Study profile: protocol outline and study perspectives of the cohort by the National Institute of Occupational Safety and Health, Japan (JNIOSH cohort)

Yuki SATO1*, Masaya TAKAHASHI1, Yuko OCHIAI1,2, Tomoaki MATSUO1, Takeshi SASAKI1, Kenji FUKASAWA3, Tsuyoshi ARAKI3, Masao TSUCHIYA3 and Group of JNIOSH cohort study

1Research Center for Overwork-Related Disorders, National Institute of Occupational Safety and Health Japan, Japan Organization of Occupational Health and Safety, Japan
2Faculty of Human Sciences, University of Tsukuba, Japan
3Advantage Risk Management Co., Ltd., Japan

Abstract: How work burden affects physical and mental health has already been studied extensively; however, many issues have remained unexamined. In 2017, we commenced a prospective cohort study of workers at companies in Japan, with a follow-up period of 5–10 years, in order to investigate the current situation of overwork-related health outcomes. From 2017 to 2020, a target population of 150,000 workers across 8 companies was identified. Of these, almost 40,000 workers agreed to participate in the baseline survey. Data on working hours, medical check-up measurements, occupational stress levels, and lifestyle habits were collected. The average age of the participants at baseline was 39.2 ± 11.7 years; 73.1% were men, and 87.7% were regular employees. The most common working hours by self-reported was 41–50 hours per week during normal season, and it increased to more than 50 hours during busy season. Furthermore, more than half of the participants reportedly experienced a form of sleep problem, and the percentage of those who experienced nonrestorative sleep was particularly high.

Key words: Occupational cohort, Working hours, Health check-ups, Job stress, Health outcome

Introduction

The prevention of brain and heart diseases, mental disorders from psychological stress, and suicide as a result of overwork are among the top priorities for ensuring a safe, healthy, productive, and prosperous working life for people in Japan. The Act of Promoting Measures to Prevent Death and Injury from Overwork was enacted in 2014, and then activities to prevent overwork have been steadily promoted. Despite this initiative, the number of cases of brain and heart disease due to overwork has not decreased dramatically, and there are signs of an increase in the number of cases of mental disorders due to the heavy psychological burden of work1–4. The association between long working hours and cardiovascular disease risk has been reported...
Recruitment began in November 2017. In total, eight companies/workplaces participated in this study, four began their participation in 2017–2018, and the last four were included in 2019. From the four companies/workplaces that commenced participation in 2017–2018, 12,563 of 16,623 workers agreed to participate (agreement rate: 75.6%) in the 2017–2018 survey, while 12,677 out of 16,703 workers agreed to participate in the 2019 survey (agreement rate: 75.9%). The number of participants varies each year because there were new participants, retirees, and withdrawals. In the companies/workplaces that participated from 2019, 31,549 out of the 136,308 workers agreed to participate (agreement rate: 23.1%). Overall, we obtained consent from 44,226 of the 153,011 workers by 2019. This study had an annual recruitment and consent process for all workers, including those who agreed to participate in a past survey. We used a dynamic cohort design because of its flexibility which ensured that those who were eligible for the survey in 2017–2018 but did not agree to participate at that time and newly employed workers can participate in a future survey.

Data collection
The study data included working conditions recorded by the companies (working hours and days of work), physical conditions from the results of regular medical health check-ups, occupational stress, self-reported occupational background, working hours and sleep habits reported via additional questionnaire. We have continuously performed the same data collection once a year with the same participants. Moreover, we continued to recruit new participants into this study.

Recorded working conditions
The working conditions provided by the companies and workplaces were as follows: monthly number of working days, vacation days, absent days, scheduled working hours, actual working hours, overtime working hours, and midnight working hours.

Medical check-ups
The data from the medical check-up included sex, age, height, weight, body mass index (BMI), waist circumference, systolic and diastolic blood pressure, medication use, past history of disease, and blood test results. The blood test investigations were total cholesterol (mg/dL), high-density lipoprotein cholesterol (mg/dL), low-density lipoprotein (LDL) cholesterol (mg/dL), triglycerides (mg/dL),
fasting blood glucose (mg/dL), hemoglobin (Hb) A1c (%), aspartate aminotransferase (AST) (IU/L), alanine aminotransferase (ALT) (IU/L), γ-glutamyl transpeptidase (γ-GTP) (IU/L), creatinine, and uric acid. We used the results of the regular medical check-ups at the company and workplace to evaluate the participants’ physical condition.

