Relationship between occupational injury and gig work experience in Japanese workers during the COVID-19 pandemic: a cross-sectional internet survey

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Abstract: This study evaluated the relationship between occupational injury risk and gig work, which included the exchange of labor for money between individuals or companies via digital platforms. As Japan has experienced a severe economic decline during the coronavirus disease 2019 (COVID-19) pandemic, an increasing number of individuals have engaged in gig work. While few studies have evaluated occupational risks in gig work, several traffic accidents associated with food delivery gig work have been reported in the mass media. In this study, 18,317 individuals completed an internet survey that collected information pertaining to their involvement in gig work and experience of related occupational injuries; data regarding several confounding factors were also recorded. Multiple logistic regression analysis showed that workers involved in gig work had a greater risk of any minor occupational injuries (odds ratio, 3.68; 95% confidence interval, 3.02–4.49) and activity-limiting injuries (odds ratio, 9.11; 95% confidence interval, 7.03–11.8) than those not involved in gig work, after adjusting for age, sex, household income, lifestyle factors, and work-related factors. The results of this study indicate that gig workers are exposed to greater occupational hazards during the COVID-19 pandemic. Additional studies are warranted to clarify the causal mechanism for this relationship.

Key words: COVID-19, Gig work, Gig economy, Occupational injury, Work-related injury, Survey

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Introduction

The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first identified in December 2019. Since then, the coronavirus 2019 disease (COVID-19) pandemic has spread across the globe. As a result, many countries have introduced a wide range of restrictions to control the infection, including social isolation, international travel bans, and suspension of non-essential activities. The Japanese government has specifically requested its citizens to maintain physical distancing and refrain from performing non-essential activities, which have been effective in reducing the incidence of COVID-19. However, such measures have also restricted economic activities. Thus, similarly to other countries, Japan has experienced a severe economic decline during the COVID-19 pandemic. A previous study reported that individuals who do not work from home or have jobs with high physical proximity (e.g., food services) have been particularly affected by this economic downturn.

Rapid advances in digital technology since the beginning of the 21st century have led to a substantial growth in the number of jobs mediated through digital online platforms. The “gig economy” emerged as a key theme in a recent independent review of modern employment practices. The term “gig” has traditionally referred to short-term employment arrangements for musical events. The Department for Business, Energy and Industrial Strategy (BEIS) currently defines gig workers as those who engage in a “gig economy,” which involves the “exchange of labor for money between individuals or companies via digital platforms (e.g., Uber, TaskRabbit, PeoplePerHour) that actively facilitate matching between providers and customers, on a short-term and payment by task basis.” Gig workers can include individuals who are employed as delivery personnel, personal assistants, drivers, handymen, cleaners, cooks, dog-sitters, and babysitters. The Chartered Institute of Personnel and Development estimates that there are currently approximately 1.3 million people (4% of all employed individuals) working in the gig economy in the United Kingdom; the most frequently cited reason for engaging in gig work is to generate additional income. While it appears that the number of gig workers has also increased in Japan during the COVID-19 pandemic, the overall contribution of gig work to the total economy in Japan remains unclear.

A previous study reported that temporary workers had a greater risk of injury due to lower levels of work experience and knowledge of workplace hazards. Moreover, gig workers do not have their own employer (multiple employers through platform companies); while temporary workers have their employers. Health and safety risks are often presumed to be worse with gig work due to the lack of security and facilitation inherent to official workplaces. However, to the best of our knowledge, no prior studies have investigated this issue.

The objective of this internet survey was to investigate the characteristics of Japanese gig workers and to determine whether gig workers have a greater risk of occupational injury.

Subjects and Methods

Participants

The Japan COVID-19 and Society Internet Survey (JACSIS) was a cross-sectional, web-based, self-reported questionnaire that was launched in 2020 to investigate how social issues such as health, medical care, work style, and economy have changed during the COVID-19 pandemic. The survey panel comprised approximately 2.2 million nationally representative respondents from diverse socio-economic backgrounds (in terms of educational level, household income, number of household members, and marital status) at a Japanese internet research company (Rakuten Insight, Inc.). Several studies using data from the JACSIS study have been previously published.

We analyzed data from the second JACSIS questionnaire conducted in 2021. From September 27, 2021, to October 29, 2021, this questionnaire was distributed to 33,081 candidates who had previously completed the JACSIS questionnaire in 2020; the response rate was 69% (n = 22,838). The questionnaire was then distributed to new panelists from the same research company until the target sample size of 31,000 respondents was reached. All respondents completed a web-based informed consent form at the time of registration. The study protocol was approved by the ethics committee of the Osaka International Cancer Institute (approval number: 20084-6).

We first excluded 2,825 respondents who had provided invalid responses in the questionnaire (i.e., those deemed to have not read the questions before providing responses). These invalid responses were categorized as follows: 1) failure to select the second item from the bottom of the list in the dummy question (n = 2,705); 2) selection of all items in the list of seven substances (alcohol, sleeping medications, opioids, sniffing paint thinner, legal psychoactive drugs, marijuana, and cocaine/heroin) (n = 97); and 3) selection of all items in the list of 16 diseases (n = 62). A total of
28,175 respondents (age range, 16–81 yr; 49.2% male) remained after these exclusions. We subsequently excluded an additional 9,858 respondents who were unemployed, full-time homemakers, retirees, or students. Thus, 18,317 respondents (age range, 16–80; 56.8% male) were included in the final analysis.

