
14 Kanagawa	NA	1,443	1,481	NA	2,885	2,788	0.260	4,500	4,970	0.272	6,281	7,832	0.280	7,785	13,434	0.291	8,948	16,366	0.285	8,340	17,587	0.299	7,566	17,916
15 Niigata	NA	1,227	1,259	NA	2,432	1,963	0.263	4,177	4,116	0.259	5,631	6,296	0.271	6,515	9,215	0.279	8,086	12,637	0.292	7,904	14,513	0.312	7,406	16,220
16 Toyama	NA	1,178	1,150	NA	2,815	2,506	0.268	4,460	5,176	0.259	5,959	7,286	0.259	7,481	10,780	0.294	8,947	15,490	0.276	8,915	15,676	0.303	8,001	16,814
17 Ishikawa	NA	1,235	1,384	NA	2,773	2,857	0.247	4,486	5,005	0.261	5,875	7,285	0.272	7,144	14,108	0.281	9,152	16,794	0.285	8,728	17,861	0.286	7,409	16,219
18 Fukui	NA	1,213	1,541	NA	2,735	3,181	0.286	5,025	5,759	0.269	6,089	7,819	0.316	7,823	13,122	0.273	8,639	16,529	0.291	8,841	19,639	0.304	8,297	19,330
19 Yamanashi	NA	1,114	927	NA	2,580	2,368	0.267	4,178	4,796	0.257	5,550	6,703	0.258	6,370	9,703	0.278	7,967	12,968	0.287	7,591	13,453	0.280	6,380	13,253
20 Nagano	NA	1,165	1,203	NA	2,463	2,314	0.254	4,347	4,939	0.260	5,525	6,656	0.270	6,547	10,632	0.280	8,041	13,811	0.284	7,970	15,089	0.275	6,807	15,597
21 Gifu	NA	1,160	1,272	NA	2,813	3,074	0.237	4,602	5,033	0.285	5,840	7,173	0.271	6,895	10,957	0.273	8,300	15,472	0.302	8,593	18,079	0.293	7,345	17,212
22 Shizuoka	NA	1,315	1,321	NA	2,615	2,420	0.276	4,380	5,196	0.267	5,666	7,009	0.282	7,156	10,970	0.288	8,183	13,564	0.287	8,057	16,410	0.298	7,361	17,622
23 Aichi	NA	1,279	1,540	NA	2,836	2,892	0.277	4,456	5,716	0.271	6,098	8,468	0.280	7,223	12,592	0.296	8,574	15,924	0.301	8,081	16,767	0.306	7,636	19,433
24 Mie	NA	1,269	1,597	NA	2,736	3,058	0.247	4,137	5,033	0.251	5,541	6,694	0.283	7,161	11,692	0.289	8,224	15,492	0.286	8,159	15,888	0.287	7,346	19,677
25 Shiga	NA	1,286	1,497	NA	2,930	3,361	0.232	4,753	5,470	0.262	6,027	7,817	0.266	7,407	12,852	0.266	8,745	15,929	0.286	7,994	16,220	0.280	7,231	17,098
26 Kyoto	NA	1,593	1,646	NA	3,004	3,105	0.260	4,439	5,632	0.270	5,485	8,077	0.272	6,678	11,127	0.294	7,458	13,633	0.303	7,434	16,289	0.295	6,565	16,383
27 Osaka	NA	1,481	1,736	NA	2,844	2,975	0.276	4,275	5,378	0.271	5,304	7,208	0.291	6,725	12,716	0.308	7,742	14,578	0.296	7,223	15,175	0.323	6,443	15,079
28 Hyogo	NA	1,367	1,779	NA	2,746	2,827	0.272	4,384	5,839	0.281	5,771	7,835	0.293	6,709	13,310	0.287	7,955	15,221	0.296	7,552	15,521	0.314	6,857	16,826
29 Nara	NA	1,220	1,733	NA	2,639	2,927	0.248	4,659	6,405	0.255	5,664	7,923	0.252	6,882	12,601	0.292	8,066	15,819	0.292	8,019	16,010	0.290	7,019	19,270
30 Wakayama	NA	1,180	1,693	NA	2,574	3,311	0.255	4,038	5,210	0.303	5,511	8,111	0.303	5,916	10,795	0.309	7,009	12,886	0.295	6,959	14,747	0.304	6,209	16,929
31 Tottori	NA	1,112	1,134	NA	2,574	2,223	0.259	4,100	4,752	0.278	5,208	6,922	0.276	6,599	9,898	0.289	7,698	13,798	0.296	7,400	14,908	0.297	6,875	16,442
32 Shimane	NA	999	777	NA	2,343	1,890	0.269	4,021	4,191	0.284	5,444	5,958	0.271	6,032	9,969	0.292	7,395	12,366	0.322	7,707	13,343	0.298	6,789	15,128