**Ethics**

This survey was conducted according to the Ethical Guidelines for Epidemiological Studies established by the Japanese government17), and it was approved by the Ethics Committee of JNIOSH (No. H2812 and H2919). We obtained informed consent from all participants via online or via a written form.

**Statistical Analyses**

For the univariate analysis, we reported the frequencies and percentages of blood test results, medical check-ups, self-reported working hours, and sleep problems by sex. We then compared proportions using the chi-squared test. All analyses were conducted using IBM SPSS Statistics (Version 26).

**Results**

Table 1 shows the summary of the participants’ backgrounds at baseline in the preliminary data. The data included 111,313 participants, with a mean of age of 39.2 ± 11.7. Majority of the participants were men (73.1%), and their mean age was 40.1 ± 11.5 years, while 26.9% were women, with a mean age of 36.3 ± 11.2 years. The majority (87.7%) of the participants were regular employees, and most (93.3%) of the male participants were regular employees. Among women, the majority (72.5%) were regular employees, followed by part-time employees (15.4%) and contract workers (6.1%). Regarding job category, 19.9% were managers (25.8% of the men and 3.9% of the women). With respect to the non-managerial positions, men worked in sales and marketing (21.6%), followed by construction (15.1%) and professional occupations (13.8%). Among women, 34.6% were office workers, 16.8% worked in sales and marketing, and 16.5% were service workers. The most common working hours were 41–50 hours/week (48.6% in total, 50.8% of the men and 42.5% of the women), followed by 51–60 hours/week for men (17.5%) and 35–40 hours/week for women (28.6%). The result for the total working hours in the busy season including outside the workplace showed that working hours were higher than usual during the busy season. In particular, the percentage of those working 51–60 hours/week increased by 10% compared to the normal season.

Table 2 shows the participant’s sleep status and sleep problems at baseline in the preliminary data. The percent-
Table 1. Characteristics and occupational background by self-administered questionnaire among participants in preliminary data

|                        | Total (n=11,313) | Men (n=8,273) | Women (n=3,040) | p-value* |
|------------------------|------------------|---------------|-----------------|----------|
| **Age group**          |                  |               |                 |          |
| under 30 yrs           | 2,769 (24.5)     | 1,676 (20.3)  | 1,093 (36.0)    | <0.001   |
| 30–39 yrs              | 3,630 (32.1)     | 2,756 (33.3)  | 874 (28.8)      |          |
| 40–49 yrs              | 2,543 (22.5)     | 1,938 (23.4)  | 605 (19.9)      |          |
| 50–59 yrs              | 1,669 (14.8)     | 1,306 (15.8)  | 363 (11.9)      |          |
| ≥60 yrs                | 702 (6.2)        | 597 (7.2)     | 105 (3.5)       |          |
| **Employment type**    |                  |               |                 |          |
| Regular employee       | 9,920 (87.7)     | 7,716 (93.3)  | 2,204 (72.5)    | <0.001   |
| Contracted employee    | 383 (3.4)        | 197 (2.4)     | 186 (6.1)       |          |
| Fixed-term employee    | 134 (1.2)        | 119 (1.4)     | 15 (0.5)        |          |
| Temporary staff        | 7 (0.1)          | 4 (0.0)       | 3 (0.1)         |          |
| Part-time              | 640 (5.7)        | 172 (2.1)     | 468 (15.4)      |          |
| Other                  | 229 (2.0)        | 65 (0.8)      | 164 (5.4)       |          |
| **Work schedule**      |                  |               |                 |          |
| Fixed time system      | 6,156 (54.4)     | 4,298 (52.0)  | 1,858 (61.1)    | <0.001   |
| Variable working hours system | 1,543 (13.6) | 1,027 (12.4) | 516 (17.0) |          |
| Flextime system        | 3,049 (27.0)     | 2,606 (31.5)  | 443 (14.6)      |          |
| Discretionary labor system | 57 (0.5) | 49 (0.6) | 8 (0.3) |          |
| Two-shift system (with night shifts) | 190 (1.7) | 131 (1.6) | 59 (1.9) |          |
| Two-shift system (without night shift) | 70 (0.6) | 39 (0.5) | 31 (1.0) |          |
| Three-shift system     | 73 (0.6)         | 35 (0.4)      | 38 (1.3)        |          |
| Only swing shift       | 20 (0.2)         | 9 (0.1)       | 11 (0.4)        |          |
| Only night shift       | 30 (0.3)         | 17 (0.2)      | 13 (0.4)        |          |
| Other                  | 125 (1.1)        | 62 (0.7)      | 63 (2.1)        |          |
| **Job categories**     |                  |               |                 |          |
| Manager                | 2,255 (19.9)     | 2,137 (25.8)  | 118 (3.9)       | <0.001   |
| Professional, technical and research jobs | 1,595 (14.1) | 1,142 (13.8) | 453 (14.9) |          |
| Office work            | 1,980 (17.5)     | 928 (11.2)    | 1,052 (34.6)    |          |
| Product sales          | 9 (0.1)          | 8 (0.1)       | 1 (0.0)         |          |
| Sales and Marketing    | 2,293 (20.3)     | 1,783 (21.6)  | 510 (16.8)      |          |
| Services               | 1,156 (10.2)     | 654 (7.9)     | 502 (16.5)      |          |
| Transport              | 41 (0.4)         | 36 (0.4)      | 5 (0.2)         |          |
| Construction           | 1,322 (11.7)     | 1,249 (15.1)  | 73 (2.4)        |          |
| Manufacturing          | 48 (0.4)         | 41 (0.5)      | 7 (0.2)         |          |
| Other                  | 614 (5.4)        | 295 (3.6)     | 319 (10.5)      |          |
Table 1. Continued