Gig work
Experience in gig work was assessed with the following question: “Have you worked on a task-based job via digital platforms (e.g., Uber eats, Lancers) in the previous 1-yr period?” Respondents were able to select either “yes” or “no.” This question was based on the aforementioned BEIS definition of a gig economy.

Incidence of injury during work or the commute to work
The incidence of injury was assessed via the following two questions: 1) “Have you ever been injured (including scratches and cuts) during your work or commute to work in the previous 1-yr period?”; and 2) “Have you ever experienced injuries that limited your usual ability to work during work or while commuting to work in the previous 1-yr period?” Respondents were prompted to select either “yes” or “no.”

Potential confounding variables
Several risk factors for occupational injury have been reported. We collected data on potential confounders such as age, sex, main occupation (based on the Japan Standard Occupational Classification), household income in 2020 (categorized as <2,999 yen, 3,000–5,999 yen, >6,000 yen, “do not want to answer,” or “do not know”), employment status (standard employment, non-standard employment, self-employed, or freelancer), working hours per week (including both the main job and second job), smoking status (current smoker, past smoker, or non-smoker), amount of alcohol consumption, and self-rated health. Self-rated health was assessed by the following question: “What is your current health status?” (excellent, good, fair, poor, or bad). This question was used in the Comprehensive Survey of Living Conditions (CSLC), which was conducted by the Ministry of Health, Labour and Welfare of the Japanese government.

Statistical analysis
Previous studies have suggested that adjusted estimates using inverse probability weighting obtained from a propensity score (from an internet-based convenience sample) provide similar parameter estimates, or at least reduced differences arising from selection bias, compared to population-based estimates. To correct for the selectivity of internet-based samples, we used a population-based sample from the CSLC that was representative of the Japanese population. The full details of the methods used can be found in a previous study that used JACSIS data.

Intergroup comparisons of categorical variables were analyzed using the chi-square test. Residual analysis was performed to identify the specific difference when the chi-square test yielded a significant difference among the groups. Multivariable logistic regression analysis was applied to evaluate the association between gig work experience and injury during work or the commute to work. The experience of any minor injury or that of activity-limiting injury (yes or no), which were outcomes of our study, inputted logistic regression analysis as a dependent variable, separately. We put the gig work experiment as an independent variable. We also put covariates as an independent variable: sex, age, household income, working hours, main occupation, self-rated health, smoking status, and amount of drinking. Some occupation types were combined in the multiple logistic regression analysis, due to the small numbers of workers in each occupation. We combined security or transportation with “Else” occupation. We also categorized construction with occupations involving carrying, cleaning, and packaging.

Results
Gig work was associated with younger age, male sex, lower household income, freelancing, fewer working hours, reduced income, and job loss (Table 1). Employees in the sales and service sectors were more likely to be engaged in gig work compared to those employed in the following occupations: clerical work, security, manufacturing, construction, mining, and carrying, cleaning, and packaging (Table 2).

The incidence rates of occupational injury in no gig work respondents were 9.2% and 2.0% for any minor injury and activity-limiting injury, respectively. Occupational injury incidence varied according to main occupation type. The incidence rates of minor and activity-limiting injuries were higher among respondents who had experience in gig work (27.8% and 17.1%, respectively) than in those with no experience (9.2% and 2.0%, respectively). Respondents with gig work experience had a greater risk of injury during work or the commute to work in almost every occupation type. Gig workers also had a greater risk of activity-limiting injury, despite its absence in some occupations (Table 3).
Table 1. The characteristics of worker with gig work experience in the last year