33 Okayama	NA	1,164	1,330	NA	2,594	2,696	0.267	4,478	5,659	0.280	5,329	7,799	0.292	6,162	11,342	0.282	7,206	14,636	0.291	7,756	16,356	0.303	6,493	17,909
34 Hiroshima	NA	1,187	1,326	NA	2,641	2,444	0.264	4,136	4,935	0.276	5,351	6,620	0.275	6,225	10,185	0.286	7,659	13,471	0.311	7,240	15,763	0.301	6,778	15,478
35 Yamaguchi	NA	1,069	1,168	NA	2,639	2,391	0.252	4,122	5,025	0.267	4,990	6,585	0.283	6,135	10,064	0.282	7,410	13,813	0.294	6,530	13,216	0.293	6,388	14,772
36 Tokushima	NA	1,101	1,292	NA	2,330	2,156	0.298	4,128	5,444	0.287	5,384	6,979	0.284	6,065	9,934	0.294	7,235	13,253	0.321	7,361	15,291	0.345	6,607	16,186
37 Kagawa	NA	1,165	1,259	NA	2,762	2,886	0.266	4,429	5,768	0.288	5,257	7,573	0.266	6,347	13,286	0.294	7,438	15,379	0.285	7,530	17,431	0.292	6,805	18,858
38 Ehime	NA	1,144	1,084	NA	2,272	2,126	0.265	3,876	4,516	0.291	4,834	6,734	0.299	5,627	10,117	0.300	6,833	12,740	0.288	6,355	12,883	0.295	6,157	15,770
39 Kochi	NA	1,074	1,058	NA	2,496	2,325	0.271	3,749	4,267	0.310	4,613	5,482	0.299	5,613	9,695	0.330	6,612	12,490	0.326	6,726	13,279	0.313	6,331	16,847
40 Fukuoka	NA	1,175	1,079	NA	2,404	1,788	0.267	4,008	4,112	0.296	5,024	5,324	0.290	5,579	8,374	0.311	7,159	11,540	0.317	6,797	11,946	0.302	6,464	13,414
41 Saga	NA	1,073	1,064	NA	2,293	2,065	0.261	3,799	3,610	0.286	4,923	5,248	0.301	6,147	8,612	0.296	7,159	11,607	0.284	7,440	12,538	0.296	6,832	13,363
42 Nagasaki	NA	1,113	942	NA	2,184	1,473	0.249	3,659	3,511	0.287	4,273	5,116	0.259	5,249	6,941	0.289	6,129	8,777	0.301	6,646	10,999	0.309	5,855	11,355
43 Kumamoto	NA	1,116	804	NA	2,233	1,750	0.276	3,713	3,716	0.286	4,791	5,155	0.308	5,721	7,603	0.313	6,874	10,354	0.310	6,640	10,824	0.316	6,388	11,657
44 Oita	NA	1,178	1,072	NA	2,281	1,969	0.275	3,666	3,944	0.274	4,470	4,539	0.299	5,560	7,827	0.291	6,406	10,268	0.283	6,764	12,249	0.299	5,811	12,271
45 Miyazaki	NA	1,037	906	NA	2,408	1,677	0.301	3,520	3,125	0.319	4,104	3,876	0.298	4,781	6,044	0.294	5,797	8,779	0.312	6,216	10,263	0.311	5,934	10,030
46 Kagoshima	NA	887	644	NA	2,037	1,423	0.272	3,236	2,854	0.291	3,730	4,031	0.310	4,583	6,318	0.302	5,831	8,461	0.282	5,885	10,217	0.293	5,827	10,410
47 Okinawa	NA	NA	NA	NA	2,128	990	0.299	3,261	2,345	0.337	3,648	2,656	0.332	4,505	4,728	0.380	5,491	5,238	0.353	5,298	5,918	0.344	4,516	5,484
Mean	NA	1,197	1,220	NA	2,562	2,357	0.265	4,170	4,637	0.276	5,278	6,335	0.282	6,368	10,054	0.291	7,575	12,971	0.296	7,457	14,261	0.302	6,753	15,120
Standard deviation	NA	144	293	NA	248	557	0.015	391	919	0.018	617	1,375	0.017	833	2,386	0.018	915	2,680	0.015	792	2,754	0.013	688	3,007
Lowest	NA	887	644	NA	2,037	990	0.232	3,236	2,345	0.251	3,648	2,656	0.252	4,505	4,728	0.266	5,491	5,238	0.275	5,298	5,918	0.275	4,516	5,484
Highest	NA	1,593	1,779	NA	3,067	3,361	0.301	5,025	6,405	0.337	6,281	8,468	0.332	7,823	14,720	0.380	9,152	16,794	0.353	8,915	19,639	0.345	8,297	19,961