|                     | Total (n=11,313) | Men (n=8,273) | Women (n=3,040) | p-value* |
|---------------------|------------------|---------------|-----------------|----------|
|                     | n (% )           | n (%)         | n (%)           |          |
| Working hours/week, at workplace |                 |               |                 |          |
| 1–34h               | 1,372 (12.1)     | 763 (9.2)     | 609 (20.0)      | <0.001   |
| 35–40h              | 2,170 (19.2)     | 1,301 (15.7)  | 869 (28.6)      |          |
| 41–50h              | 5,498 (48.6)     | 4,205 (50.8)  | 1,293 (42.5)    |          |
| 51–60h              | 1,647 (14.6)     | 1,448 (17.5)  | 199 (6.5)       |          |
| 61–65h              | 325 (2.9)        | 295 (3.6)     | 30 (1.0)        |          |
| 66–70h              | 146 (1.3)        | 134 (1.6)     | 12 (0.4)        |          |
| ≥71h                | 155 (1.4)        | 127 (1.5)     | 28 (0.9)        |          |
| Working hours/week during busy term, including outside of workplace |                 |               |                 |          |
| 1–34h               | 1,916 (16.9)     | 1,083 (13.1)  | 833 (27.4)      | <0.001   |
| 35–40h              | 1,354 (12.0)     | 793 (9.6)     | 561 (18.5)      |          |
| 41–50h              | 3,172 (28.0)     | 2,266 (27.4)  | 906 (29.8)      |          |
| 51–60h              | 2,877 (25.4)     | 2,364 (28.6)  | 513 (16.9)      |          |
| 61–65h              | 1,012 (8.9)      | 879 (10.6)    | 133 (4.4)       |          |
| 66–70h              | 492 (4.3)        | 444 (5.4)     | 48 (1.6)        |          |
| ≥71h                | 490 (4.3)        | 444 (5.4)     | 46 (1.5)        |          |

* Test of the difference between the proportions of men and women (chi-squared test)

age of people who had some type of sleep problem at least once a month (the sum of the percentage “1 or more times/month”, “1–2 times/week”, “3 or more times/week", and “almost every day”) was calculated. The most common sleep problem was “nonrestorative sleep” (67.7%), which was noted to be higher among women (71.8%) than men (66.5%). Other common sleep problems were “excessive sleepiness on the job” (44.5%), difficulty maintaining sleep (37.8%), and early morning awakening (30.3%).