|                              | Gig work experience in the last year |        |        | p Value<sup>a</sup> |
|------------------------------|-------------------------------------|--------|--------|--------------------|
|                              | Yes (591)                           | 3.3%   | 17,366 | 96.7%              | <0.001 |
| Age (year)                   | –19                                 | 313    | 1.7%   | 23                 | 7.3%   | ▲ 290       | 92.7%   | ▼<0.001  |
|                              | 20–29                               | 2,968  | 16.5%  | 187                | 6.3%   | ▲ 2,781    | 93.7%   | ▼         |
|                              | 30–39                               | 3,458  | 19.3%  | 126                | 3.6%   | ▼ 3,332    | 96.4%   | ▲         |
|                              | 40–49                               | 4,493  | 25.0%  | 120                | 2.7%   | ▼ 4,373    | 97.3%   | ▲         |
|                              | 50–59                               | 3,682  | 20.5%  | 85                 | 2.3%   | ▼ 3,597    | 97.7%   | ▲         |
|                              | 60–69                               | 2,248  | 12.5%  | 26                 | 1.2%   | ▼ 2,222    | 98.8%   | ▲         |
|                              | 70–79                               | 795    | 4.4%   | 24                 | 3.0%   | ▲ 771      | 97.0%   | ▲         |
| Sex                          | Men                                 | 10,279 | 57.2%  | 382                | 3.7%   | ▲ 9,897    | 96.3%   | ▼<0.001  |
|                              | Women                               | 7,678  | 42.8%  | 208                | 2.7%   | ▲ 7,470    | 97.3%   | ▲         |
| Household income in 2020 (1,000yen) | –2,999                             | 2,304  | 12.8%  | 103                | 4.5%   | ▲ 2,201    | 95.5%   | ▼<0.001  |
|                              | 3,000–5,999                         | 5,425  | 30.2%  | 179                | 3.3%   | ▲ 5,246    | 96.7%   | ▲         |
|                              | 6,000+                              | 6,527  | 36.3%  | 196                | 3.0%   | ▲ 6,331    | 97.0%   | ▲         |
|                              | Do not want to answer               | 1,803  | 10.0%  | 51                 | 2.8%   | ▲ 1,752    | 97.2%   | ▲         |
|                              | Do not know                         | 1,896  | 10.6%  | 60                 | 3.2%   | ▲ 1,836    | 96.8%   | ▲         |
| Employment status            | Regular employment                 | 10,158 | 56.6%  | 292                | 2.9%   | ▼ 9,866    | 97.1%   | ▲<0.001  |
|                              | Non-regular employment              | 5,872  | 32.7%  | 173                | 2.9%   | ▲ 5,699    | 97.1%   | ▲         |
|                              | Self-employed                       | 1,451  | 8.1%   | 55                 | 3.8%   | ▲ 1,396    | 96.2%   | ▲         |
|                              | Freelance                           | 475    | 2.6%   | 69                 | 14.5%  | ▲ 406      | 85.5%   | ▼         |
| Duration of work (hours/week) | –20                                 | 2,570  | 14.3%  | 114                | 4.4%   | ▲ 2,456    | 95.6%   | ▼<0.001  |
|                              | 20–29                               | 2,221  | 12.4%  | 100                | 4.5%   | ▲ 2,121    | 95.5%   | ▼         |
|                              | 30–39                               | 3,417  | 19.0%  | 104                | 3.0%   | ▲ 3,313    | 97.0%   | ▲         |
|                              | 40–49                               | 7,418  | 41.3%  | 211                | 2.8%   | ▼ 7,207    | 97.2%   | ▲         |
|                              | 50–59                               | 1,284  | 7.2%   | 31                 | 2.4%   | ▲ 1,253    | 97.6%   | ▲         |
|                              | 60+                                 | 1,046  | 5.8%   | 30                 | 2.9%   | ▲ 1,016    | 97.1%   | ▲         |
| Household income reduction   | Yes                                 | 6,507  | 36.2%  | 325                | 5.0%   | ▲ 6,182    | 95.0%   | ▼<0.001  |
|                              | No                                  | 11,449 | 63.8%  | 265                | 2.3%   | ▲ 11,184   | 97.7%   | ▲         |
| Work reduction               | Yes                                 | 5,288  | 29.4%  | 331                | 6.3%   | ▲ 4,957    | 93.7%   | ▼<0.001  |
|                              | No                                  | 12,667 | 70.5%  | 258                | 2.0%   | ▲ 12,409   | 98.0%   | ▲         |
### Table 1. Continued

|                          | Gig work experience in the last year | Yes  | 3.3% | No   | 96.7% | \(p\) Value\)
|--------------------------|--------------------------------------|------|------|------|------|------------|
|                          |                                      | 591  |      | 17,366 |      |            |
| **Job loss**             |                                      |      |      |      |      |            |
| Yes                      |                                      | 1,230| 6.8% | 134  | 10.9% | 1,096 89.1%| <0.001 |
| No                       |                                      | 16,726| 93.1%| 456  | 2.7%  | 16,270 97.3%|        |
| **Self-rated health**    |                                      |      |      |      |      |            |
| Excellent                |                                      | 3,813| 21.2%| 149  | 3.9%  | 3,664 96.1%| ▼ 0.013 |
| Good                     |                                      | 3,649| 20.3%| 121  | 3.3%  | 3,528 96.7%|        |
| Fair                     |                                      | 8,743| 48.7%| 256  | 2.9%  | 8,487 97.1%| ▲        |
| Poor                     |                                      | 1,571| 8.7% | 52   | 3.3%  | 1,519 96.7%|        |
| Bad                      |                                      | 180  | 1.0% | 11   | 6.1%  | 169 93.9% | ▽        |
| **Smoking status**       |                                      |      |      |      |      |            |
| Non smoker               |                                      | 8,801| 49.0%| 276  | 3.1%  | 8,525 96.9%| 0.009   |
| Past smoker              |                                      | 4,283| 23.9%| 122  | 2.8%  | 4,161 97.2%|        |
| Current smoker           |                                      | 4,871| 27.1%| 191  | 3.9%  | 4,680 96.1%| ▽        |
| **Amount of drinking** (alcohol g/day) |      |      |      |      |      |            |
| Non drinker              |                                      | 6,856| 38.2%| 232  | 3.4%  | 6,624 96.6%| 0.280   |
| –19.9                    |                                      | 4,290| 23.9%| 144  | 3.4%  | 4,146 96.6%|        |
| 20–39.9                  |                                      | 3,500| 19.5%| 97   | 2.8%  | 3,403 97.2%|        |
| 40.0–                    |                                      | 3,310| 18.4%| 117  | 3.5%  | 3,193 96.5%|        |
| **Main occupation**      |                                      |      |      |      |      |            |
| Professional and engineering |                                  | 3,196| 17.8%| 108  | 18.3% | 3,088 17.8%| <0.001 |
| Clerk                    |                                      | 3,944| 22.0%| 107  | 18.1% | 3,837 22.1%| ▲        |
| Shop and market sale     |                                      | 2,214| 12.3%| 88   | 14.9% | 2,126 12.2%| ▽        |
| Service                  |                                      | 1,552| 8.6% | 69   | 11.7% | 1,483 8.5% | ▼        |
| Security                 |                                      | 258  | 1.4% | 2    | 0.3%  | 256 1.5% | ▲        |
| Manufacturing process    |                                      | 1,649| 9.2% | 38   | 6.4%  | 1,611 9.3%| ▲        |
| Transport and machine operation |                | 403  | 2.2% | 15   | 2.5%  | 388 2.2% |        |
| Construction and mining  |                                      | 375  | 2.1% | 5    | 0.8%  | 370 2.1% | ▲        |
| Carrying, cleaning, packaging |                  | 677  | 3.8% | 13   | 2.2%  | 664 3.8% | ▲        |
| Else                     |                                      | 3,689| 20.5%| 144  | 24.4% | 3,545 20.4%| ▽        |