NA; not available

[a] These data were obtained from the *National Survey of Family Income and Expenditure* . All variables were calculated among two-or-more-person households. Average yearly income and average savings are shown in thousand yen.

[b] The data for Okinawa prefecture were not available in 1969.

[c] Gini's coefficients of yearly income were not available in these years, and we imputed the values of 1979 forwardly in the analysis.

Supplementary Table 10. Odds ratios for all-cause premature mortality of prefecture-level socioeconomic status variables, Japan, 1970-2005 [a]

	Overall		1970 [b]		1975 [b]		1980		1985		1990		1995		2000		2005	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Men																		
Gini's coefficient of yearly income [c]																		
Low	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.01	(0.99 to 1.03)	1.03	(0.98 to 1.07)	1.03	(0.99 to 1.07)	1.01	(0.97 to 1.06)	1.00	(0.97 to 1.04)	1.03	(0.99 to 1.07)	0.99	(0.93 to 1.04)	1.02	(0.96 to 1.08)	0.99	(0.92 to 1.07)
High	1.01	(0.98 to 1.03)	1.03	(0.99 to 1.07)	1.01	(0.97 to 1.05)	0.99	(0.95 to 1.04)	0.98	(0.94 to 1.01)	0.99	(0.95 to 1.03)	1.00	(0.94 to 1.06)	0.98	(0.93 to 1.05)	0.98	(0.91 to 1.06)
Average yearly income [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	0.99	(0.97 to 1.02)	0.99	(0.95 to 1.03)	1.04	(1.00 to 1.08)	1.05	(1.00 to 1.09)	0.99	(0.95 to 1.03)	1.00	(0.96 to 1.04)	1.05	(0.99 to 1.11)	1.07	(1.01 to 1.13)	0.99	(0.91 to 1.07)
Low	0.99	(0.96 to 1.02)	1.04	(1.00 to 1.08)	1.05	(1.01 to 1.08)	1.04	(0.99 to 1.09)	0.98	(0.94 to 1.02)	0.96	(0.92 to 1.00)	1.01	(0.96 to 1.07)	1.04	(0.98 to 1.10)	1.03	(0.96 to 1.11)
Average savings [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.00	(0.97 to 1.02)	1.04	(1.00 to 1.08)	1.04	(1.00 to 1.08)	1.02	(0.97 to 1.07)	1.02	(0.98 to 1.06)	0.99	(0.95 to 1.03)	1.05	(0.99 to 1.11)	1.07	(1.01 to 1.13)	1.03	(0.95 to 1.11)
Low	1.01	(0.98 to 1.05)	1.07	(1.03 to 1.12)	1.05	(1.01 to 1.09)	1.02	(0.98 to 1.07)	0.99	(0.95 to 1.03)	0.97	(0.93 to 1.01)	1.04	(0.98 to 1.10)	1.07	(1.01 to 1.14)	1.08	(1.00 to 1.16)
Women																		
Gini's coefficient of yearly income [c]																		
Low	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.00	(0.97 to 1.02)	0.98	(0.93 to 1.05)	1.01	(0.95 to 1.08)	1.00	(0.95 to 1.05)	1.04	(0.99 to 1.09)	1.02	(0.97 to 1.07)	0.97	(0.90 to 1.03)	0.96	(0.89 to 1.03)	0.99	(0.91 to 1.07)
High	1.01	(0.98 to 1.04)	1.01	(0.95 to 1.07)	1.04	(0.98 to 1.11)	1.04	(0.98 to 1.10)	1.05	(1.00 to 1.10)	1.02	(0.97 to 1.07)	0.99	(0.93 to 1.06)	0.99	(0.92 to 1.07)	1.00	(0.93 to 1.09)
Average yearly income [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.01	(0.98 to 1.04)	1.09	(1.03 to 1.15)	1.07	(1.01 to 1.13)	1.01	(0.96 to 1.06)	1.04	(0.99 to 1.10)	1.01	(0.97 to 1.07)	1.00	(0.94 to 1.07)	1.06	(0.99 to 1.14)	0.96	(0.89 to 1.04)
Low	1.02	(0.99 to 1.06)	1.10	(1.05 to 1.16)	1.09	(1.04 to 1.16)	1.05	(0.99 to 1.11)	1.04	(0.98 to 1.09)	1.02	(0.97 to 1.08)	1.04	(0.98 to 1.12)	1.04	(0.97 to 1.12)	1.04	(0.96 to 1.13)
Average savings [c]																		
High	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Middle	1.00	(0.97 to 1.03)	1.09	(1.03 to 1.15)	1.05	(0.99 to 1.12)	1.01	(0.96 to 1.07)	1.02	(0.96 to 1.07)	1.08	(1.03 to 1.13)	1.03	(0.96 to 1.10)	1.05	(0.98 to 1.13)	1.01	(0.93 to 1.09)
Low	1.02	(0.98 to 1.06)	1.08	(1.02 to 1.14)	1.04	(0.98 to 1.11)	1.02	(0.96 to 1.07)	1.01	(0.96 to 1.07)	1.03	(0.98 to 1.07)	1.06	(0.99 to 1.13)	1.08	(1.00 to 1.16)	1.05	(0.97 to 1.14)