Table 3 shows the baseline health status of the participants among 9,549 participants, including 7,254 men (76%) and 2,293 women (24%). The total number of participants with available and missing medical check-up data was different for each item, as shown in the Appendix Table. The coverage of medical check-up data among 11,313 participants (8,273 men and 3,040 women) with fixed background data was 84.4%, with 87.7% in men and 75.4% in women. The items with the highest rate of abnormalities in total were LDL (42.3%), HbA1c (31.5%), and BMI (28.3%). Moreover, around 20% of the participants, which was one in five of the participants, have above normal level of triglyceride, ALT, and γ-GTP. The percentage of participants with abnormal values was significantly higher in men than in women for all items (p<0.001). The percentage of participants with a BMI of 25 or more, i.e., overweight was 33.4% for men, which is almost three times higher than women (12.3%).

Discussion

The JNIOSH cohort study is one of the occupational cohorts in Japan that could provide a comprehensive analysis of the relationship between working hours and health outcomes. An important goal of this cohort is to examine intermediate indicators like overwork that are likely to be associated with health outcomes using a cross-sectional and longitudinal data set to determine the contribution and multiple effects. Given that the results presented in this paper were based on preliminary data, only a superficial outline can be shown. The results showed a difference in the distri-
bution of working hours between men and women. This difference might be attributed to the differences in terms of the background of working conditions, such as employment type, work schedule, and job category. Moreover, the results of the baseline blood tests by medical check-up showed differences in men and women; hence, biological differences and differences in working backgrounds could be complicated in this cohort population. Adjustments for lifestyle, medication use, and medical history could also lead to more reliable results. This information will be accumulated and completed accordingly.

The unique points of this cohort study were that it included a wide range of industries and multiple companies and two types of methods were used to assess working

Table 2. Sleep status and sleep problems among participants in preliminary data

|                      | Total (n=11,313) | Men (n=8,273) | Women (n=3,040) | p-value* |
|---------------------|------------------|---------------|-----------------|----------|
| **Difficulty maintaining sleep** |                  |               |                 |          |
| Almost never        | 5,107 (45.1)     | 3,655 (44.2)  | 1,452 (47.8)    | <0.001   |
| A few times a year (occasionally) | 1,927 (17.0)     | 1,428 (17.3)  | 499 (16.4)      |          |
| 1 or more times/month | 1,718 (15.2)     | 1,306 (15.8)  | 412 (13.6)      |          |
| 1–2 times/week      | 1,430 (12.6)     | 1,058 (12.8)  | 372 (12.2)      |          |
| 3 or more times/week| 623 (5.5)        | 471 (5.7)     | 152 (5.0)       |          |
| Almost every day    | 508 (4.5)        | 355 (4.3)     | 153 (5.0)       |          |

| **Early morning awakening** |                  |               |                 |          |
| Almost never          | 6,227 (55.0)     | 4,327 (52.3)  | 1,900 (62.5)    | <0.001   |
| A few times a year (occasionally) | 1,647 (14.6)     | 1,244 (15.0)  | 403 (13.3)      |          |
| 1 or more times/month | 1,464 (12.9)     | 1,173 (14.2)  | 291 (9.6)       |          |
| 1–2 times/week        | 1,158 (10.2)     | 888 (10.7)    | 270 (8.9)       |          |
| 3 or more times/week  | 478 (4.2)        | 398 (4.8)     | 80 (2.6)        |          |
| Almost every day      | 339 (3.0)        | 243 (2.9)     | 96 (3.2)        |          |

| **Nonrestorative sleep** |                  |               |                 |          |
| Almost never           | 2,078 (18.4)     | 1,577 (19.1)  | 501 (16.5)      | <0.001   |
| A few times a year (occasionally) | 1,541 (13.6)     | 1,184 (14.3)  | 357 (11.7)      |          |
| 1 or more times/month  | 1,934 (17.1)     | 1,451 (17.5)  | 483 (15.9)      |          |
| 1–2 times/week         | 2,529 (22.4)     | 1,845 (22.3)  | 684 (22.5)      |          |
| 3 or more times/week   | 1,469 (13.0)     | 1,079 (13.0)  | 390 (12.8)      |          |
| Almost every day       | 1,762 (15.6)     | 1,137 (13.7)  | 625 (20.6)      |          |