The numbers on this Table were adjusted using inverse probability weighting.

a) Chi-square test, ▼: statistically significant lower than expected value by residual analysis,
▲: statistically significant higher than expected value by residual analysis
Table 2. The relationship between gig work experience and occupational injury according to main occupation

| Main occupation                  | Gig work experience in the last year |                    | No gig work experience |                    |
|----------------------------------|--------------------------------------|--------------------|------------------------|--------------------|
|                                  | Number of workers  | Any minor injury | Activity-limiting injury | Number of workers  | Any minor injury | Activity-limiting injury |
|                                  | n              | n incidence* | n | incidence* | n              | n incidence* | n |
| Professional and engineering    | 108            | 24           | 22.2 | 12 | 11.1 | 3,088            | 256          | 8.3 | 53 | 1.7 |
| Clerk                            | 107            | 31           | 29.0 | 20 | 18.7 | 3,837            | 196          | 5.1 | 57 | 1.5 |
| Shop and market sale             | 88             | 23           | 26.1 | 15 | 17.0 | 2,126            | 165          | 7.8 | 31 | 1.5 |
| Service                          | 69             | 31           | 44.9 | 25 | 36.2 | 1,483            | 189          | 12.7 | 33 | 2.2 |
| Security                         | 2              | 0            | 0.0 | 0 | 0.0 | 256              | 23           | 9.0 | 7 | 2.7 |
| Manufacturing process            | 38             | 10           | 26.3 | 6 | 15.8 | 1,611            | 209          | 13.0 | 29 | 1.8 |
| Transport and machine operation  | 15             | 6            | 40.0 | 0 | 0.0 | 388              | 37           | 9.5 | 9 | 2.3 |
| Construction and mining          | 5              | 4            | 80.0 | 0 | 0.0 | 370              | 76           | 20.5 | 15 | 4.1 |
| Carrying, cleaning, packaging    | 14             | 5            | 35.7 | 1 | 7.1 | 664              | 124          | 18.7 | 32 | 4.8 |
| Else                             | 144            | 30           | 20.8 | 22 | 15.3 | 3,545            | 328          | 9.3 | 83 | 2.3 |
| Total                            | 590            | 164          | 27.8 | 101 | 17.1 | 17,368           | 1,603        | 9.2 | 349 | 2.0 |

* Incidence rate of injury in each main occupation per 100 person

The prevalence of main occupations were significantly different between worker with and without gig work experience ($p<0.001$, Chi-square test).

▽: statistically significant lower than expected value by residual analysis

▲: statistically significant higher than expected value by residual analysis

The numbers on this Table were adjusted using inverse probability weighting.
The results of the multivariate logistic regression analysis indicated that gig workers had a significantly higher risk of injury after adjustments for covariates (Table 3). The odds ratios of any minor injury and activity-limiting injury were 3.40 (95% confidence interval, 2.81–4.11) and 8.37 (95% confidence interval, 6.47–10.82), respectively. Younger age, lower income, longer working hours, non-standard employment, and self-employment were associated with a significantly higher risk of injury. Occupation involving carrying, cleaning, and packaging had the highest occupational injury risk.

Discussion

This study investigated the characteristics of gig workers and the relationship between gig work and occupational injury. Our results showed that 3.3% of Japanese workers had experience in gig work. Involvement in gig work was associated with younger age, male sex, lower income, freelancing, work reduction, and prior job loss. Gig workers had a much higher incidence rate of occupational injury (27.8% for any minor injury and 17.1% for activity-limiting injury) than those who did not have gig work experience (9.2% and 2.0%, respectively). Multiple regression analysis indicated that gig workers had a three times greater risk of any minor occupational injury and an eight times greater risk of activity-limiting injury, after adjustment for potential confounders.