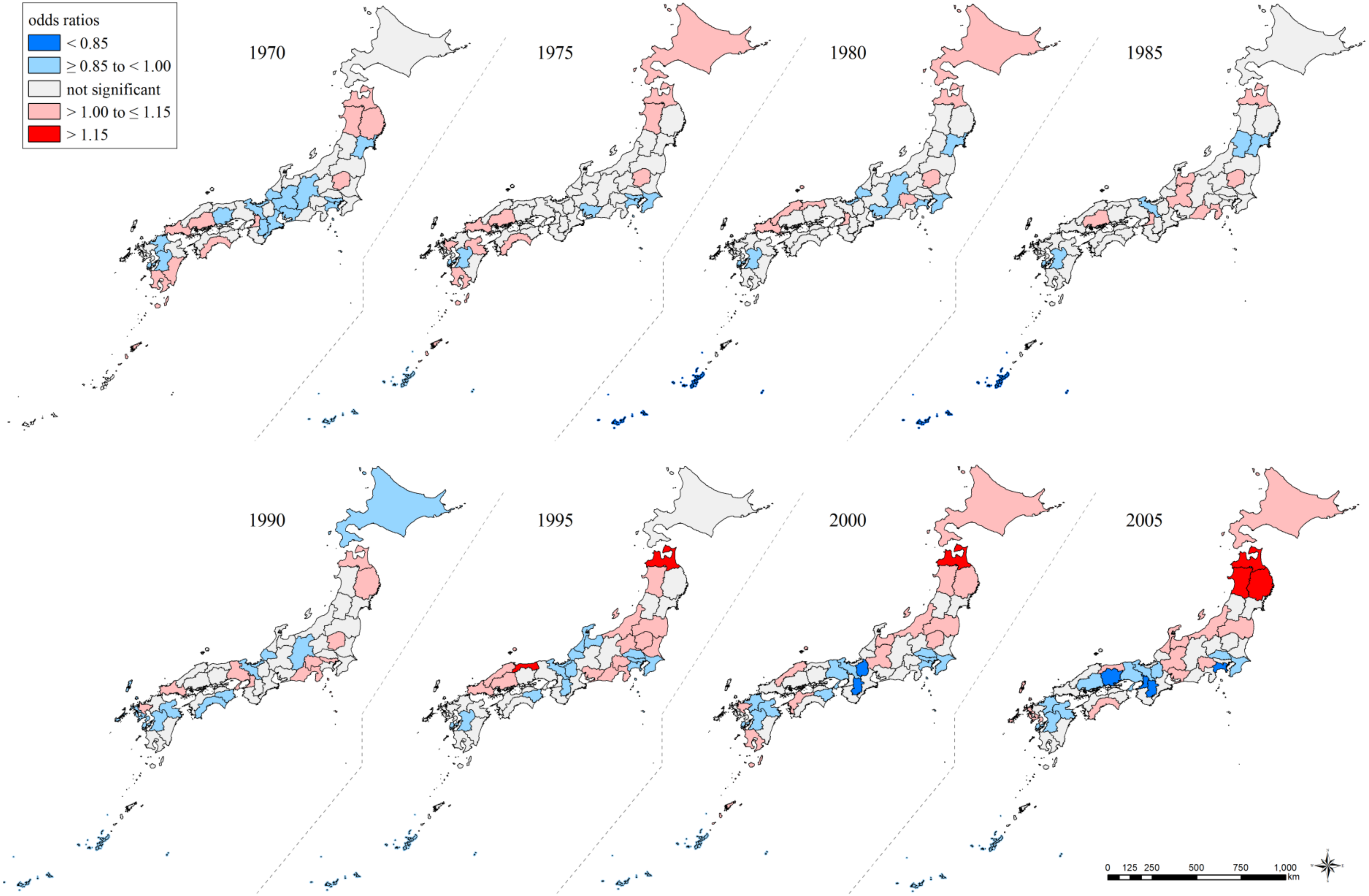
CI; confidence interval, OR; odds ratio

[a] These odds ratios were adjusted for age, occupations, and year (only in the overall model). Prefecture-level variables were adjusted for separately.