| **Excessive sleepiness on the job** |                  |               |                 |          |
| Almost never            | 3,933 (34.8)     | 2,706 (32.7)  | 1,227 (40.4)    | <0.001   |
| A few times a year (occasionally) | 2,354 (20.8)     | 1,777 (21.5)  | 577 (19.0)      |          |
| 1 or more times/month   | 2,292 (20.3)     | 1,723 (20.8)  | 569 (18.7)      |          |
| 1–2 times/week          | 1,743 (15.4)     | 1,324 (16.0)  | 419 (13.8)      |          |
| 3 or more times/week    | 644 (5.7)        | 497 (6.0)     | 147 (4.8)       |          |
| Almost every day        | 347 (3.1)        | 246 (3.0)     | 101 (3.3)       |          |

* Test of the difference between the proportions of men and women (chi-squared test)
Table 3. Health status according to medical check-ups among participants in preliminary data

| Measured item           | Total n (%) | Men n (%) | Women n (%) | p-value* |
|-------------------------|-------------|-----------|-------------|----------|
|                         | n (%)       | n (%)     | n (%)       |          |
| Body mass index         |             |           |             |          |
| <25 kg/m²               | 6,822 (71.7)| 4,813 (66.6)| 2,009 (87.7)| <0.001   |
| ≥25 kg/m²               | 2,692 (28.3)| 2,409 (33.4)| 283 (12.3) |          |
| Systolic blood pressure |             |           |             |          |
| <140 mm Hg              | 8,684 (91.0)| 6,464 (89.1)| 2,220 (96.8)| <0.001   |
| ≥140 mm Hg              | 862 (9.0)  | 789 (10.9) | 73 (3.2)   |          |
| Diastolic blood pressure|             |           |             |          |
| <90 mm Hg               | 8,702 (91.2)| 6,478 (89.3)| 2,224 (97.0)| <0.001   |
| ≥90 mm Hg               | 844 (8.8)  | 775 (10.7) | 69 (3.0)   |          |
| HDL cholesterol         |             |           |             |          |
| ≥40 mg/dL               | 8,850 (93.2)| 6,593 (91.4)| 2,257 (98.9)| <0.001   |
| <40 mg/dL               | 647 (6.8)  | 621 (8.6)  | 26 (1.1)   |          |
| LDL cholesterol         |             |           |             |          |
| <120 mg/dL              | 5,477 (57.7)| 3,791 (52.6)| 1,686 (73.9)| <0.001   |
| ≥120 mg/dL              | 4,012 (42.3)| 3,415 (47.4)| 597 (26.1) |          |
| Triglycerides           |             |           |             |          |
| <150 mg/dL              | 7,583 (79.8)| 5,426 (75.1)| 2,157 (94.4)| <0.001   |
| ≥150 mg/dL              | 1,923 (20.2)| 1,796 (24.9)| 127 (5.6)  |          |
| Fasting blood glucose   |             |           |             |          |
| <100mg/dL               | 6,277 (82.5)| 4,530 (79.4)| 1,747 (92.0)| <0.001   |
| ≥100mg/dL               | 1,327 (17.5)| 1,176 (20.6)| 151 (8.0)  |          |
| HbA1c                   |             |           |             |          |
| <5.6 %                  | 4,795 (68.5)| 3,758 (67.0)| 1,037 (74.8)| <0.001   |
| ≥5.6 %                  | 2,204 (31.5)| 1,854 (33.0)| 350 (25.2) |          |
| AST                     |             |           |             |          |
| <30 IU/L                | 8,329 (87.6)| 6,114 (84.6)| 2,215 (97.0)| <0.001   |
| ≥30 IU/L                | 1,178 (12.4)| 1,110 (15.4)| 68 (3.0)   |          |
| ALT                     |             |           |             |          |
| <30 IU/L                | 7,250 (76.3)| 5,075 (70.3)| 2,175 (95.3)| <0.001   |
| ≥30 IU/L                | 2,257 (23.7)| 2,149 (29.7)| 108 (4.7)  |          |
| γ-GTP                   |             |           |             |          |
| <50 IU/L                | 7,461 (78.5)| 5,263 (72.9)| 2,198 (96.3)| <0.001   |
| ≥50 IU/L                | 2,044 (21.5)| 1,960 (27.1)| 84 (3.7)   |          |

* Test of the difference between the proportions of men and women (chi-squared test)

The measurements were divided by general standard criteria. The number of participants differs for each test item due to the lack of measured values. The numbers used in the tabulations are shown in the appendix table.