Previous surveys have suggested that 8%, 4%, and 7.1% of respondents in the United States (2016)\(^3\), United Kingdom (2017, 2018\(^8\)), and Australia (2019\(^9\)) engaged in gig work, respectively. These studies reported that gig workers were more likely to be younger, male, and have a lower annual income. The most common motives for participating in gig economy platforms were additional income and work flexibility. These findings are consistent with our results.

In the present study, respondents in the marketing, sales, and service sectors were more likely to engage in the gig economy for additional income. These respondents were more likely to have experienced a reduction in the amount of available work and job loss due to COVID-19 social distancing policies\(^4\). Furthermore, freelancers appeared to have the greatest amount of experience in gig work during the COVID-19 pandemic. This was not unexpected, as the characteristics of gig work are similar to those of freelancing, where work availability is intermittent, and payment is provided for specific tasks.

The rate of activity-limiting injury in no gig workers (2.0%) was larger than Japanese workers’ accident rate (0.23%) in 2020 reported by Japan Industrial Safety & Health Association (JISHA)\(^2\). This discrepancy may be attributed to the differences in defining ‘accident’, where JISHA considers fatalities and injuries requiring absence of 4 days or more, while our definition of accident includes less than 4 days of absence owing to injury. Our results of activity-limiting injury rate (2.0%) were consistent with a previous Japanese study which reported 3.35% of occupational injury from an organizations’ records\(^3\) regardless of the number of absentee days or other previous studies in the US or Europe which reported an occupational injury rate of 3–5% for those with paid sick leave\(^20, 34\), and 5–10% for those with any restriction of activity\(^14, 35\). In contrast, the incidence rate of any minor injury in our study (9.2% in no gig workers and 27.8% in gig workers) was lower than rates of 30–40% reported by previous studies\(^14, 36, 37\). This discrepancy may be attributed to differences in the way in which the questions were phrased, as well as differences in the respondents’ occupation types.

To the best of our knowledge, the present study is the first to report the risk of occupational injury among gig workers. The elevated risk of occupational injury among gig workers may be explained by a lack of experience with the jobs offered in the gig economy. A previous study found that workers who were employed in temporary agencies had higher overall injury rates than permanently employed workers; this was attributed to lower levels of work experience and knowledge of workplace hazards among temporary workers\(^32\). Another study reported that prior work experience was associated with a lower rate of injury\(^38\).

The type of gig work should also be considered. Courier and food delivery services account for more than 60% of the gig economy\(^39\). Moreover, most Japanese gig workers deliver foods using their bicycles or scooters because of legal restrictions. The traffic accident risk could thus be higher. We suspect that the 8.5-fold increase in activity-limiting injuries (17.1%) among gig workers may be largely due to traffic accidents during food deliveries. Our results were consistent with previous results in a Greece study which reported that 25.3% of food delivery riders were involved in serious accidents\(^20\). In the present study, we found that such work (e.g., carrying) posed a high risk of injury (Tables 2 and 3). These jobs are often hazardous even for permanent employees with a high level of experience\(^30\). The risk of injury may be further exacerbated by a low decision latitude among these gig workers, as well as the progressive saturation of the food delivery market.
### Table 3. Relationship between gig work experience and occupational injury