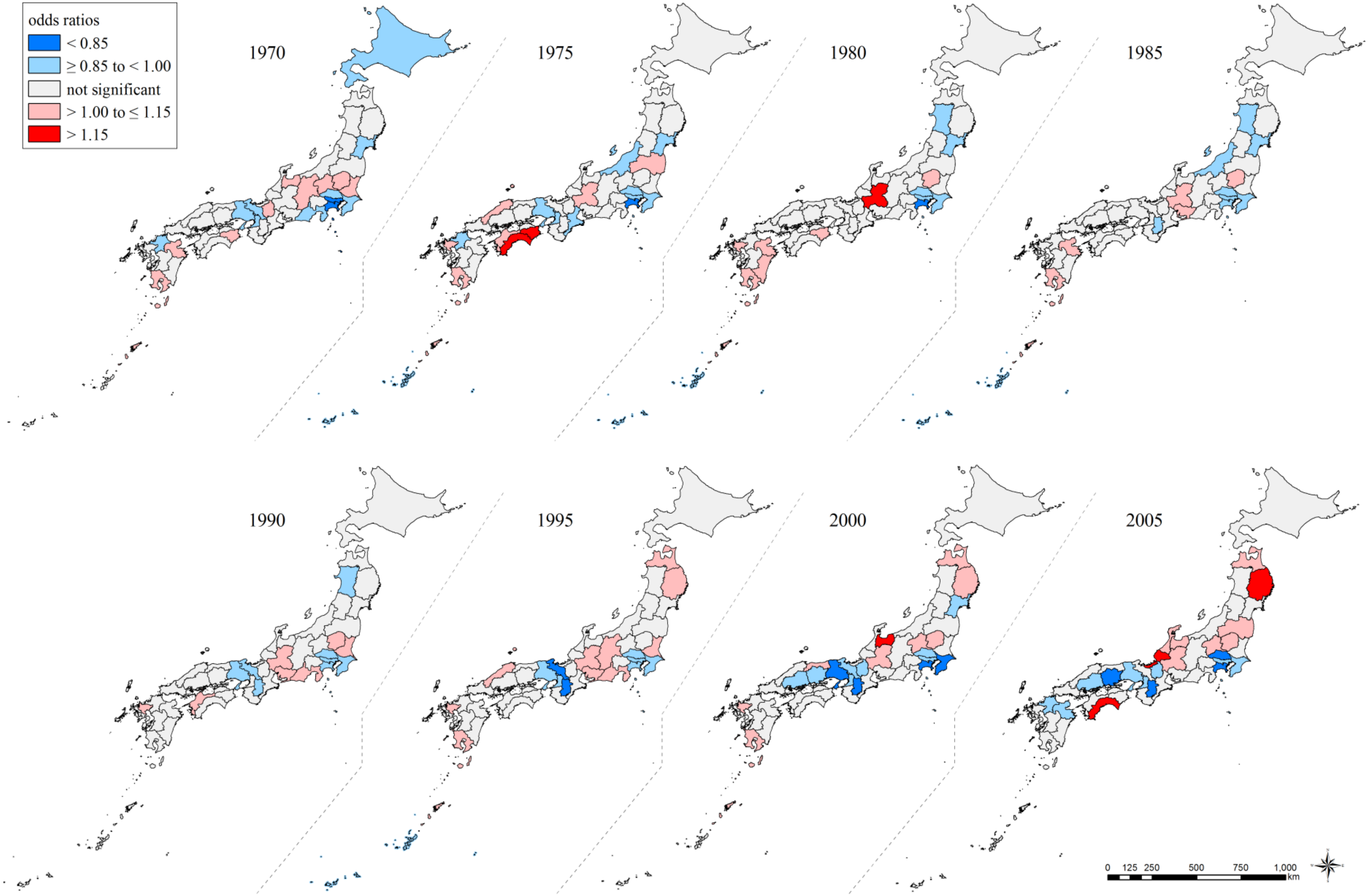
[b] Gini's coefficients of yearly income were not available in these models, and we imputed the vlaues of the 1980 model to them.

[c] These variables were calculated among two-or-more-person households.