Abbreviations; HDL cholesterol: high density lipoprotein cholesterol; LDL cholesterol: low density lipoprotein cholesterol; HbA1c: hemoglobin A1c; AST: aspartate aminotransferase; ALT: alanine aminotransferase; γ-GTP: γ-glutamyl transpeptidase.
Conflict of Interest Statement

None declared.

Funding

This study was supported by the Industrial Disease Clinical Research Grants from the Ministry of Health, Labour and Welfare, Government of Japan (Comprehensive study for the current status and preventive strategies of overwork-related disorders, 150903-01 and 180902-01).

References

1) Takahashi M (2019) Sociomedical problems of overwork-related deaths and disorders in Japan. J Occup Health 61, 269–77.
2) Yamauchi T, Yoshikawa T, Takamoto M, Sasaki T, Matsumoto S, Kayashima K, Takeshima T, Takahashi M (2017) Overwork-related disorders in Japan: recent trends and development of a national policy to promote preventive measures. Ind Health 55, 293–302.
3) Ministry of Health, Labour and Welfare (2020) [White Paper on Prevention of Karoshi] (in Japanese). https://www.mhlw.go.jp/wp/hokusyo/karoushi/20/index.html. Accessed March 10, 2021.
4) National Institute of Occupational Safety and Health, Japan (2020) [Annual report: Comprehensive study for the current status and preventive strategies of overwork-related disorders] (in Japanese).
5) Virtanen M, Heikkilä K, Jokela M, Ferrie JE, Batty GD, Vahtera J, Kivimäki M (2012) Long working hours and coronary heart disease: a systematic review and meta-analysis. Am J Epidemiol 176, 586–96.
6) Kang MY, Park H, SEO JC, Kim D, Lim YH, Lim S, Cho SH, Hong YC (2012) Long working hours and cardiovascular disease: a meta-analysis of epidemiologic studies. J Occup Environ Med 54, 532–7.
7) Sokejima S, Kagamimori S (1998) Working hours as a risk factor for acute myocardial infarction in Japan: case-control study. BMJ 317, 77580.
8) Steptoe A, Kivimäki M (2012) Stress and cardiovascular disease. Nat Rev Cardiol 9, 360–70.
9) Kivimäki M, Jokela M, Nyberg ST, Singh-Manoux A, Fransson EI, Alfredsson L, Bjorner JB, Borritz M, Burr H, Casini A, Clays E, De Bacquer D, Dragano N, Erbel R, Geuskens GA, Hamer M, Hootman WE, Houtman IL, Jöckel KH, Kittel F, Knutsson A, Koskenvuo M, Lunau T, Madsen IE, Nielsen ML, Nordin M, Oksanen T, Pejtersen JH, Pentti J, Rugulies R, Salo P, Shipley MJ, Siegrist J, Steptoe A, Suominen SB, Theorell T, Vahtera J, Westerholm PJ, Westerlund H, O’Reilly D, Kumari M, Batty GD, Ferrie
10) Hayashi R, Iso H, Yamagishi K, Yatsuya H, Saito I, Kokubo Y, Eshak ES, Sawada N, Tsugane S; Japan Public Health Center-Based (JPHC) Prospective Study Group (2019) Working hours and risk of acute myocardial infarction and stroke among middle-aged Japanese men - The Japan Public Health Center-Based Prospective Study Cohort II. Cire J 83, 1072–9.

11) General Rules of the Japan Standard Industrial Classification, Japan Standard Industrial Classification (Rev. 13, October 2013 ). https://www.soumu.go.jp/english/dgpp_ss/seido/sangyo/san13-2.htm. Accessed April 1, 2021.

12) Iso H, Shimamoto T, Sankai T, Tanigawa T, Ohira T (1998) [Cohort Studies of Cardiovascular Diseases and Biostatistics] (in Japanese), Statistical Mathematics 46, 21–38.

13) Ministry of Health, Labour and Welfare, Tokyo: The Brief Job Stress Questionnaire English version. https://www.mhlw.go.jp/bunya/roudoukijun/anzeneseisei12/dl/stress-check_e.pdf. Accessed March 11, 2021.