|                                | Any minor injury | Activity-limiting injury |
|--------------------------------|-----------------|--------------------------|
|                                | OR   | 95% CI  | OR   | 95% CI  |
| Gig work experience in the last year |      |          |      |          |
| No                             | 1.00 | (reference) | 1.00 | (reference) |
| Yes                            | 3.68 | 3.02    | 4.49 | 7.03    | 11.8 |
| Age (year)                     |      |          |      |          |
| –19                            | 2.17 | 1.54    | 3.07 | 1.48    | 0.70 | 3.09 |
| 20–29                          | 1.85 | 1.58    | 2.16 | 2.17    | 1.64 | 2.89 |
| 30–39                          | 1.00 | (reference) | 1.00 | (reference) |
| 40–49                          | 0.85 | 0.72    | 0.99 | 0.68    | 0.50 | 0.94 |
| 50–59                          | 0.69 | 0.58    | 0.82 | 0.66    | 0.47 | 0.93 |
| 60–69                          | 0.79 | 0.65    | 0.97 | 0.89    | 0.61 | 1.29 |
| 70–79                          | 0.72 | 0.54    | 0.97 | 0.51    | 0.27 | 0.94 |
| Sex                            |      |          |      |          |
| Female                         | 1.00 | (reference) | 1.00 | (reference) |
| Male                           | 0.97 | 0.86    | 1.10 | 0.92    | 0.73 | 1.16 |
| Household income in 2020 (1,000yen) |      |          |      |          |
| 6,000+                         | 1.00 | (reference) | 1.00 | (reference) |
| 3,000–5,999                    | 1.38 | 1.21    | 1.57 | 1.02    | 0.80 | 1.30 |
| –2,999                         | 1.52 | 1.29    | 1.79 | 1.14    | 0.84 | 1.54 |
| Do not want to answer          | 1.04 | 0.85    | 1.28 | 0.67    | 0.44 | 1.02 |
| Do not know                    | 1.23 | 1.02    | 1.47 | 0.87    | 0.61 | 1.24 |
| Employment status              |      |          |      |          |
| Standard employment            | 1.00 | (reference) | 1.00 | (reference) |
| Non-standard employment        | 1.44 | 1.25    | 1.67 | 0.67    | 0.50 | 0.90 |
| Self employed                  | 1.44 | 1.19    | 1.75 | 2.09    | 1.52 | 2.88 |
| Freelance                      | 0.68 | 0.46    | 1.00 | 0.73    | 0.40 | 1.31 |
| Duration of work (hours/week)  |      |          |      |          |
| –20                            | 1.00 | (reference) | 1.00 | (reference) |
| 20–29                          | 1.30 | 1.07    | 1.59 | 1.28    | 0.88 | 1.85 |
| 30–39                          | 1.47 | 1.21    | 1.79 | 1.06    | 0.73 | 1.54 |
| 40–49                          | 1.77 | 1.46    | 2.14 | 1.14    | 0.80 | 1.64 |
| 50–59                          | 1.91 | 1.48    | 2.46 | 0.85    | 0.51 | 1.42 |
| 60+                            | 1.94 | 1.50    | 2.52 | 1.10    | 0.67 | 1.80 |
| Main occupationa)              |      |          |      |          |
| Clerk                          | 1.00 | (reference) | 1.00 | (reference) |
| Professional and engineering   | 1.58 | 1.31    | 1.91 | 0.97    | 0.68 | 1.37 |
| Shop and market sale           | 1.36 | 1.11    | 1.68 | 0.87    | 0.59 | 1.28 |
| Service                        | 2.11 | 1.72    | 2.60 | 1.47    | 1.01 | 2.14 |
| Manufacturing process          | 2.25 | 1.83    | 2.75 | 1.04    | 0.68 | 1.58 |
| Carrying, cleaning, packaging  | 3.58 | 2.89    | 4.44 | 2.24    | 1.50 | 3.33 |
| Else                           | 1.62 | 1.36    | 1.94 | 1.30    | 0.95 | 1.77 |
| Self-rated health              |      |          |      |          |
| Excellent                      | 1.00 | (reference) | 1.00 | (reference) |
| Good                           | 1.14 | 0.96    | 1.35 | 1.05    | 0.75 | 1.46 |
| Fair                           | 1.35 | 1.18    | 1.56 | 1.48    | 1.13 | 1.94 |
| Poor                           | 2.00 | 1.66    | 2.42 | 2.46    | 1.73 | 3.49 |
| Bad                            | 1.80 | 1.51    | 2.00 | 3.49    | 1.84 | 6.63 |
| Smoking status                 |      |          |      |          |
| Non smoker                     | 1.00 | (reference) | 1.00 | (reference) |
| Past smoker                    | 1.29 | 1.12    | 1.48 | 1.55    | 1.18 | 2.02 |
| Current smoker                 | 1.41 | 1.24    | 1.61 | 1.52    | 1.19 | 1.95 |
| Amount of drinking (alcohol g/day) |      |          |      |          |
| Non drinker                    | 1.00 | (reference) | 1.00 | (reference) |
| –19.9                          | 1.13 | 0.99    | 1.29 | 0.92    | 0.70 | 1.19 |
| 20–39.9                        | 0.90 | 0.77    | 1.04 | 0.83    | 0.62 | 1.12 |
| 40+                            | 1.17 | 1.01    | 1.35 | 1.24    | 0.95 | 1.62 |

a) Security or transportation were combined with “Else” occupation.
Construction was also combined with occupations involving carrying, cleaning, and packaging.
during the COVID-19 pandemic\textsuperscript{31, 42}. In order to protect temporary workers, including those engaged in the gig economy, the Occupational Safety and Health Administration and National Institute for Occupational Safety and Health have recommended the following practices to staffing agencies and host employers\textsuperscript{43, 44}: 1) evaluate the host employer’s worksite; 2) train agency staff to recognize safety and health hazards; 3) ensure the employer meets or exceeds the standards of other employers; 4) assign occupational safety and health responsibilities and define the scope of work in the contract; and 5) injury and illness tracking. The Japan Food Delivery Service Association was established in February 2021\textsuperscript{45} by major platforms (e.g., Uber Eats Japan, Demiaekan, Menu, RIDE ON EXPRESS HOLDINGS) in the Japanese food delivery sector and it developed traffic safety guidelines in October 2021\textsuperscript{46}. It is hoped that digital platforms for gig work in other sectors will adopt a similar approach to ensure occupational safety.

Our study has some limitations. First, available data was restricted to whether the respondents had prior experience of gig work; information pertaining to the type of work (e.g., food delivery, transport using a self-owned vehicle, translation, professional service) was not available. We were also unable to obtain details regarding the injuries sustained by gig workers. Second, as we analyzed data obtained via self-reported questionnaires, our results may have been affected by recall bias. Nevertheless, a previous study demonstrated that self-reported data on workplace injuries accurately reflected actual incidence rates\textsuperscript{30}. Fourth, it is possible that freelancing and self-employment were misclassified, due to their overlapping definitions. Professional workers tended to select “freelance,” while construction and retail workers tended to select “self-employed” (data not shown). Finally, as this was a cross-sectional study, we could not demonstrate a causal relationship between gig work experience and occupational injury. Nevertheless, while the increased risk of occupational injury may be explained by exposure to gig work, there would be no rational explanation for the reverse causal relationship.