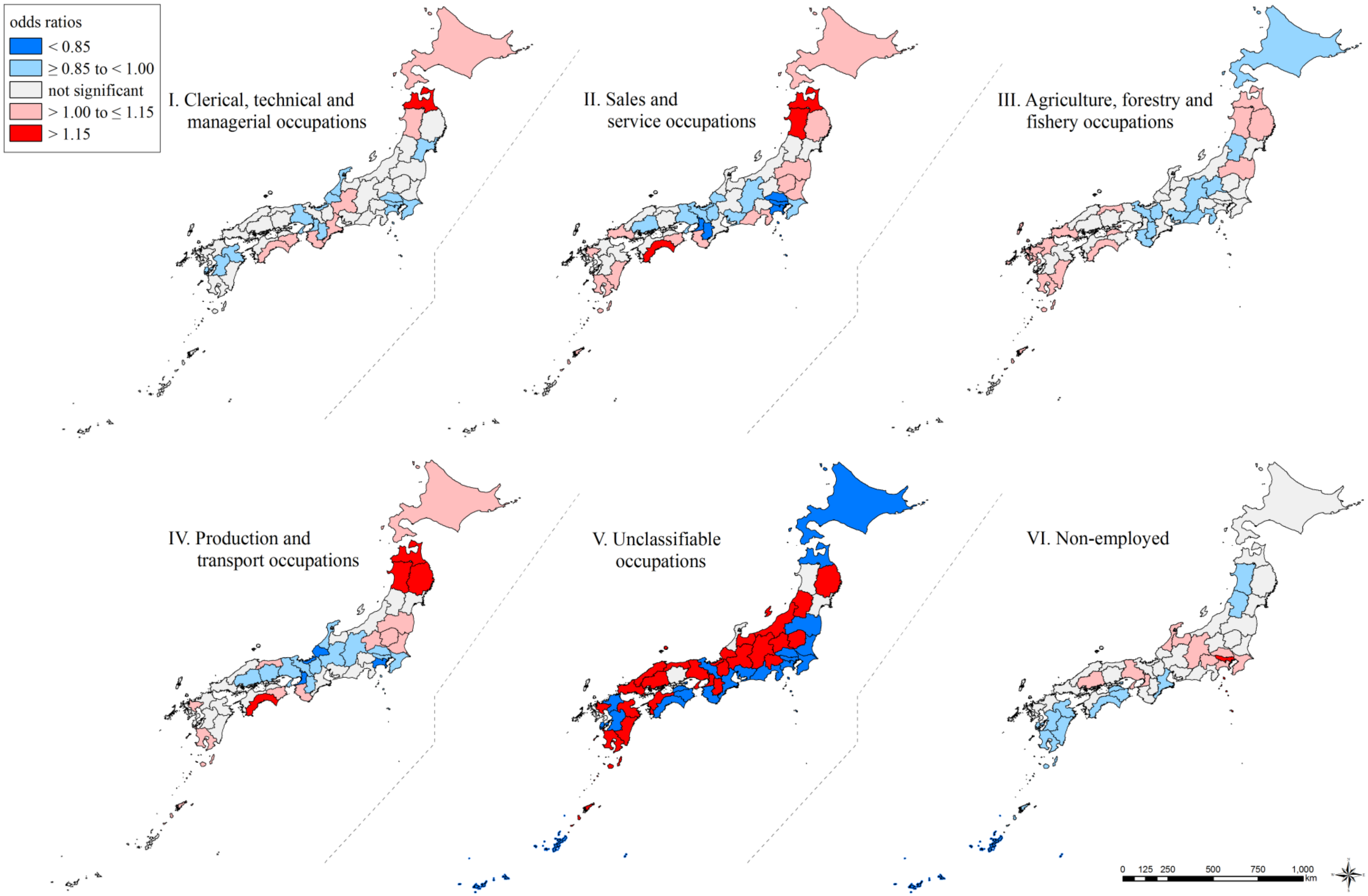
Supplementary Figure 1. A blank map of Japan.