14) Takahashi M, Tsutsumi A, Kurioka S, Inoue A, Shimazu A, Kosugi Y, Kawakami N (2014) Occupational and socioeconomic differences in actigraphically measured sleep. J Sleep Res 23, 458–62.

15) Takahashi M, Iwasaki K, Sasaki T, Kubo T, Mori I, Otsuka Y (2011) Worktime control-dependent reductions in fatigue, sleep problems, and depression. Appl Ergon 42, 244–50.

16) Yamauchi T, Sasaki T, Takahashi K, Umezaki S, Takahashi M, Yoshikawa T, Suka M, Yanagisawa H (2019) Long working hours, sleep-related problems, and near-misses/injuries in industrial settings using a nationally representative sample of workers in Japan. PLoS One 14, e0219657.

17) Ministry of Health, Labor and Welfare & Ministry of Education, Culture, Sports, Science and Technology (2013) [Ethical Guideline for Epidemiological Studies] (in Japanese). http://www.mhlw.go.jp/general/seido/ekigaku/0504sisin.html. Accessed March 11, 2021.

18) Imai T, Kuwahara K, Miyamoto T, Okazaki H, Nishihara A, Kabe I, Mizoue T, Dohi S, Japan Epidemiology Collaboration on Occupational Health Study Group (2016) Validity and reproducibility of self-reported working hours among Japanese male employees. J Occup Health 58, 340–6.

19) Ochiai Y, Takahashi M, Matsuo T, Sasaki T, Fukasawa K, Araki T, Tsuchiya M, Otsuka Y (2020) Objective and subjective working hours and their roles on workers’ health among Japanese employees. Ind Health 58, 265–75.
### Appendix Table. Measured item at medical check-ups, the number of participants with available and missing data

| Measured item               | Total (n=9,549) |                  | Men (n=7,256) |                  | Women (n=2,293) |                  |
|-----------------------------|----------------|-----------------|---------------|-----------------|-----------------|-----------------|
|                             | Measured       | Unmeasured or Missing | Measured       | Unmeasured or Missing | Measured       | Unmeasured or Missing |
|                             | n    | %    | n    | %    | n    | %    | n    | %    | n    | %    |
| Body mass index             | 9,514 (99.63) | 35 (0.37) | 7,222 (99.53) | 34 (0.47) | 2,292 (99.96) | 1 (0.04) |
| Blood pressure              | 9,546 (99.97) | 3 (0.03) | 7,253 (99.96) | 3 (0.04) | 2,293 (100.00) | 0 (0.00) |
| HDL cholesterol             | 9,497 (99.46) | 52 (0.54) | 7,214 (99.42) | 42 (0.58) | 2,283 (99.56) | 10 (0.44) |
| LDL cholesterol             | 9,489 (99.37) | 60 (0.63) | 7,206 (99.31) | 50 (0.69) | 2,283 (99.56) | 10 (0.44) |
| Triglycerides               | 9,506 (99.55) | 43 (0.45) | 7,222 (99.53) | 34 (0.47) | 2,284 (99.61) | 9 (0.39) |
| Fasting blood glucose       | 7,604 (79.63) | 1,945 (20.37) | 5,706 (78.64) | 1,550 (21.36) | 1,898 (82.77) | 395 (17.23) |
| HbA1c                       | 6,999 (73.30) | 2,550 (26.70) | 5,612 (77.34) | 1,644 (22.66) | 1,387 (60.49) | 906 (39.51) |
| AST                         | 9,507 (99.56) | 42 (0.44) | 7,224 (99.56) | 32 (0.44) | 2,283 (99.56) | 10 (0.44) |
| ALT                         | 9,507 (99.56) | 42 (0.44) | 7,224 (99.56) | 32 (0.44) | 2,283 (99.56) | 10 (0.44) |
| γ-GTP                       | 9,505 (99.54) | 44 (0.46) | 7,223 (99.55) | 33 (0.45) | 2,282 (99.52) | 11 (0.48) |

Abbreviations: HDL cholesterol: high density lipoprotein cholesterol; LDL cholesterol: low density lipoprotein cholesterol; HbA1c: hemoglobin A1c; AST: aspartate aminotransferase; ALT: alanine aminotransferase; γ-GTP: γ-glutamyl transpeptidase.