In conclusion, the results of this study demonstrated a relationship between gig work and an increased risk of occupational injury. Our findings highlight the need for measures to ensure the safety of gig workers, particularly during the COVID-19 pandemic.

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References

1) Adams-Prassl A, Boneva T, Golin M, Rauh C (2020) Inequality in the impact of the coronavirus shock: evidence from real time surveys. J Public Econ \textbf{189}, 104245.
2) Mongey S, Pilossof L, Weinberg A (2021) Which workers bear the burden of social distancing? J Econ Inequal \textbf{19}, 509–26.
3) Ahmad T, Haroon, Baig M, Hui J (2020) Coronavirus disease 2019 (COVID-19) pandemic and economic impact. Pak J Med Sci \textbf{36}, S73–8.
4) Kikuchi S, Kitao S, Mikoshiba M (2020) Who suffers from the COVID-19 shocks? Labor market heterogeneity and welfare consequences in Japan. Covid Economics \textbf{40}, 76–114.
5) Woodcock J, Graham M (2019) The gig economy. A critical introduction. Polity Cambridge.
6) Lepanjuuri K, Wishart R, Cornick P (2018) The characteristics of those in the gig economy. UK Department for Business, Energy and Industrial Strategy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/687553/The_characteristics_of_those_in_the_gig_economy.pdf. Accessed April 27, 2022.
7) CIPD. To gig or not to gig? Stories from the modern economy. CIPD Survey report March 2017. https://www.cipd.co.uk/Images/to-gig-or-not-to-gig_2017-stories-from-the-modern-economy_tcm18-18955.pdf. Accessed April 27, 2022.
8) Benavides FG, Benach J, Muntaner C, Deleclos GL, Catot N, Amable M (2006) Associations between temporary employment and occupational injury: what are the mechanisms? Occup Environ Med \textbf{63}, 416–21.
9) Tran M, Sokes RK (2017) The gig economy and contingent work: an occupational health assessment. J Occup Environ Med \textbf{59}, e63–6.
10) Amano H, Fukuda Y, Shibuya K, Ozaki A, Tabuchi T (2021)
Factors associated with the work engagement of employees working from home during the COVID-19 pandemic in Japan. Int J Environ Res Public Health 18, 10495.

11) Matsuyma Y, Aida J, Takeuchi K, Koyama S, Tabuchi T (2021) Dental pain and worsened socioeconomic conditions due to the COVID-19 pandemic. J Dent Res 100, 591–8.

12) Gotanda H, Miyawaki A, Tabuchi T, Tsugawa Y (2021) Association between trust in government and practice of preventive measures during the COVID-19 pandemic in Japan. J Gen Intern Med 36, 1–7.

13) Koyama T, Takeuchi K, Tamada Y, Aida J, Koyama S, Matsuyama Y, Tabuchi T (2021) Prolonged sedentary time under the state of emergency during the first wave of coronavirus disease 2019: assessing the impact of work environment in Japan. J Occup Health 63, e12260.

14) Nakata A, Ikeda T, Takahashi M, Haratani T, Hozou M, Fujioka Y, Araki S (2006) Non-fatal occupational injury among active and passive smokers in small-and-medium-scale manufacturing enterprises in Japan. Soc Sci Med 63, 2452–63.

15) Mo F, Neutel IC, Morrison H, Hopkins D, Da Silva C, Jiang Y (2013) A cohort study for the impact of activity-limiting injuries based on the Canadian National Population Health Survey 1994-2006. BMJ Open 3, e002052.

16) Abdalla S, Apariman SS, Cantley LF, Cullen MR, Mock C, Nugent R, Kobusinge O, Smith K (2017) Occupation and risk for injuries. Injury Prevention and Environmental Health. 3rd ed. Washington (DC).

17) Berhanu F, Gebrehiwot M, Gizaw Z (2019) Workplace injury and associated factors among construction workers in Gondar town, Northwest Ethiopia. BMC Musculoskelet Disord 20, 1–9.

18) Bhattacharjee A, Chau N, Sierra CO, Legras B, Benamghar L, Michaely JP, Ghosh AK, Guillen F, Ravaud JF, Mur JM (2003) Relationships of job and some individual characteristics to occupational injuries in employed people: a community-based study. J Occup Health 45, 382–91.

19) Morita Y, Ohta M, Jiang Y, Tanaka H, Yamato H (2018) Relationship between nicotine dependency and occupational injury in a Japanese large-scale manufacturing enterprise: a single-center study. J Occup Environ Med 60, e656–62.

20) Asfaw A, Pana-Cryan R, Rosa R (2012) Paid sick leave and nonfatal occupational injuries. Am J Public Health 102, e59–64.

21) Ministry of Internal Affairs and Communications J. The History of the Japan Standard Occupational Classification. 2009. https://www.soumu.go.jp/main_content/000327409.pdf. Accessed April 27, 2022.