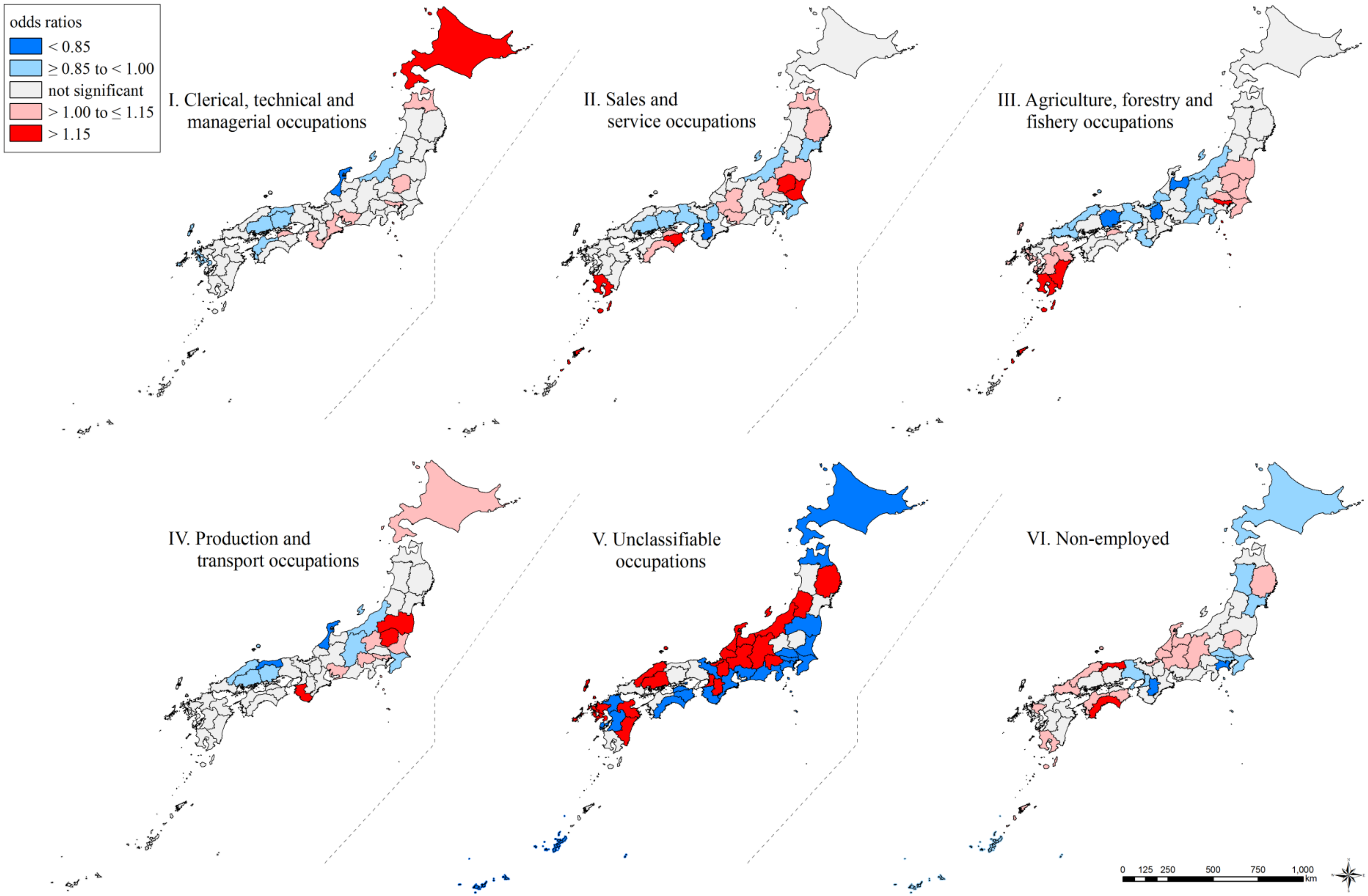
Supplementary Figure 2. Geographic and temporal variation in all-cause premature mortality among men, Japan.



Supplementary Figure 3. Geographic and temporal variation in all-cause premature mortality among women, Japan.



Supplementary Figure 4. Geographic inequality of all-cause premature mortality by occupational groups among men, Japan, 1970-2005.



Supplementary Figure 5. Geographic inequality of all-cause premature mortality by occupational groups among women, Japan, 1970-2005.

Legends of Supplementary Figures

Supplementary Figure 1. A blank map of Japan.

We show the locations of 47 prefectures in Japan.

Supplementary Figure 2. Geographic and temporal variation in all-cause premature mortality among men, Japan.

We show year-specific geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age and occupation. (The data for Okinawa prefecture were not available in 1970.) Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Supplementary Figure 3. Geographic and temporal variation in all-cause premature mortality among women, Japan.

We show year-specific geographic inequality of all-cause mortality across 47 prefectures, conditional on individual age and occupation. (The data for Okinawa prefecture were not available in 1970.) Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Supplementary Figure 4. Geographic inequality of all-cause premature mortality by occupational groups among men, Japan, 1970-2005.

We show the geographic inequality of all-cause mortality across 47 prefectures for the six collapsed occupational groups, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

Supplementary Figure 5. Geographic inequality of all-cause premature mortality by occupational groups among women, Japan, 1970-2005.

We show the geographic inequality of all-cause mortality across 47 prefectures for the six collapsed occupational groups, conditional on individual age, occupation, and year. Prefecture-level residuals are described in odds ratios with the reference being the grand mean of all the prefectures. Prefectures with a lower and a higher estimate of odds for mortality are filled with blue and red, respectively. Regarding areas filled with gray, prefecture-level residuals were not statistically significant.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes
Methods			
Study design	4	Present key elements of study design early in the paper	Yes
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Yes
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	Yes
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes
		(*b*) Describe any methods used to examine subgroups and interactions	Yes
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	Yes
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which	Yes

		confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Yes
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Yes
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.