22) Sugisawa H, Harada K, Sugihara Y, Yanagisawa S, Shimmei M (2016) Socioeconomic status and self-rated health of Japanese people, based on age, cohort, and period. Popul Health Metr 14, 1–11.

23) Aiyoshi M, Nishikitani M, Tsurugano S, Inoue M, Yano E (2021) The association of health status and employment status for each occupation: results from a comprehensive survey of living conditions in Japan. Jpn Psychol Res, doi: 10.1111/jpr.12379. In press.

24) Kachi Y, Inoue M, Nishikitani M, Yano E (2014) Differences in self-rated health by employment contract and household structure among Japanese employees: a nationwide cross-sectional study. J Occup Health 56, 339–46.

25) Kawata T, Suzuki S (2011) Marital status and self-rated health in rural inhabitants in Japan: a cross-sectional study. J Divorce Remarriage 52, 48–54.

26) Schonlau M, Van Soest A, Kapteyn A, Couper M (2009) Selection bias in web surveys and the use of propensity scores. Sociol Methods Res 37, 291–318.

27) Berrens RP, Bohara AK, Jenkins-Smith H, Silva C, Weimer DL (2003) The advent of Internet surveys for political research: a comparison of telephone and Internet samples. Political Anal 11, 1–22.

28) Sharpe D (2015) Chi-square test is statistically significant: now what? Pract Assess Res Evaluation 20, 8.

29) Sperandei S (2014) Understanding logistic regression analysis. Biochem Med 24, 12–8.

30) Smith A. Gig work, online selling, and home sharing. Pew Research Center. November 17, 2016. https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2016/11/PI_2016.11.17_Gig-Workers_FINAL.pdf. Accessed April 27, 2022.

31) McDonald P, Williams P, Stewart A, Oliver D, Mayes R (2019) Digital platform work in Australia: Preliminary findings from a national survey. https://eprints.qut.edu.au/203119/1/65060881.pdf. Accessed April 27, 2022.

32) Japan Industrial Safety and Health Association. OSH Statistics in Japan. https://www.jisha.or.jp/english/statistics/index.html. Accessed April 27, 2022.

33) Sakurai K, Nakata A, Ikeda T, Otsuka Y, Kawahito J (2013) How do employment types and job stressors relate to occupational injury? A cross-sectional investigation of employees in Japan. Public Health 127, 1012–20.

34) Dembe AE, Erickson JB, Delbos R (2004) Predictors of work-related injuries and illnesses: national survey findings. J Occup Environ Hyg 1, 542–50.

35) Wilkins K, Mackenzie SG (2007) Work injuries. Health Rep 18, 25–42.

36) Uehli K, Miedinger D, Bingisser R, Durr S, Holsboer-Trachsler E, Maier S, Mehta AJ, Muller R, Schindler C, Zogg S, Kunzli N, Leuppi JD (2014) Sleep quality and the risk of work injury: a Swiss case-control study. J Sleep Res 23, 545–53.

37) Nakata A, Ikeda T, Takahashi M, Haratani T, Fujioka Y, Fukui S, Swanson NG, Hozou M, Araki S (2005) Sleep-related risk of occupational injuries in Japanese small and medium-scale enterprises. Ind Health 43, 89–97.

38) Bena A, Giraudo M, Leombruni R, Costa G (2013) Job tenure and work injuries: a multivariate analysis of the relation with previous experience and differences by age. BMC public health 13, 1–9.

39) Papakostopoulos V, Nathanael D (2021) The complex
40) Driscoll T, Marsh S, McNoe B, Langley J, Stout N, Feyer AM, Williamson A (2005) Comparison of fatalities from work related motor vehicle traffic incidents in Australia, New Zealand, and the United States. Inj Prev 11, 294–9.

41) Swaen G, Van Amelsvoort L, Bültmann U, Slangen J, Kant I (2004) Psychosocial work characteristics as risk factors for being injured in an occupational accident. J Occup Environ Med 46, 521–7.

42) Nakata A, Ikeda T, Takahashi M, Haratani T, Hojou M, Fujioka Y, Swanson NG, Araki S (2006) Impact of psychosocial job stress on non-fatal occupational injuries in small and medium-sized manufacturing enterprises. Am J Ind Med 49, 658–69.

43) Occupational Safety and Health Administration & National Institute for Occupational Safety and Health. Recommended practices: Protecting temporary workers. https://www.cdc.gov/niosh/docs/2014-139/pdfs/2014-139.pdf?id=10.26616/NIOSHPUB2014139. Accessed April 27, 2022.

44) Randolph SA (2019) Gig workers. Workplace Health Saf 67, 439–40.

45) Japan Food Delivery Service Association. Japan Food Delivery Service Association.  https://www.jafda.or.jp/news/pressrelease_20210303.pdf (in Japanese). Accessed April 27, 2022.

46) Japan Food Delivery Service Association. Japan Food Delivery Service Association traffic safety guideline. https://www.jafda.or.jp/documents/jafda_traffic_safety_guidelines_20211029.pdf (in Japanese). Accessed April 27, 2022.